Habitat Equivalency Analysis

Excerpt from the draft SAB Committee report, *Valuing the Protection of Ecological Systems and Services*: *Another cost-related concept is habitat equivalency analysis (HEA), which has been used in Natural Resource Damage Assessments under the Comprehensive Environmental Response, Compensation and Liability Act and the Oil Pollution Act. HEA seeks to determine the restoration projects that would provide ecosystem or other related services (including capital investments such as boat docks) sufficient to compensate for a loss from a natural-resource injury (e.g., a hazardous waste release or spill). In principle, to determine whether a set of projects provides sufficient compensation for a loss, HEA should determine the tradeoffs required to make the public whole using utility equivalents of the associated losses and gains – i.e., it should use a value-to-value approach (see Roach and Wade, 2006; Jones and Pease, 1997). However, in practice HEA is often based on a service-to-service approach specified in biophysical equivalents (e.g., acres) rather than utility equivalents (value). Restoring habitat far from where people live and recreate, however, may not create value equivalent to nearby lost habitat, even if the replacement habitat is of the same size.*

Although HEA can provide dollar estimates of the cost of providing replacement services or projects, these estimates do not necessarily satisfy the two conditions noted above that are necessary for replacement cost to provide a lower bound on value. For example, the value of the ecosystem or other services provided by the restoration projects may not exceed the cost of providing those services. Even if it does, several other assumptions are needed to ensure that HEA will provide an actual estimate of the economic value of the lost ecosystem services and these assumptions will often not be met in practice. These include fixed proportions between services and values, as well as unit values that are constant over time and space (Dunford et al., 2004).

Because costs and benefits are two distinctly different concepts, the committee urges caution in the adoption of any methods using costs as a proxy for value. The above conditions for valid use must be satisfied. Analyses of costs should not be interpreted as measures of benefits unless these conditions are met. Nonetheless, when appropriately applied, methods such as replacement cost and HEA may be useful to EPA in policy contexts where there are multiple ways of providing an ecosystem service.

Further reading

Dunford, R.W., T.C. Ginn and W.H. Desvousges. 2004. The use of habitat equivalency analysis in natural resource damage assessment. Ecological Economics 48: 49-70.

King, D.M. 1997. Comparing ecosystem services and values: With illustrations for performing habitat equivalency analysis. Service Paper Number 1. Washington, DC: National Oceanic and Atmospheric Administration.

U.S. National Oceanic and Atmospheric Administration. 1995. Habitat equivalency analysis: An overview. Policy and Technical Paper Series No. 95-1 (revised 2000). Washington, DC: National Oceanic and Atmospheric Administration.

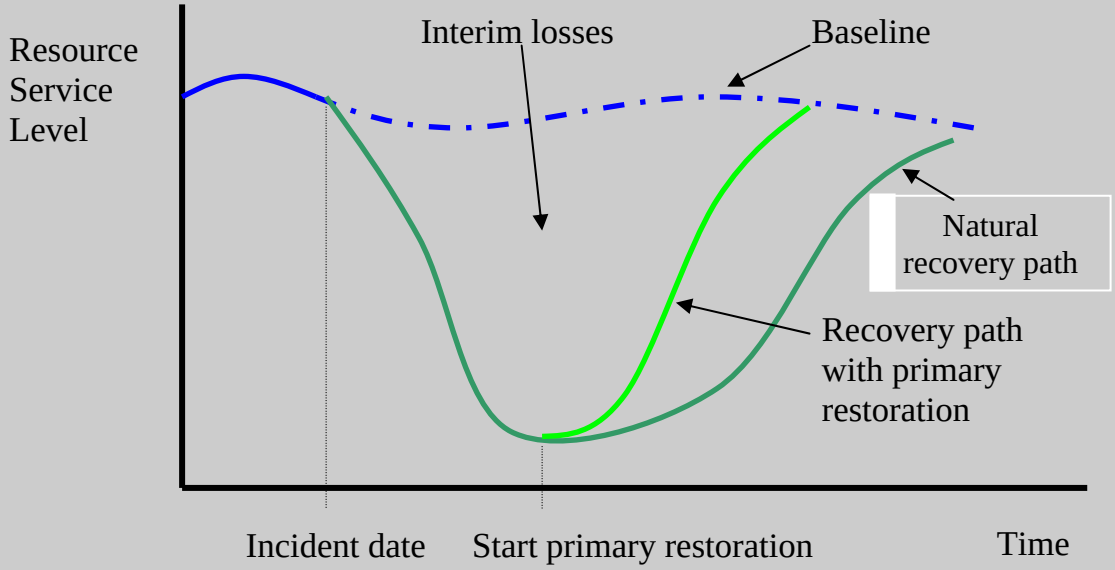
U.S. National Oceanic and Atmospheric Administration. 1999. Discounting and the treatment of uncertainty in natural resource damage assessment. Technical Paper 99-1. Washington, DC: National Oceanic and Atmospheric Administration, Damage Assessment and Restoration Program.

U.S. National Oceanic and Atmospheric Administration. 2001. Damage assessment and restoration plan and environmental assessment for the Point Comfort/ Lavaca Bay NPL site recreational fishing service losses. Washington, DC: National Oceanic and Atmospheric Administration.

U.S. National Oceanic and Atmospheric Administration. Coastal Service Center Web site. Habitat Equivalency Analysis. www.csa.noaa.gov/economics/habitatequ.htm

Brief description of the method. Habitat Equivalency Analysis (HEA) is an analytical framework originally developed to calculate compensation for loss of ecological services resulting from injury to a natural resource over a specific interval of time (King and Adler 1991, NOAA 1995). Figure 1 provides a graphic representation of the relationship between the interim lost from an environmental incident or activity and the recovery of the environment over time both due to natural mechanisms and from primary restoration actions.

Figure 1: Graphical Representation of Ecosystem Service Loss and Recovery through Natural and Active Restoration Over Time



Essentially, HEA calculates the amount (e.g. acres, hectares) of habitat to be created or enhanced to replace an equivalent level of ecological services over time as were lost due to the injury. The basic HEA formula is shown in Text Box 1. Ultimately the HEA approach is not a valuation method but rather more appropriately defined as a "cost-replacement" method. Yet it is important to recognize that an implicit operational assumption for an HEA is that the quantity of ecological service flows, and their as yet undefined value, associated with any given unit of lost or injured habitat are equivalent (same type and comparative value) to a unit of the proposed replacement habitat.

Text Box 1: Equation for Habitat Equivalency Analysis

"Debit: PDV Loss" "Credit: PDV Gain"

$$\sum_{t=t_0}^{t_l} L_t (1+i)^{(P-t)} = \sum_{S=S_0}^{s_l} R_s (1+i)^{(P-s)}$$

where

L_t =	lost services at time *t*
R_s	replacement services at time *s*
t_0	t m when lost services are first
t_l	time when lost services are last
s_0	time when replacement services are first
s_l	time when replacement services are last
P	present time when the natural resource damage claim is
i	periodic discount

There are two main steps in a HEA which are accomplished simultaneously: a) quantifying the injury, and b) scaling the size of restoration to compensate for the lost service over time due to that injury. To be clear, injury is not determined in a HEA, but such a determination of injury is a necessary pre-step to provide the input for scaling the restoration to match the degree of injury. The HEA approach focuses on scaling replacement costs on a service-to-service basis. Therefore in quantitative expressions HEA relies on biophysical units such as acres of habitat as a surrogate of service, and calculates the increase in habitat over time in service acre years. A similar methodology, Resource Equivalency Analysis (REA) focuses on scaling replacement costs on a resource-to-resource approach. In this context, resources are generally defined in terms of biotic type and mass (e.g., kilograms of fish) for the quantification of injury, but often ultimately revert back to an estimate of habitat required to replace or generate those lost resources in estimating the size and type of replacement actions required to restore the environment. HEA can also handle injuries to biotic resources but needs to equate those resource losses to the unit of habitat it would take to create or support that mass of birds, fish, and invertebrates in the first place. Those performing an HEA will thus need to be careful in this translation to avoid the potential for double counting if they are estimating habitat needs for species which are supported by a common habitat such as coastal wetlands.

Temporal assumptions are very important in working with HEA, especially in a damage assessment. Questions such as the following need to be answered or estimated:

- How long has the injury or lost service been in place?

- How much time is required to implement the restoration project?
- How long will the restoration project take before it reaches full replacement service?

Obviously, the answers to these questions can have a significant impact on the estimated compensatory value required to offset the injury. In HEA, a discount rate must be selected for the Net Present Value calculations.

There are some crucial assumptions associated with the HEA method. It can be used only when values per unit of replacement services and lost services are comparable, when it is possible to use a common metric to define an injury and the value of replacement services, and when replacement of ecological services is feasible and measurable.

Since HEA is a restoration/compensation method that is projected into the future, the final unit is a Net Present Value (NPV) measure of the services in the future stated in discounted terms (e.g., Discounted Service-Acre Years or DSAYs). Discounting or scaling of the equivalency of any given sets of injured or restored habitat is required since the resource types that are being addressed are not static over time (NOAA 1999). Injured resources can recover to baseline conditions on their own and planted habitat takes time to develop to full maturity. So factors such as baseline conditions and recovery times become key opportunities for uncertainty in any HEA. Additionally for HEA to operate effectively it must fully explore and determine that capacity of any project or suite of projects to achieve the required level of restoration. To accomplish this assurance step, in advance of an HEA, a process referred to as C.O.P.E. was developed (King 1997). The acronym C.O.P.E. stands for the attributes desired in the HEA, which are: a) Capacity to provide service; b) Opportunity for project(s) in the correct location; c) Payoff of comparable services; and d) Equity to provide service to people in the location that suffered the injury. Each restoration project must satisfy the presumptions of C.O.P.E. to be worth further quantification via HEA as a contribution to satisfy the needed service years equivalent to the lost interim service.

<u>Example of how the method could be used as part of the C-VPESS expanded & integrated framework</u>. The spatial scale at which HEA has typically operated has been at the level of local to regional decisions. Therefore it is not reasonable in its current state of development for HEA to be considered as a tool useful for creating input to national rule-

making. HEA also operates over past and future time scales, involving compensation for injury or estimate service produced by past action, as well as allowing time for restoration projects to mature to full ecosystem service capacity.

With regard to where to place HEA in the C-VPESS integrated and expanded approach to valuation, it would seem to bridge a number of the process elements. Although it would not be fair to say that it is currently applied in a manner that would be classed as characterizing value, it does provide a framing for characterizing bio-physical change. The HEA methodology relies on structural or spatial measures of ecological components such as acres of habitat. Specific service categories such as provisioning, regulating, cultural, and supporting services as expressed in the Millennium Ecosystem Assessment framework (2005) are not identified or expressed but would be considered to be present and operating But if the type of habitat or resources can, with further research, be equated to a unitized measure of values or service flows, either monetary or otherwise, then HEA could be used to scale that associated value over time and across alternative actions. If, through research and development, service flows and associated values can be quantified for given habitat categories (e.g., an acre of coastal wetlands in Louisiana), then there is some hope that HEA may evolve to be a support for valuation.

Additionally, although HEA and REA are currently used in the post-hoc context of injury, damages, and compensation, there is no reason that these methods are constrained to managing adverse outcomes after the fact. They could just as easily be used ex ante to compare alternative future actions to identify the action with the least impact and to compare alternative actions to identify which will yield the most service or equal service in the shortest time frame. These methods or variations could be a fruitful avenue for the Agency to explore through its research and development activities.

As noted, HEA is a tool that has application constraints. Typically, the HEA is applied to support local decisions by scientific experts to evaluate project alternatives for achieving restoration objectives. Such analyses allow those experts to arrive at convincing trades among restoration options. Although there is not much evidence to indicate the use of HEA in support of a facilitated or mediated process that includes the general public, there do not appear to be any technical reasons why this could not be a useful application of HEA to project the services provided by possible alternative future scenarios resulting from a suite of restorations actions.

Such engagement of the public in the identification of restoration projects and desired services is likely to leadto more widely accepted restoration decisions.

Status as a method. The HEA approach was originally developed in 1992 to quantify damages associated with contaminated wetlands (King and Adler 1991, Malcolm v. National Gypsum 1993 as referenced in Unsworth and Bishop 1993) and has since been applied to cover injuries due to chronic contamination, spills, and vessel groundings in a variety of habitats (Chapman, et al. 1998, Fonseca, et al. 2000, Milon and Dodge 2001, NOAA 2001). HEA is currently used in Natural Resource Damages Assessment (NRDA) under Oil Pollution Action (OPA) and CERCLA (Superfund). The purpose of NRD actions is to make the public's interest whole for injuries to natural resources that result from the release of hazardous substances or oil. It is important to note that restoration for damages is distinct from remediation activities.

Interestingly, under these two regulatory frameworks there is a different focus on compensation. Under Superfund actions, compensation for damages is focused on monetary compensation, which requires restoration of service ultimately to be converted to replacement costs in dollars. Under OPA, the focus is on replacement of resources to achieve compensation. The question is how much in the way of new public resources does the public require to be made whole for their loss. Therefore, value is scaled from resource or habitat lost to resource or habitat replaced. As noted previously, there are no barriers to applying these methods in proactive support of decisions. Therefore the Agency should explore such proactive applications of HEA and REA in other regulatory contexts and especially in collaborative partnerships with conservation as a focus.

Strengths/Limitations. The HEA method can be used as a way to scale surrogates measures (e.g. acres of Habitat or mass of fish) of non-market services often overlooked by other valuation methods when the specific assumptions associated with HEA can be met. The method is not complicated mathematically. It is by nature inter-disciplinary because determination of comparability per unit of replacement services and lost services requires collaboration between ecologists and economists.

Since HEA and REA are currently applied to support regulatory actions which link to a litigation process, to define compensation the analysis and supporting data need to be legally defensible with regards to analytical quality. The chief analytical difficulty is to determine

defensible input parameters, especially an appropriate metric for lost and restored services and related time functions for recovery and development to maturity.

The HEA method is not appropriate for standard benefit-cost analysis, where the goal is to determine optimal (efficient) allocation of scarce resources. The cost of compensatory restoration projects should not be communicated as the benefit of the resources to the public.

Treatment of Uncertainty. Uncertainty can be, and should be, directly incorporated into any HEA analysis. Addressing uncertainty in inputs (e.g., percent service lost per unit of habitat and recovery time) can be effectively done. Tracking the effects of uncertainty on HEA outputs can be easily performed. One of the benefits of HEA is the transparency of the method. Sensitivity and uncertainty analysis can be directly incorporated into a HEA evaluation and the resulting change can be tracked in outputs (see NOAA 1999 for more details)

Research needs. There are a number of key areas for research and development that the Agency should explore in connection with HEA.

The Agency should look at HEA for its applications in contexts other than Natural Resource Damage Assessment. In particular, it should consider its utility tandem with Net Environmental Benefit Analysis (Efroymson, et al. 2004) in the selection of best alternatives for project investment.

The Agency should consider research to develop a more complete understanding of the service flows and the associated values of goods and services derived from those flows in specific important habitat types (e.g., coastal wetlands, bottomland hardwood forests). Such value definitions for ecosystem service could then be coupled to HEA to estimate values associated with a project or restoration action.

EPA should consider developing operating principles for considering on-site, in-kind changes in resources and ecological services, as compared with off-site and out-of-kind resources. In support of this objective, methods to assess and compare ecological capacity and the opportunity and payoff for restoration in the evaluation and design of restoration projects will also strengthen the method to assess comparability of ecological resources.

Finally, this method will be strengthened if the Agency develops guidance on the appropriate aggregation and accounting of services related to biotic resources and their

supporting habitats in order to advance the utility of HEA to support local and regional valuation efforts.

Key References

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