(Opinion Article)

Wind power compensation is not for the birds: An opinion from an environmental economist

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ABSTRACT

This article advocates for better implementation of the Environmental Impact Assessment (EIA) framework as applied to wind power development, with a particular focus on improving compensatory restoration scaling. If properly enforced, the environmental impacts hierarchy "avoid - minimize - compensate" provides the regulated community with incentives to *prevent* wildlife and habitat impacts in sensitive areas and, if necessary, *compensate* for residual impacts through restoration or conservation projects. Given the increase in legislation requiring resource-based environmental compensation, methods for scaling an appropriate quantity and quality of resources is of increasing relevance. I argue that Equivalency Analysis (EA) represents a transparent and quantitative approach for scaling compensation in the case of wind power development. Herein, I identify the economic underpinnings of environmental compensation legislation and identify weaknesses in current scaling approaches within wind power development. I demonstrate how the recently-completed REMEDE Toolkit, which provides guidance on EA, can inform an improved scaling approach and summarize a case study involving raptor collisions with turbines that illustrates the EA approach. Finally, I stress the need for further contributions from the field of restoration ecology. The success of ex ante compensation in *internalizing* the environmental costs of wind development depends on the effective implementation of the environmental impacts hierarchy, which must effectively encourage avoidance and minimization over environmental restoration and repair.

Keywords: compensatory mitigation, compensatory restoration, Equivalency Analysis (EA), restoration scaling, Environmental Impact Assessment (EIA), no net loss

Caption: An adult White Tailed Eagle (Haliaeetus albicilla) found under Turbine #61 on April 16, 2008. A total of 38 dead sea eagles have been found under turbines at the Smøla wind farm in Norway between 2005 and June 2010. (photo: Espen Lie Dahl, Norwegian Institute for Nature Research)

Introduction: Wind power and birds

The issue of birds and wind turbines recently appeared in the Wall Street Journal (Bryce 2009). Based on contemporary mortality figures estimated by the wind industry and projected US wind-energy goals by 2030, the editorial extrapolated an annual mortality of 300,000 birds. Besides Altmont pass in California (Smallwood & Thelander 2008), avian collisions have been documented in Norway (Bevanger et al. 2008), Germany (Krone et al. 2008), Spain (de Lucas et al. 2008), and Sweden (Ahlen 2008), to name a few. Although direct mortality rates from turbines vary widely (Smallwood et al. 2007) and comparisons to other causes of avian mortality are difficult (see non-random sampling bias in Helander et al. 2009), the risks to bird (and bat) populations are real, as is increased habitat fragmentation (Kuvlesky et al. 2007; Arnett et al. 2008; USDOE 2010). Current trends in wind energy development -- capacity worldwide has more than doubled every third year since 2005 (WWEA 2010) -- will likely exacerbate this problem.

The growth of wind development is a call for improving the science of ecological restoration to address this emerging threat to wildlife. Just as carbon emissions are external to fossil fuel production, wildlife impacts represent a spill-over effect on a third party (the public) that is *external* to the private costs of developing wind energy (see also noise and aesthetic impacts). One efficient way to encourage developers to internalize this external effect is through better use of the environmental impacts hierarchy in general and compensatory restoration in particular.

This paper argues for the use of Equivalency Analysis (EA) as a method to specify appropriate types and amounts of environmental compensation at wind farms. Before introducing EA and a case study in Section 5, I identify the existing policy framework for compensatory restoration (Section 2), examine the economic underpinnings of compensation (Section 3), and point to the somewhat inadequate scaling approaches used in wind development today (Section 4). Section 6 identifies improvements to the policy framework to ensure effective use of compensatory restoration.

The environmental impacts hierarchy: avoid - minimize - compensate

The pressure for wind development raises two questions: Where is the best place to put turbines and associated roads/structures to *avoid* and/or *minimize* impacts on wildlife and habitat? And how to *compensate* for residual environmental impacts if/when they occur?

Both questions are addressed through Environmental Impact Assessment (EIA) associated with wind development, where guidance documents suggest the "avoid-minimize-compensate" hierarchy *(Langston & Pullan 2003; WTGAC 2010)*. The objective is to prioritize avoidance and/or minimization of environmental impacts through proper siting, operational constraints, etc. Because some environmental impacts are unavoidable for otherwise socially-beneficial projects, the EIA framework allows for compensation to offset residual impacts on species and/or habitat. The objective of *compensatory restoration* (called *compensatory mitigation* in the US) is to rehabilitate or restore the quantity or quality of resources that is lost or diminished.

Connecting ecology and economics: Is compensation '*for the birds*'?

Environmental economists suggest that social welfare depends on, among other things, access to natural resources and the services they provide. Damage to resources or services leads to welfare losses, which may be addressed through environmental compensation (Dunford et al. 2004). Thus, compensation is not '*for the birds'* but *for society* in the sense that the success of environmental compensation is judged by whether it addresses the 'social welfare' metric (Because the expression '*for the birds'* refers to something that is "objectionable or not worth doing," the double-meaning in this article's title is relevant: environmental economics suggests that compensation *is* worthwhile). Importantly, restoration that offsets welfare losses will almost certainly improve, for example, bird populations because of society's well-established preference for bird conservation -- assuming that society, with the help of ecologists and economists, can meaningfully interpret the impact of ecological protection on its collective well-being. While alternative paradigms motivate ecological restoration based on nature's intrinsic value (Clewell & Aronson 2007), the starting point for this article is the EU and US legislation that requires compensation to address social welfare losses (Admittedly, the objective measurement of social welfare is difficult and requires ethical decisions about how to weight the well-being of different individuals in a society, see Johansson 1991).

Economic compensation is based on the notion that an individual is willing to trade-off different amounts of goods without it affecting his/her overall sense of well-being (Johansson 1991). The extent to which an individual is willing to trade one good (resource loss) for another (resource gain or money) reveals his/her *preferences* about what is -- and is not -- an acceptable trade-off (non-market environmental valuation tries to measure how individuals make these trade-offs, see Mitchell & Carson 1989). Consider a resource-based compensation example. Without economics, an environmental loss could be replaced with an environmental gain on a simple 1-to-1 ratio: e.g., X birds lost can be replaced with X birds gained. But an economist would assert that the value society places on a bird lost or gained may depend on: (1) *timing* (a loss/gain in 50 years may be valued lower than a loss/gain that occurs today); (2) *type of environmental loss/gain* (the public may prefer, for example, on-site restoration gains for contamination losses but off-site conservation gains for development losses); (3) *scarcity* (the public may place a higher value on losing the last bird in a population than on losing the first); and/or (4) *proximity of compensation* (it is often argued that the segment of society that suffers an ecological loss should be the one that benefits from the subsequent compensation). As discussed further in Section 5, EA is designed to address these interdisciplinary issues: (1) is addressed through discounting (Cole & Kriström 2008); (2) can be addressed by measuring public preferences when the resource/service provided through compensation differs from that which was lost (Breffle & Rowe 2002; Thur & Berry 2006); and (3) and (4) are addressed through criteria for compensatory project selection (see Lipton et al. 2008).

Further, economic theory suggests that compensation measures ensure efficiency (English et al. 2009). Efficiency refers to the production of goods (e.g., wind power) at the lowest possible cost to society, where *all* costs are included in the production decision. The intent of compensation requirements is to provide an incentive for developers to internalize the *full* environmental cost of siting turbines in a particular location. Consider an analogous example. Carson et al. 2003 assert that the costly compensation required of Exxon following the 1989 Valdez oil spill may explain the subsequent reduction in the number of very large oil spills in the US compared to other countries during the 1990s. That is, shipping companies doing business in US waters presumably took new measures to avoid large oil spills, thus internalizing these previously external environmental costs. Similarly, wind companies will be encouraged to avoid and minimize impacts on sensitive areas if they face the full costs of turbine development.

Because compensatory restoration addresses the loss of resource services and the associated decline in human welfare, scaling requires an interdisciplinary approach (Ozdemiroglu et al. 2009). The welfare assessment of environmental damage and subsequent compensation must be made with reference to an ecological baseline, which implies that an economist's estimation of welfare changes requires the language of ecology to characterize expected outcomes. Thus, scaling of resource-based compensation requires a merging of ecological measurement with the tools and theories of economics. Before explaining how EA fills this interdisciplinary demand, I highlight compensatory scaling approaches used in wind power development today.

Current compensatory restoration for wind development

Although practiced sporadically, compensatory restoration has been implemented by wind developers in the US and EU to address wildlife and habitat impacts (Smallwood 2008; Solano Partners 2009). Examples include, among others, acquisition of bird habitat in California (EEI 2007), and conservation of land for raptors displaced by wind development in the UK (Walker et al. 2005).

In my opinion, current restoration scaling fails to make a connection between the extent of damage and the amount of compensation. For example, the amount of habitat conservation to offset avian collisions in California is scaled based on the "rotor-swept area of a turbine" (EEI 2007) or the megawatts generated (CCC 2005) rather than relevant collision factors and expected restoration gains to the public. Other compensatory schemes are laudable for conserving habitat, but fail to justify specific acreages using quantification metrics (monetary or otherwise). In other cases, wind proponents may fund a restoration project that would have been funded by a government agency, thus failing to provide *additional* environmental gains to the public.

While these "compensation" efforts are well-intentioned, I argue that scaling should be based on ecological and economic measurement to be sure the public is compensated. Below I briefly summarize Equivalency Analysis (EA) as an improved scaling methodology and illustrate its principles with a case study.

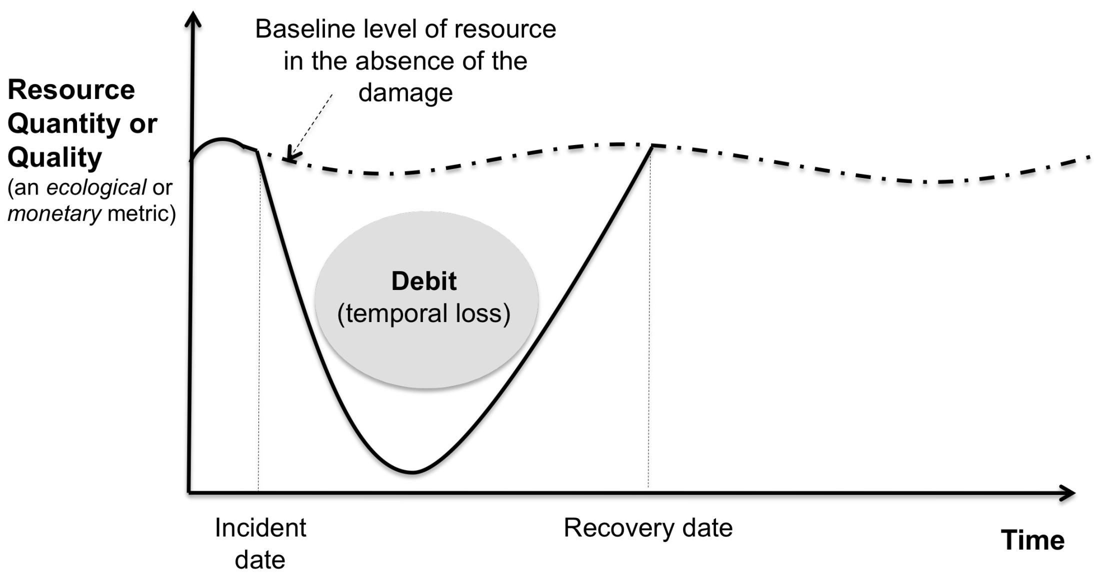
Compensatory restoration scaling using Equivalency Analysis (EA)

Under some US and European statues compensatory restoration is mandatory following environmental accidents (*ex post*). The practice of measuring appropriate amounts of compensation, referred to as scaling, has evolved over the last 30 years in the US (English et al. 2009). Since the mid-1990s, the primary scaling method has been EA, a quantitative approach that ensures equivalence between the environmental loss and subsequent gain (compensation) (Unsworth & Bishop 1994; Jones & Pease 1997; Zafonte & Hampton 2007). For example, resource trustees in the US rely on Habitat Equivalency Analysis (HEA) or Resource Equivalency Analysis (REA) to determine how much is enough compensation (NOAA 1995). Compensation is now frequently required (or provided voluntarily) before undertaking infrastructure projects (*ex ante*). However, to this author's knowledge, wind power compensation has not yet been scaled using EA.

Due to the demand for compensatory scaling under the EU's Environmental Liability, Habitats, and EIA Directives, the European Commission funded REMEDE, a three-year interdisciplinary project to formalize the EA approach in a Toolkit (Lipton et al. 2008). I argue that the Toolkit's five step process, which is based on ecological and economic measurement, represents a transparent, consistent, and defensible approach which can be replicated across (wind) development projects.

EA determines how much compensation is required to offset welfare losses due to environmental damage by ensuring that the value of the environmental gain (credit) is *equivalent* to the value of the environmental loss (debit) over time, where value is a function of the metric used and the length of time the resource is injured (Figures 1a and 1b). The metric, or 'currency' of restoration, may be monetary or ecologically-based. A temporal loss in social welfare accrues because a resource takes time to recover to its baseline level as in Figure 1a (see also time discrepancy in Moilanen et al. 2008). To ensure the public suffers "no net loss" of welfare over time, EA scales compensatory resource gains such that the Figures' two shaded areas are equal. EA assumes the public is willing to substitute the value gained from a restored, enhanced or protected resource for the temporal loss in value of the damaged resource.

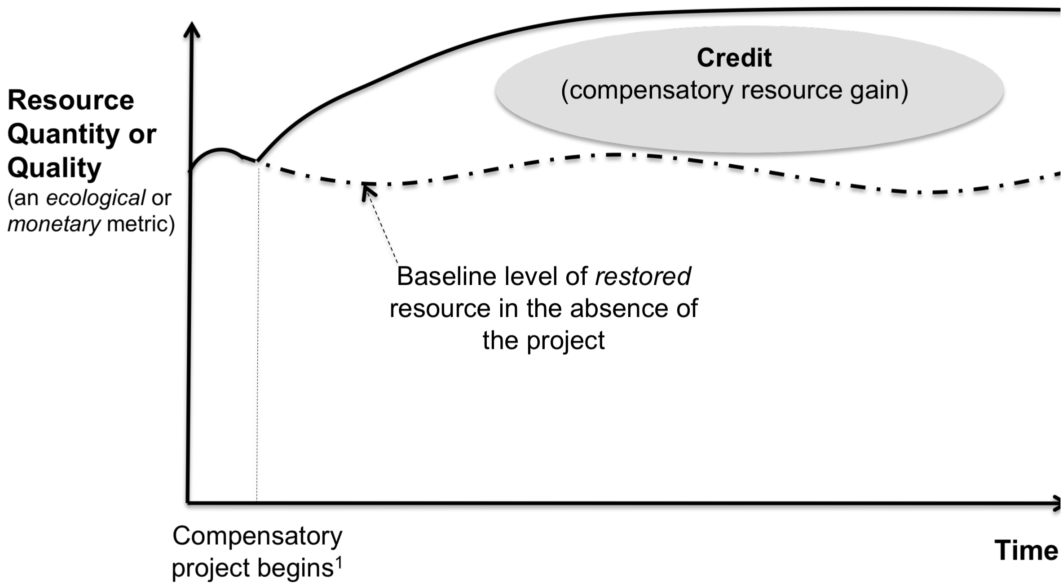
Figure 1a. The environmental loss (debit) in Equivalency Analysis



Source: Based on NOAA (1995)

The credit (Figure 1b) represents an additional and quantifiable compensatory resource gain beyond the restoration site's current and future baseline condition. Without generating *additional* gains, losses are not offset, leading to a "net loss" of social welfare. In general there are two mechanisms for achieving an additional gain: *restoration* (including rehabilitation, enhancement, re-creation) or *conservation* (including preservation or protection). Wetland mitigation policy in the US aims for "no net loss" and explicitly prefers restoration over conservation (FIMW 2002). Conservation arguably provides a credit in certain circumstances, although it may not address aggregate resource loss over time nor be useful in conservation-saturated areas. If a habitat will be lost under a future baseline scenario involving development, then conserving this land by sending development to less sensitive areas would lead to compensatory resource gains (Kiesecker et al. 2009). Assuming both mechanisms would offset a given temporal loss, an interdisciplinary EA might incorporate public preferences in selecting either *restoration* or *conservation* (see Section 3). However, land acquisition can be an expensive compensation strategy in some urban and coastal areas.

Figure 1b. The compensatory resource gain (credit) in Equivalency Analysis



[1] In theory, the credit may begin accruing *before*, *during*, or *after* the environmental loss.
Source: Based on NOAA (1995)

Case study: Equivalency Analysis and wind power

Cole (2010) presents a quantitative, yet hypothetical EA case study to illustrate compensatory scaling in the case of White Tailed Eagle, WTE (*Haliaeetus albicilla*) collisions with wind turbines. The study, which follows the five step REMEDE process, considers the number of WTE collisions over time (past and projected losses), and quantifies the debit and credit using a "bird-year" non-monetary metric (Zafonte & Hampton 2005). This metric, which acts as a currency in measuring appropriate compensation, quantifies a bird's foregone life expectancy in years had it not collided with a turbine. For example, a five-year old WTE that collides with a turbine would have lived approximately 25 more years based on life history characteristics. The debit -- measured as *total discounted bird-years* lost -- includes both *direct* losses for WTEs that collide and *indirect* losses for offspring not born and captures the local incremental impact of turbines on top of existing human-caused mortality, e.g. electrocution, illegal hunting, habitat loss, etc. Similar approaches have been used to scale compensation for bird losses in the US (Swartzman 1996; Sperduto et al. 2003; IEc 2004).

A restoration project is selected based on factors limiting the WTE population. Table 1 identifies possible projects and the data required to quantify the bird-year gain. Cole (2010) illustrates the credit calculations by examining power line retrofitting near the wind farm aimed at preventing WTE electrocution. By estimating the current extent of electrocution mortality in the restoration project area -- and making assumptions about the *reduction* in mortality associated with the retrofit project -- the study calculates the *discounted bird-years produced* ("saved") *per retrofitted pole*, accounting for the remaining life expectancy of a WTE had it not been electrocuted (we assume retrofitting would not be undertaken in the absence of our compensatory project). Compensatory restoration is scaled by dividing the total bird-years lost (debit) by the bird-years produced per retrofitted pole which gives the number of poles to retrofit today to ensure equivalence over time between debit and credit. The use of bird-years assumes that the change in this ecological metric -- both loss and gain -- is proportional to the change in society's welfare. The transparency of the EA approach is manifested through the exchange of the same restoration 'currency' across the loss and the gain side of the equation (quantified using ecological data), which is independent of the compensatory project selected from Table 1.

Table 1. Examples of compensatory projects (credit)[1] that could be scaled using EA to offset White-Tailed Eagle (WTE) mortality from wind turbines

Category	Compensatory project	Data required to quantify gain
Reduce threats to species	Retrofit power lines to reduce electrocution	Current mortality from power lines & future reduction from retrofitting
	Fund measures to prevent/reduce train collisions	Current mortality from collisions & future reduction from measures
	Fund campaign to educate hunters/lawmakers about impact of lead shot on WTE	Current mortality from lead & future reduction from campaign
Improve breeding opportunities	Conserve and protect key habitat areas	Additional raptor production in protected vs. non-protected areas
	Restore habitat lands already protected but degraded	Additional raptor production in restored vs. non-restored areas
	Build artificial nests in trees or on cliffs	Additional raptor production in artificial vs. adjacent natural nests
Improve breeding success	Protect (or enhance) WTE nests from predators or human disturbance	Additional raptor production in protected vs. adjacent natural nests
Other	Re-introduce WTE to previously occupied areas	Population increase in re-introduction area[2]

[1] Based on factors limiting WTE populations (Helander and Stjernberg. 2003)
[2] Assumes chicks in source population would have died due to sibling competition, ensuring global population gain

Improving the environmental impacts hierarchy

Under US and EU statutes requiring *ex post* compensation economic incentives -- in the form of penalties, fines, and clean-up requirements -- encourage operators to prioritize damage prevention (avoidance/minimization) over environmental repair (compensation). In contrast, ex ante compensation schemes (e.g., wind power) prefer avoidance/minimization over repair but lack the economic incentives to steer project proponents toward the former rather than the latter, i.e., there are no penalties or fines for failing to adequately avoid or minimize. The lack of proper incentives makes it difficult to integrate the "avoid-minimize-compensate" hierarchy into coherent EIA guidance. As a result, existing ex ante compensation projects are generally *ad hoc* and the compensation component of the hierarchy is vulnerable to misuse (see "license to trash" in McKenney & Kiesecker, 2010). Thus, ex ante compensation schemes should better define: (1) how much avoidance/minimization is enough? (Kiesecker et al. 2010) And (2) when and how much compensation is required? I address these issues below.

First and foremost, we should improve the transparency and credibility of the EIA process by improving our understanding of environmental impacts at proposed wind development sites (GAO 2005). This will reduce the uncertainties associated with (1) estimating future compensation requirements *today* and (2) identifying which impacts should be avoided/minimized and which can be addressed through compensation. Solano Partners (2009) suggests that the lack of clear guidance on allowable levels of impact and required amounts of compensation - a key complaint from the wind industry - is due to our poor understanding of wind power's environmental impacts. This lack of knowledge makes cost-effective management of such impacts challenging. Thus, we should strive at a minimum for *mandatory* pre- and post-construction monitoring surveys (e.g., Kunz et al. 2007). Site-specific data should be collected cooperatively between wildlife agencies, local ecological experts and developers, and made publically available so that other wind proposals can be reviewed in light of these data (Maisonneuve, C, 2009, Quebec MNR, personal communication); see also AWWI (2010) for a promising development in this regard). Finally, when data are diligently collected but unforeseen impacts arise, they could be addressed through *ex post* compensation (see recommendations in WTGAC, 2010, Chapter 4).

To address the issue of how much avoidance is enough, we could incorporate society's preferences for avoidance over compensation directly into the environmental loss calculation. In practice, this would imply a higher marginal value for each lost unit (e.g., bird-year), such that the value of the temporal loss (debit) increases exponentially (J. Dwyer, 2009, Virginia Tech, personal communication). A larger debit requires greater (and more costly) compensation, making avoidance more attractive (In theory, the marginal value could increase until we reach society's "unacceptable" level of damage -- at this point, the debit is infinite and cannot be compensated.

Avoidance is the only option). An economic survey of the public could measure the intensity of society's preferences, e.g., how they trade-off bird losses from turbines against bird gains from compensation projects.

The implementation of the impacts hierarchy could be improved through a "reclamation fund" that wind power companies pay into prior to development. Funds are used only if damage occurs and returned (with interest) in the absence of future damage, where damage is defined in a pre-construction contract. Similar funds exist to compensate for losses associated with reduced migratory fish runs from hydropower production (BPA 2010). Similarly, oil producers/importers in the US pay into a fund to cover costs of, among other things, compensatory restoration when damage exceeds liability limits (USCG 2006). A fund provides firms with an incentive to undertake avoidance and mitigation measures to ensure re-capturing of reclamation funds while also ensuring the public receives compensation for any possible future environmental losses.

Finally, we need to improve our ability to restore affected populations and damaged ecological systems -- a key challenge for readers of this journal. This requires *mandatory* reporting of post-restoration monitoring to determine what works, what does not, and how much it costs. This journal's new focus on "failed" projects is an important effort in this regard (Hobbs 2009), as is the evidence-based approach to conservation (conservationevidence.com). Wilkinson et al. (2009) note that the future of compensatory restoration will require cooperation across scientists, agencies and developers through comprehensive region-wide projects, which may provide greater ecological benefits at a lower cost to society.

Implications for the practice

- Compensatory restoration activity is increasing in Europe and the US -- based either on new legal requirements or on the voluntary action of the regulated community.
- The Environmental Impact Assessment (EIA) process for constructing a wind farm includes provisions for *compensatory restoration*, and thus an opportunity to improve the science and practice of ecological restoration.
- Equivalency Analysis (EA) represents a transparent and quantitative method to match loss and gain in scaling compensatory restoration. Its use of an ecological or monetary metric ('currency') can be used to improve existing compensation efforts by the wind industry .
- The success of EA within wind development requires expertise from restoration ecologists. Besides innovative restoration projects for raptors and bats, practitioners should consider region-wide compensatory projects that dovetail with wildlife action plans.

- Compensatory restoration aimed at improving social welfare underscores the importance of measuring ecological change so that the public can understand how such changes affect their well-being.
- The objective of the "avoid-minimize-compensate" hierarchy is to prevent damage from occurring rather than repairing it afterwards, but doing so requires that (wind) project proponents internalize all external costs of their projects, including the temporal loss to the public.

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