Frontiers in Ecology and the Environment

A derivative approach to endangered species conservation

James T Mandel, C Josh Donlan, and Jonathan Armstrong

Front Ecol Environ 2009; doi:10.1890/070170

A derivative approach to endangered species conservation

James T Mandel[1,2]*, C Josh Donlan[1,2], and Jonathan Armstrong[3]

Two major shortcomings of the US Endangered Species Act have led to inefficient use of conservation dollars: (1) it only provides conservation protection to distressed or rapidly declining species, and (2) it does not take full advantage of the market to reduce costs in conservation. New, derivative-based insurance products (financial instruments designed to allow the commoditization and sale of risk) have been developed that allow investors to insure risk in exchange for fixed payments. Modifications to these financial derivatives, which are used to distribute risk and stabilize forecasts across many corporate and social scenarios, could allow purchasers to take preventative action to simultaneously protect their investment and decrease the likelihood of the insured event. We propose that governments issue modified derivative contracts to sell species' extinction risk to market investors and stakeholders. Using the endangered red-cockaded woodpecker (*Picoides borealis*) in the US as an example, we show how a biodiversity derivatives program could proactively generate new funding, result in more cost-effective conservation, align stakeholders' interests, and create incentives for private conservation efforts.

Front Ecol Environ 2009; doi:10.1890/070170

The US Endangered Species Act (ESA) is arguably one of the most important pieces of environmental legislation in US history. It has been a success, since at least half of the listed species have benefited (Male and Bean 2005). However, implementation of the ESA has involved inefficiencies, including an exclusive focus on species that are already declining in numbers and its failure to use the full power of the market to distribute the burden of conservation. As a result, the financial demands on the US Government, particularly as a result of litigation, overwhelm the resources that have been allocated to protect endangered species. For example, in 2003, $9 million was appropriated to the US Fish and Wildlife Service's (FWS) endangered species listing program, yet the agency faced an estimated $8 million in court-related fees involving already-listed species (US Department of Interior 2003). This imbalance has led to listing delays and inadequate recovery efforts. A further problem is that recovery initiatives often look only at benefits, ignoring cost-effectiveness concerns. Given that conservation funds are limited, the incorporation of economic costs into conservation planning often leads to interventions that are an order of magnitude more efficient (Naidoo *et al.* 2006).

In a nutshell:

- Biodiversity conservation strategies should include economic costs and incentive structures
- Modified derivative products – biodiversity derivatives – could be designed to finance species recovery efforts and align the interests of landowners and conservationists, making earlier, private interventions more likely
- Such financial instruments could create markets around biodiversity conservation, providing an insurance policy against species jeopardy while also providing incentives for environmental stewardship

[1]*Department of Ecology and Evolutionary Biology, Cornell University, Ithaca, NY* [*]*(jtm39@cornell.edu);* [2]*Advanced Conservation Strategies, Midway, Utah;* [3]*Cornell Law School, Cornell University, Ithaca, NY*

Another critical issue that affects US conservation law is that stakeholders' interests are not aligned (Brook *et al.* 2003). When conservationists and the US Federal Government argue on behalf of endangered species and ecosystems, they are often at odds with landowners, businesses, and local governments. Landowners face perceived or potential uncompensated devaluation of their assets through stays on development, while governmental agencies face substantial expenses for preservation or rehabilitation, along with pressure from special interest groups. Consequently, landowners often take preemptive actions (eg land modification) in order to avoid the potential application of conservation law (Bean 1998; Lueck and Michael 2003), and the government has increasingly resisted listing species (Greenwald and Suckling 2005). Financial instruments can be used effectively to align these interests and reduce tension among stakeholders.

Market-influenced conservation schemes within the ESA have been effective at aligning stakeholders' interests for listed species when habitat conservation is both expensive and essential to success. For example, safe-harbor agreements, conservation banking, and habitat trading have been implemented for the red-cockaded woodpecker (*Picoides borealis;* Figure 1), with some success

© B Beck

Figure 1. *Red-cockaded woodpecker (*Picoides borealis*).*

(Bonnie and Bean 1996). Nonetheless, "shoot, shovel, and shut up" is common parlance among landowners of southern long-leaf pine forests, who often resort to clear-cutting and early harvest to preemptively prevent the chance of these endangered woodpeckers nesting on their land (Bonnie and Bean 1996; Lueck and Michael 2003). If carefully implemented, a derivative product could concurrently finance species recovery efforts and align the interests of landowners and conservationists, making earlier and private interventions more likely. By issuing a derivative whose value is based on the population viability of a species prior to becoming distressed, the government would proactively raise funds for recovery efforts, should these be needed. If the trading of species derivatives were responsibly permitted, those who do not currently incorporate a conservation ethic into their economic decisions would stand to profit from a change in behavior towards environmental stewardship.

Many companies use derivatives and similar financial products as a way of paying market investors to take certain risks. For example, insurance companies often foresee that they will lack the capacity to meet all of the claims against them in the event of a major catastrophe, such as a Category Five hurricane. To protect against this risk, insurance companies can issue catastrophe bonds, which pay an interest rate substantially higher than the risk-free rate. If the catastrophe occurs, the insurance company will use the bonds' principal to pay the claimants, rather than returning it to the investors. If the catastrophe does not occur, however, the bondholders will reap the benefits of the high interest rate. Natural disasters correlate poorly with the performance of stocks and traditional bonds, so catastrophe bonds have a natural market in investors who are interested in diversifying their portfolios (Leoni and Luchini 2004).

Derivatives of this nature have recently been adopted in the fields of economic and social development, as a way of managing risk. A weather derivatives market was created in 1997, which quickly developed into an $8 billion industry (Hess *et al.* 2002). Companies whose business depends heavily on weather (eg power companies) often use weather derivatives to hedge against the risk of extreme weather. Weather derivatives have a structure similar to stock options, where a certain weather event (eg number of days in a month below a certain temperature), rather than a set stock price, triggers a payout. The UN World Food Program has recently solicited donors to subsidize weather derivatives pegged to a set amount of rainfall in Ethiopia, to hedge against the risk of drought-induced famine there (Linnerooth-Bayer *et al.* 2005). If a sufficient amount of rain falls, the UN makes a payment to the investors; on the other hand, if the rainfall threshold is not reached, then the country (or organization) collects money from the investors, which is immediately available to combat the resulting food shortages. This preemptive approach is more cost effective than traditional insurance policies and disaster relief, and because the threshold is tied to rainfall rather than famine (as in the case of insurance and disaster relief), funds can be used to prevent suffering rather than simply alleviating it. This risk-distribution model is being extended to other countries and crises, such as hedging against economic damage caused by locusts or the underproduction of antiretroviral drugs in anticipation of a HIV/AIDS vaccine (Leoni and Luchini 2004). While the risk profiles of all of the above events differ substantially, hedging against that risk can be accomplished with the same type of financial instrument.

A second type of derivative does not hedge risk, but rather can be used to align incentives among stakeholders in an enterprise. Employee stock options, for example, give employees the potential for future ownership of a portion of the company for which they work. Those options encourage employees to proactively solve problems and guard against risk, since they stand to profit from the success of the company (Huddard 1994). Those types of derivatives differ from the insurance derivatives, in that the employee is motivated to manipulate the underlying asset: the success of the company. Since the company often gifts options to employees, they have no insurance against poor performance. An alternative perspective is that the company has paid, in the form of ownership, to ensure that their employees have the business' best interests in mind. This type of derivative serves primarily to align the interests of owners and management.

A hybrid of these two types of financial instruments, in which an insurance derivative is issued with modifications to allow responsible action to decrease the likelihood of the insured event, could be applied to a whole suite of social problems, encouraging social change that is incentivized through market forces. Here, we propose a derivative based on species decline, that could both transfer the financial risk associated with last-minute conservation and align the interests of stakeholders with those of the government or large non-governmental organizations (NGOs).

Potential structure

An biodiversity derivatives program could be structured as follows. A species shows a decline in numbers, while current anthropogenic forces on its environment (eg habitat destruction) make it a likely candidate for future listing and protection under the ESA within the next 5–10 years. The government, or a suitably funded NGO, issues derivatives based on the likelihood that the species will need protection in the form of land purchases, changes in land use, and/or rehabilitation. The derivative is priced so that the expected value of the contract *prior to the event* is equal to investing in US treasury bonds, figuring in the present risk of species decline, the time line, and current interest rates. The government will issue a sufficient number of contracts to raise enough money to cover estimated recovery costs if the species continues to decline (Panel 1). Alternatively, the derivative could be priced at a strong discount to this value, if the issuer has funds available and desires primarily to create a distributed financial incentive (Figure 2). If the species declines to a predetermined threshold, the principal that the investors paid in will become immediately available for species recovery initiatives. Threshold levels could be set, preferably according to ecologically effective densities (Soulé *et al.* 2005), or alternatively at a somewhat higher population size than will require listing under the ESA. Either threshold would allow the funds to be spent on efforts to prevent the species from being listed (Figure 3). Census methods and schedules, to determine actual species levels in relation to the threshold, would be clearly spelled out in advance, and would be measured by a disinterested third party. This third party would most likely be an independent trust, created for the sole purpose of monitoring species status in relation to the predefined threshold, and disbursing funds when necessary. The impartiality of such a group would be essential.

Since independent verification is likely to be a central challenge, the composition of the auditing agency and the existence of clear, quantitative audit rules are critical. The environmental markets movement can supply examples of both successes and failures on which to model a species market. The sulfur dioxide market serves as an example of a clear success; there is little dispute over the actual emissions, transaction costs are low, and this initiative resulted in substantial cost-effective reductions (Sandor *et al.* 2002). At the other end of the spectrum, wetlands markets are saddled with both high transaction costs and poor verification, which is currently limiting marketplace activity (Shabman *et al.* 2002). The more recent examples of species conservation banking suggest that impartial monitoring can be accomplished with reasonable transaction costs (Fox and Nino-Murcia 2005).

Under the ESA, the recovery target for the red-cockaded woodpecker is 500 active groups within designated recovery populations (Bonnie and Bean 1996). Under a derivative with a threshold set at 600 active groups, the government will repay the principal to the investors if >600 groups are present when the contract matures (eg 5–10 years). If the species declines below the threshold, the forfeited principal is immediately available to the government, to be spent on species recovery initiatives (Figure 3). Like catastrophe bonds, when the government issues biodiversity derivatives priced on the cost of recovery, it transfers the risk of listing a species to the market, thereby stabilizing its costs for listing and protecting species over a set time period.

In contrast to weather derivatives and similar to stock options, investors will have the ability to affect the outcome of biodiversity derivatives. The current lack of incentives for the owners of critical habitat to leave the land undeveloped is a pivotal issue (Brook *et al.* 2003; Lueck and Michael 2003; Stokstad 2005). Because early conservation interventions are always cheaper and more cost effective than waiting until a species is critically endangered, biodiversity derivatives would provide large-scale investors with the financial incentive to undertake proactive, private conservation efforts (Figure 3). For example, investors could engage in widespread species recovery, use habitat trading to establish ecologically effective population sizes (Soulé *et al.* 2005), pay for the implementation of conservation easements on critical habitat, or compensate private landowners if they forgo development or other harmful activities in the target

Panel 1. An example of pricing an biodiversity derivative

(Probability of payout x expected return) + (probability of default x expected return) = capital raised at issuance x interest earned over time period

In this example for the red-cockaded woodpecker, and using a risk-neutral pricing model, $4.4 million (present day) is the necessary capital to conserve 500 active population groups, if all groups require intervention and all groups are on spatially heterogeneous logging land. This could serve as the target for capital raised.

Preferred structure may be a rolling issuance. Thus, a 10-year derivative is issued every year for 1/10 of the total capital. After an initial period, there will be $4.4 million worth of incentive in the system at all times, with pricing flexibility as risks change.

If a species has a 30% chance of a listing event over 10 years, and the interest rate on amassed capital is 5%, then the cost to the government to issue such an insurance policy is $307 000 per year. With a 10% risk of ESA listing, the cost is less than $80 000 per year, and a 50% outlook translates to $717 000 per year.

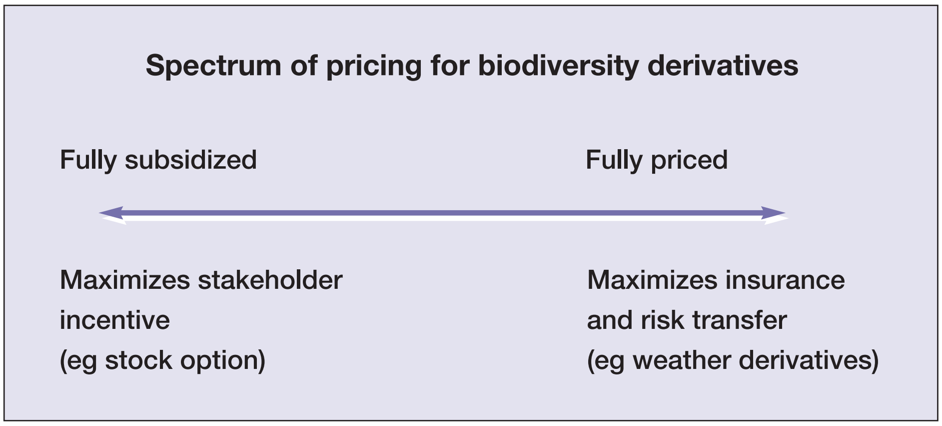

Figure 2. *A spectrum of issuance options for a biodiversity derivative, ranging from fully priced (Panel 1) to fully subsidized, which would maximize stakeholder conservation incentive.*

species' habitat. Any or all of these actions might be cheaper than forfeiture of the biodiversity derivative. As the risk of extinction decreases, the value of the derivative on the secondary market would increase and investors could sell at a profit.

A legal perspective

From a legal perspective, the best-case scenario would be for Congress to amend the ESA to grant the FWS explicit authority to issue biodiversity derivatives. Assuming, however, that the legislature does not act, one important constraint on FWS's authority is that §4(f)(1) of the ESA only authorizes the FWS to implement recovery plans for the conservation and survival of threatened and endangered species. In other words, FWS cannot engage in recovery efforts for species that are not yet on the threatened list, which would make it difficult, legally, for FWS to spend money on derivatives for non-threatened species. However, the FWS could use derivatives to keep threatened species from reaching endangered status. Since the payout on biodiversity derivatives is linked to preserving the population of the species in question, thus providing stakeholders with an incentive to engage in conservation efforts, FWS could argue that issuing biodiversity derivatives is the procurement of third party services to assist in recovery efforts for threatened or endangered species, as authorized under §4(f)(2) of the ESA.

The appropriations bill granting funds to FWS is broadly written to cover all "necessary expenses…as authorized by law". It limits the amount FWS may spend on listing efforts and on the designation of critical habitat, but contains no such limitation for the amount it may spend on recovery efforts (HR 2643, S 1696). In any event, the cost of issuing derivatives should not increase the total amount FWS spends on recovery initiatives. Even if the derivatives do not improve the viability of the species, FWS would roughly break even on the derivatives over time, because the amount of principal that investors forfeit will be roughly equal to the amount of interest paid by FWS. If investors do affect the outcome by conserving species, their costs will, rationally, be less than the amount of interest paid by FWS, but FWS will not need to spend additional money with regard to the species. This should more than offset the cost of the derivatives.

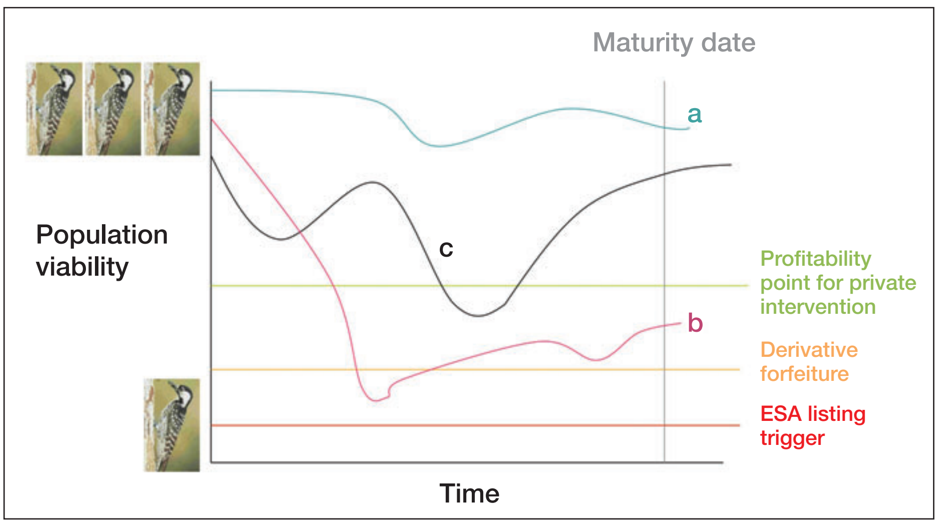

Figure 3. *A derivative approach to endangered species conservation. A derivative is priced and issued for a declining species, either by the government or other interested party. Based on demographic and environmental data, a derivative forfeiture threshold is set (eg 600 active groups). There are three possible outcomes: (a) the species remains above the set threshold over the time period of the derivative, and investors are rewarded; (b) the species undergoes rapid, unpredicted decline, investors forfeit their investment, and the money is immediately made available for research, remediation, and recovery; and (c) the species faces predicted, gradual threats from development, human encroachment, or global change. Investors engage in preemptive interventions, such as land purchases, research, and public education campaigns, to protect their investment.*

Because derivatives are zero-sum instruments, ie one party's gain is necessarily the other party's loss, the manipulation of a derivative's underlying asset by one party is often illegal. For derivatives that are structured as bonds, the investors have no obligations beyond paying for the bonds. Also, the derivative does not call for future delivery of any commodity. This would make biodiversity derivatives hybrid instruments under §105 of the Commodity Futures Modernization Act; this indicates that the securities law regime governs. Since the underlying asset of a biodiversity derivative is a species, §9(a)(2) of the US Securities Exchange Act would not forbid biodiversity derivative-holders from engaging in conservation efforts; this Act only prohibits manipulation of the price of an underlying *security*. Furthermore, under securities law, manipulation cases generally succeed only in the presence of fraud, which does not include attempts to manipulate the underlying asset in order to affect the price of the overlying derivative. Therefore, conservation efforts that increase the price of biodiversity derivatives would not be illegal.

Risks and challenges

Structuring and valuing biodiversity derivative contracts would necessitate greater communication between ecologists and bankers, but would not require substantially new toolsets for practitioners. Calculating the risk of decline and extinction for a species, both by predicting the course of human impacts and through strictly ecological techniques, such as population viability analysis, are well-developed and a common conservation practice (Morris and Doak 2002). For biodiversity derivatives, the fundamental methodology would be similar, although the tools would need to be applied earlier, because of their proactive nature. Investment banks are adept at pricing derivatives based on volatility or the probability of a particular event occurring. Differences in the nature of volatility, due to time scales or underlying trends, can be accounted for within current pricing models, and the government could avoid the cost of registering the derivatives with the Securities and Exchange Commission, due to the exemption from the Securities Act of government-issued securities. Biodiversity derivatives could potentially be issued by a large NGO or intergovernmental institution, which, as non-profit organizations, would both be exempt from the Securities Act. This would allow standardized incentives for conservation to extend beyond national boundaries, aiding cosmopolitan species and those for which no government is willing to act. Multi-species "baskets" could also be issued, which would increase market size to encourage secondary market trading and create sensible ecosystem groupings.

For biodiversity derivatives to be effective, certain issues must be addressed, and rules and regulations for manipulation should be carefully articulated. While manipulation in favor of a species' viability should be encouraged, manipulation that harms the species to profit on the decline in derivative price would be forbidden. Profiting on the decline of a stock or bond price, or short selling, takes place when an investor borrows shares and sells them, with the intent of buying them back at a lower price to complete the transaction. There are several precedents where this practice is banned or heavily regulated (ie Lindgren, 2007). Furthermore, a mechanism is needed to prevent derivative-holders who buy land for conservation purposes from taking actions that harm the target species once the derivative expires. Rolling issuances, where derivatives are issued annually (each with the same time to maturity, with the amount equal to a fraction of the total required capital) would help ensure that conservation incentives remain in place for the long term. In this way, it will always be more profitable for the investor to reinvest and continue the conservation effort, rather than to engage in actions that will be harmful to the species (Panel 1). Criteria for determining payout would need to be clearly presented, transparent, and neutral. Market oversight would also be needed to protect against some predatory aspects of the financial world, such as the destruction of a habitat or species to financially harm a competitor or to ensure the profitability of a "short sell". In order to create sufficient market liquidity and to encourage ecosystem-level conservation, species derivatives could be bundled, based on ecosystem or landscape characteristics. The derivatives market would then be large enough for efficient trading, and the needs of interacting species would be taken into account. Even at low levels of liquidity, however, biodiversity derivatives should be an efficient vehicle of value transfer, allowing stakeholders to experience the financial cost of decisions that harm the environment. There would also probably be additional expense upfront, in terms of fees for structuring and issuance, and preliminary research to identify appropriate candidate species.

Despite structural precautions and regulation, the market is likely to be volatile: there are winners and losers in any market. In this context, it is critical that short-term volatility in the price of the derivative does not affect the underlying asset – the species itself. Evidence from other derivatives markets, such as the commodities market, suggests that stocks and industries are not damaged by the presence of short-term volatility in their derivatives. In fact, those markets are meant to transfer the risk away from the asset.

A pivotal question, of course, is cost. Will this new method actually be more cost-effective for the government than waiting until last-minute, critical care is legally mandated? Will biodiversity derivatives attract sufficient investors? A retrospective examination of the case of the red-cockaded woodpecker suggests that biodiversity derivatives may be an effective tool. Costs to the government simply for creating recovery plans can run into millions of dollars. For 2007, the government spent more than $250 000 to provide preliminary research for a conservation plan in one region of Arkansas, one of 11 states where the woodpecker is known to occur (US FWS 2007). This does not include the costs that result from slower economic growth once a habitat conservation plan is implemented. Woodpecker credits trade for as much as $250 000 per breeding pair, which suggests that the unreported costs to landowners of conserving the woodpeckers are quite high (Bayon 2002). Since woodpeckers seem to do just as well in poor timberlands as prime ones, ideally, woodpecker conservation should not conflict drastically with logging. Estimates on public timberlands in North Carolina suggest that an active group can be conserved at a cost of $8817 per year (Hyde 1989), and internalizing both carbon sequestration and woodpecker conservation brings the cost of switching to slow rotations of long-leaf pine within $16 of the current logging approach (Alavalapati *et al.* 2002). With the ESA's stated recovery goal of 500 active groups within designated recovery populations, a conservative first estimate suggests that $4.4 million dollars per year is necessary to conserve a sustainable population of the species on logging land (calculated from Alavapati *et al.* [2002], and assuming that all active groups are on spatially heterogeneous timberlands). If the government had issued biodiversity derivatives 10–20 years prior to listing this species, the necessary capital would now be available for an outlay of somewhere between $7000 per year (priced according to a prior probability of listing of 1% per year) and $717 000 per year (assuming a probability of listing of 50% per year; Panel 1) per designated population. While an ecologically based population viability analysis would be necessary for initial pricing, the market could price subsequent issuances. Furthermore, if investors undertake preemptive conservation efforts, the premium that the government will need to pay over the risk-free interest rate will decline over time.

In the end, biodiversity derivatives would be an escalation of the legal and moral obligation towards environmental stewardship, not a replacement of those incentives. Yet, since successful investment depends on careful research, an added benefit to a biodiversity derivatives market would be the increase in information regarding threatened species. Private investors would be motivated to fund research on the decline and restoration of species, in an effort to maximize their investments. This could lead to closer relationships between the academic and business worlds, and additional career paths and funding for the best and brightest environmentalists.

References

Alavalapati JRR, Stainback GA, and Carter DR. 2002. Restoration of the longleaf pine ecosystem on private lands in the US south: an ecological economic analysis. *Ecol Econ* **40**: 411–19.

Bayon R. 2002. A bull market in woodpeckers. *Milken Institute Review* **First quarter**: 30.

Bean MJ. 1998. The Endangered Species Act and private land: four lessons learned from the past quarter century. *Environ Law Report News An* **28**: 1070–10.

Bonnie R and Bean M. 1996. Habitat trading for red cockaded woodpeckers: enhancing recovery, reducing conflicts. *Endangered Spec Up* **13**: 7–9.

Brook A, Zint M, and Young RD. 2003. Landowners' responses to an endangered species act listing and implications for encouraging conservation. *Conserv Biol* **17**: 1638–49.

Fox J and Nino-Murcia A. 2005. Status of species conservation banking in the United States. *Conserv Biol* **19**: 996–1007.

Greenwald DN and Suckling KF. 2005. Progress or extinction? A systematic review of the US Fish and Wildlife Service's Endangered Species Act Listing Program 1974–2004. Tucson, AZ: Center for Biological Diversity.

Hess U, Richter K, and Stoppa A. 2002. Weather risk management for agriculture and agribusiness in developing countries. In: Dischel R (Ed). Climate risk and the weather market, financial risk management with weather hedges. London, UK: Risk Books.

Huddard S. 1994. Employee stock options. *J Account Econ* **18**: 207–31.

Hyde WF. 1989. The marginal costs of managing endangered species: the case of the red-cockaded woodpecker. *J Agr Econ Res* **41**: 12–19.

Leoni P and Luchini S. 2004. Designing the financial tool to promote universal free-access to AIDS care. Zurich, Switzerland: Institute for Empirical Research in Economics, University of Zurich.

Linnerooth-Bayer J, Mechler R, and Pflug G. 2005. Refocusing disaster aid. *Science* **309**: 1044–46.

Lueck D and Michael JA. 2003. Preemptive habitat destruction under the Endangered Species Act. *J Law Econ* **46**: 27–60.

Lindgren, H. 2007. Long–short story short. *New York Magazine* **April** 2007 edn.

Male TD and Bean MJ. 2005. Measuring progress in US endangered species conservation. *Ecol Lett* **8**: 986–92.

Morris WF and Doak DF. 2002. Quantitative conservation biology: theory and practice of population viability analysis. Sunderland, MA: Sinauer.

Naidoo R, Blamford A, Ferraro PJ, *et al.* 2006. Integrating economic costs into conservation planning. *Trends Ecol Evol* **21**: 681–87.

Sandor RL, Bettelheim EC, and Swingland IR. 2002. An overview of a free-market approach to climate change and conservation. *Phil Trans Roy Soc Lond A* **360**: 1607–20.

Shabman L, Stephenson K, and Shobe W. 2002. Trading programs for environmental management: reflections on the air and water experiences. *Environ Pract* **3**: 153–62.

Soulé ME, Estes JA, Miller B, and Honnold DL. 2005. Strongly interacting species: conservation policy, management, and ethics. *BioScience* **55**: 168–76.

Stokstad E. 2005. What's wrong with the Endangered Species Act? *Science* **309**: 2150–52.

US Department of the Interior. 2003. Endangered species act "broken" – flood of litigation over critical habitat hinders species conservation. Washington, DC: US Department of the Interior.

US FWS (US Fish and Wildlife Service). 2007. Budget report. www.fws.gov/budget/. Viewed 24 Oct 2008.

