DESPERATELY SEEKING NUMBERS: GLOBAL WARMING, SPECIES LOSS, AND THE USE AND ABUSE OF QUANTIFICATION IN CLIMATE CHANGE POLICY ANALYSIS

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Wayne Hsiung and Cass Sunstein's article, *Climate Change and Animals*,[1] has two objectives. The first is to present the argument that, in addition to being concerned about species loss due to climate change, people should (and at least some do) care about the suffering that climate change will inflict upon animals. As the authors only sketch this argument,[2] I focus here on their primary objective, which is to derive a dollar value for the expected loss to Americans from species extinctions caused by climate change. This analysis is easy to summarize: Hsiung and Sunstein take a number representing the number of species projected to be lost from climate change and then multiply this number by the estimated dollar loss per species. Under this basic methodology, when all kinds of value generated by species are included, they estimate that the global-warming-induced species loss would cost Americans between $162 and $399 billion per year, or 1.4% to 3.5% of GDP.[3]

Even in the big-numbers world of the costs and benefits of climate change, this is a very big number. Indeed, Hsiung and Sunstein admit that their estimated cost of species lost due to climate change would alone justify the United States in incurring the $125 billion that Nord-

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[1] 155 U. PA. L. REV. 1697 (2007).

[2] Here I note only that the likelihood of conflicts between the objectives of protecting and recovering species and preventing animal suffering is much, much greater than Hsiung and Sunstein acknowledge. For example, the recent wave of predator reintroduction programs in the United States—such as the reintroduction of wolves to Yellowstone National Park—has clearly led to much suffering by various prey, including elk that inhabit the enormous land area into which the Yellowstone wolves have now migrated. However, environmentalists generally support such reintroduction programs because they allow the restoration of "natural" ecosystems with stable (albeit oscillating) predator-prey relationships, while promising something that some environmentalists want just as much: the elimination of human elk hunters from the ecosystem.

[3] Hsiung & Sunstein, *supra* note 1, at 1736, tbl.11.

haus estimated in 2001 as the cost of U.S. compliance with the Kyoto Protocol.[4] This number is intended to remedy what Hsiung and Sunstein call the "virtual[] ignor[ance]" in previous economic analysis of the deleterious effect of climate change on nonhuman species.[5] It is a number that is clearly intended to alert people to the potentially devastating impact of global warming on many species around the world.

But it is not a number to be taken seriously. It is a number based upon a methodology that reflects fundamental errors and misconceptions about economics, a partial and misleading selection from the biological literature on climate change and species loss, and deep confusion over the distinction between government spending and private values.

Essentially, they multiply n, an estimated number of vertebrate species, by p, an estimated probability of species extinction due to climate change, and then multiply this figure by v, an estimate of the total per-species value to all Americans. If we let L denote the expected total loss due to climate-change-induced species extinction, then what Hsiung and Sunstein are supplying is a number for:

$$L = npv.$$

I have no quarrel with their estimated number n of vertebrate species (about 57,000).[6] Biologists are quite certain about the number of vertebrate species, and the number n that Hsiung and Sunstein use is in any event the number of known vertebrate species, so n, if anything, *underestimates* the total number of such species that now exist.

For the probability of extinction, p, the authors use a recent estimate provided by a team of biologists.[7] The biological literature on climate change and species loss is much richer than this, however, and carries at least two main lessons. One is that techniques for generating quantitative estimates of the global probability of species loss from climate change are especially new and controversial developments in biology. The second and more important lesson is that there are many other results in the biological literature on the impact of climate change on biodiversity species loss that are not controversial at all, and that carry concrete lessons for climate change policies. I con-

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[4] William Nordhaus, *Global Warming Economics*, 294 SCIENCE 1283, 1284 (2001).

[5] Hsiung & Sunstein, *supra* note 1, at 1699.

[6] *Id.* at 1714.

[7] *Id.* at 1712 (citing Chris D. Thomas et al., *Extinction Risk from Climate Change*, 427 NATURE 145, 145 (2004)).

clude my analysis by discussing these issues. The bulk of my discussion, however, is focused on the methodologies that Hsiung and Sunstein use to come up with *v*, their estimate of the dollar value aggregate U.S. valuation of a species. As I shall argue, these methods are deeply flawed in a variety of ways. After briefly summarizing the way that their numbers are generated, I focus below on three major steps that they take.

I. THE SEARCH FOR A NUMBER, ANY NUMBER: A QUICK OVERVIEW OF HSIUNG AND SUNSTEIN ON THE SOCIAL COST OF SPECIES (OR IS IT ANIMAL?) LOSS DUE TO GLOBAL WARMING

Before delving into a more detailed critique of the methods that Hsiung and Sunstein use to come up with aggregate willingness to pay for species preservation, it is important that readers understand that in this critique, I do not assess a straw man, but the actual analysis presented in their article. Hence, I begin by briefly surveying the remarkable number of twists and turns that Hsiung and Sunstein take in arriving at their final number for the aggregate value to Americans of the expected species loss due to climate change.

Hsiung and Sunstein begin by noting that they cannot do the first best valuation analysis, which apparently would be to elicit from species how much they would need to be paid to consent to their extinction. They lament that such "[a] contingent valuation study based on the preferences of animals would be infeasible. Polar bears do not have money, and they cannot tell us how much they care about Arctic sea ice."[8] And so Hsiung and Sunstein ultimately concede that "any monetary valuation of animals will inevitably be made by human beings."[9]

Having conceded that we are stuck with human valuation of nonhuman species, Hsiung and Sunstein next concede that people might not be willing to spend as much per species to save, say, one million species, as they would to save one or two species, and that people are willing to spend much more to save some species (so-called "charismatic megafauna," such as the bald eagle) than others. These problems they simply assume away.[10] They then concede that much of the species loss caused by climate change might happen a long time from now. But rather than discounting those losses to a present value, Hsi-

[8] *Id.* at 1709-10.
[9] *Id.* at 1710-11.
[10] *See id.* at 1711.

ung and Sunstein simply assert that existing survey evidence on how much people are willing to pay to save species already presumes that all that people are getting is a reduction in the probability of loss, which is pretty much the same thing as discounting for possible future species loss due to climate change.[11] Hence, they conclude that it is acceptable to use survey data on willingness to pay to save *particular* species as measuring willingness to pay to reduce the chances of global species loss due to climate change.[12] Further, they argue, whatever numbers they use will be seriously biased downward because extinction rates ignore the death and suffering of individual animals[13] and do not "account for the expected costs of extreme weather events or abrupt climate change."[14] In summary, because some people care about the suffering that species will undergo if the global climate warms and becomes stormier, it is acceptable to apply economic estimates of willingness to pay to protect *particular* species to *all* the species that are expected to become extinct due to climate change, and to act as if all of those species are going to become extinct today.

Hsiung and Sunstein are now ready to derive their estimate of species value. First, they get a number for what economists call the use value of species—the value that people get from using wild species in various ways (e.g., as pollinators, for pest control, and as sources of chemical compounds used in pharmaceuticals). They initially attempt to set this value by taking a recent estimate of the global value of biological services,[15] and multiplying it by the U.S. share of world GDP (remember that what they derive is aggregate American value from species that will be lost due to climate change). But Hsiung and Sunstein say that this first number underestimates the true value of "nonhuman life" because it fails to include the value of ecosystem services such as erosion control that "are of mixed biological and nonbiological origin."[16] So, they use another study that does include all ecosys-

[11] *Id.* at 1714-15.

[12] Apparently afraid that they have failed to convince at this point in their study, Hsiung and Sunstein reiterate their defense of assuming that per-species value is constant across all species, no matter how many are at risk, and that there is no need to discount, even though global warming will not cause some extinctions until decades or centuries from now. *Id.* at 1716.

[13] *Id.* at 1715.

[14] *Id.*

[15] *Id.* at 1718. The use value estimate that Hsiung and Sunstein use is derived from Robert Costanza et al., *The Value of the World's Ecosystem Services and Natural Capital*, 387 NATURE 253, 259 (1997).

[16] Hsiung & Sunstein, *supra* note 1, at 1719.

tem services to which "biological sources" contribute. Taking this study's number and multiplying by the U.S. share of world GDP, they come up with a lost use value from species to become extinct due to climate change of between $58 and $144 billion annually, or 0.6% to 1.4% of GDP.[17] In sum, Hsiung and Sunstein take estimates of the global use value of biodiversity or biological services as a measure of the global value of species, and assume that the United States gets a fraction of this use value equal to its share of world GDP.

The authors now come to the final stop in their derivation of aggregate species value: the assessment of what economists call existence or nonuse value. Existence value is the value that people get from a species' existence even if they never actually incur any real expenses to see or visit the species, and even if they never get any concrete economic benefit from the species' existence. There is, obviously, no market measure for existence value. Instead, to measure existence value of various natural resources, including species, economists have developed a technique known as contingent valuation. Contingent valuation is a survey in which samples of people are asked how much they would be willing to pay for measures taken to protect or preserve a species.

Hsiung and Sunstein did not conduct their own contingent valuation study, but instead use two meta-analyses (studies of studies) of contingent valuation studies concerning willingness to pay for species preservation. These studies, surveyed by the meta-analyses used by Hsiung and Sunstein, valued partially overlapping sets of ten and seventeen threatened species,[18] but when put on per-household bases, the two meta-studies generate roughly the same willingness to pay for species protection—about $12 per species.[19] Multiplying once again by the number of Americans and the number of vertebrate species that are expected to become extinct due to climate change, Hsiung and Sunstein's contingent valuation studies give them an annual U.S. loss from species extinction at between $29 and $71 trillion, anywhere from three to seven times GDP.[20]

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[17] *Id.* at 1720 (using data from Daniel Pimentel et al., *Economic and Environmental Benefits of Biodiversity*, 47 BIOSCIENCE 747, 748 tbl.2 (1997)).

[18] *Id.* at 1725-26 (citing DAVID W. PEARCE, ECONOMIC VALUES AND THE NATURAL WORLD 74-77 (1993); John B. Loomis & Douglas S. White, *Economic Benefits of Rare and Endangered Species: Summary and Meta-Analysis*, 18 ECOLOGICAL ECON. 197, 199 (1996)).

[19] *Id.* at 1727.

[20] *Id.* at 1728.

As soon as the authors get this number, they reject it as implausible. They then dispense with contingent valuation and decide to use, as their measure of willingness to pay to protect species, recent estimates of public and private spending to comply with the federal Endangered Species Act (ESA).[21] Why, one might ask, would the authors look to legally compelled spending on species protection to measure aggregate (American) willingness to pay to protect species? Because they believe that "[c]urrent expenditures on endangered species act as a (minimum) 'revealed preference' for species loss more generally."[22] Finding that total ESA spending is still too high to generate a plausible estimate for the value of all species expected to be lost due to global warming (total ESA spending would generate an annual value for species loss of between $4.9 and $12 trillion), Hsiung and Sunstein look only at vertebrates. Then, finding that salmon have had an especially large amount spent on their protection, they end up presenting two final estimates for the annual value of vertebrate species expected to be lost due to global warming: $179 to $439 billion, or 1.4% to 3.5% of GDP; or, if fish are excluded, $104 to $255 billion, or 0.8% to 2.1% of GDP.[23]

II. VALUING SPECIES

As Hsiung and Sunstein correctly state, environmental economists currently recognize two kinds of value from the preservation of species and other natural or biological assets: the market value of the services provided to humanity by such assets—called the use value of natural resources—and the value that people get from preserving the resource, even if they never see or receive any concrete services from it. The latter is known as nonuse or existence value.

For use values, there is at least the possibility of finding market values by looking at the cost of built infrastructure that would substitute for natural capital (such as species), as in providing services valuable to humans. But even then, estimates such as those found in the study by Costanza et al.[24] are likely to be highly uncertain at best, and are very likely to massively overstate the value of "biological ecosystem services." The difficulty is that even if it is fair to assume, as Hsiung and Sunstein do, that the nonuse value of species is linear—with the

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[21] *Id.* at 1731.
[22] *Id.* at 1733.
[23] *Id.* at 1736.
[24] *See* Costanza et al., *supra* note 15, at 253.

value of saving a species constant, no matter how many species are saved—this is not a reasonable assumption for the use value of species. Consider, for example, the value of biological entities and species in generating new pharmaceutical products. The problem here, as Brown and Shogren nicely summarize it, is that

> measuring commercial value requires insight into substitution possibilities and the marginal contribution that each species makes to finding a new and useful product. The expected value of a marginal species equals the expected payoff from testing it times the probability that all other species fail to provide the desired product. If one species substitutes for another in potential market success, the marginal value of an extensive genetic exploration declines as the odds increase that a firm will find a profitable species quickly.[25]

Indeed, if there are many species from which to choose and a fairly high probability of finding a successful product, "the expected value of preserving a marginal species can be less than one cent."[26]

The use value of ecosystem services, such as species, is a complex topic about which much more could be said, but I will focus my discussion here on how Hsiung and Sunstein attempt to measure nonuse value. As observed earlier, they first look to contingent valuation studies of the nonuse value of species preservation. Finding that the number they get from using these studies is absurdly high, they turn ultimately to using the federal and state government expenditures on species protection reported by the U.S. Fish and Wildlife Service (FWS) as a measure of people's "revealed preference" for species preservation. As this is their ultimate measure, I begin my critique of their approach to species preservation value where they end: with government spending as a measure of people's willingness to pay to preserve species.

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[25] Gardner M. Brown, Jr. & Jason F. Shogren, *Economics of the Endangered Species Act*, 12 J. ECON. PERSP. 3, 11 (1998).

[26] *Id.* at 11. Brown and Shogren make this point using an example generated in R. David Simpson et al., *Valuing Biodiversity for Use in Pharmaceutical Research*, 104 J. POL. ECON. 163, 175-79 (1996).

A. *By Using Government Spending on Species Protection as a "Revealed Preference" for Willingness To Pay To Protect Species, Hsiung and Sunstein Conflate Individual Value with Government Spending and Provide No Useful Information on the Social Value of Species Preservation*

ESA expenditure data is not a revealed preference measure of willingness to pay. What economists mean by revealed preferences are the market choices that people make—what to buy and sell, and at what price. Such market behavior is voluntary and free from government coercion. That is, in market economies, while the law may restrict personal market choices in some ways (e.g., by declaring that prostitution is criminal and that meretricious contracts will not be legally enforced), the state does not command that people buy and sell things at state-determined prices. Even in a centrally planned economy, as the Soviet and Eastern European experience illustrates, the state may command that certain quantities of certain goods and services be produced, but it cannot force people to buy those goods and services.

ESA expenditures are expenditures that are, to a greater or lesser extent, mandated by Congress and determined by the congeries of agencies responsible for implementing the ESA (primarily the FWS). They are not market choices, but taxpayer-financed government spending. ESA expenditures are not voluntary market choices made by individuals, but rather choices made by bureaucrats and politicians. Taxpayer-financed bureaucratic expenditures do not reveal anything about individual willingness to pay for the goods or services being purchased.

Let me be more concrete. When a person goes out into the market and spends $10 for a coat, economists say that such a person has revealed that she values the coat at least at $10. But, when a bureaucrat decides to spend $1 million restoring an endangered species' habitat, economists do not say that the bureaucrat values habitat restoration at $1 million, because the bureaucrat is spending not her own, but other people's money. Nor does the fact that the bureaucrat has decided to spend $1 million on habitat restoration mean that American taxpayers as a whole (or any subset thereof, for that matter) value habitat restoration by $1 million. People might attach little or no value to the bureaucrat's pet $1 million habitat restoration policy, but they may have no idea how much money is being spent—because the bureaucrat has not told them. And even if they did know about the planned spending beforehand, it would be enormously costly and perhaps even impossible for a private citizen or group of private citizens to stop the expenditure.

In the United States, there are laws that enable citizens to demand that federal agencies disclose some aspects of their proposed project spending (and in the case of the National Environmental Policy Act, for example, the consequent environmental impacts). But it is exceedingly difficult for a person or group of persons actually to halt a proposed expenditure of federal monies on the ground that such spending is unlawful or beyond the range of bureaucratic discretion. Anyone who does not believe this should perform the simple experiment of attempting to stop, say, spending on a local road improvement project the next time she gets wind of one.

In a democracy, if a large number of people think that the bureaucrat's $1 million habitat restoration project is a waste of money—because they value habitat restoration at a lot less than the bureaucrat (perhaps even negatively), or because they would like to see the land used as the site for a new hospital or playground—then they might get together and complain to their elected representatives in Washington. And if there were a sufficiently large number of species protection projects that triggered a sufficiently large number of complaints from sufficiently influential constituents, then eventually those representatives might lobby the bureaucrats to stop spending so much money on projects that their constituents did not want. Now of course there might be people from other parts of the country who care very much about the species whose habitat is being restored but are not concerned with whether or not the targeted locality gets a new hospital or playground; and those people would lobby various members of Congress to continue the bureaucrat's spending on habitat restoration.[27]

It is the outcome of such a lobbying influence game, rather than market choice, that will ultimately determine whether our bureaucrat is allowed to spend the $1 million on habitat restoration under the ESA.[28] Crucially, an outcome that allows the $1 million spending to

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[27] For evidence that the pattern of congressional voting on the ESA does indeed take this form, with opposition from representatives of the affected districts but support from districts that do not have any ESA impacts, see Jason Scott Johnston, *The Tragedy of Centralization: The Political Economics of Natural Resource Federalism*, 74 U. COLO. L. REV. 487, 577-83 (2003).

[28] For evidence that congressional influence—the ultimate lobbying pressure on agencies—rather than statutory preferences determines which species are listed by the FWS under the ESA, and how much funding FWS devotes to species recovery plans, see J.R. DeShazo & Jody Freeman, *The Congressional Competition To Control Delegated Power*, 81 TEX. L. REV. 1443, 1475-85 (2003).

go ahead in no way demonstrates that Americans' net valuation of the restoration equals or exceeds $1 million. Consider, for example, a case in which local residents all oppose the restoration and believe that it will cost them $500,000 in lost local value from development (which may of course include the provision of local public goods such as the playground).[29] Suppose also that all the benefits of restoration accrue nonlocally, and that nonlocal supporters of restoration perceive a benefit from restoration of $600,000. In a legislative lobbying contest between the local losers and nonlocal winners from restoration, the nonlocal winners are willing to spend up to $600,000, while the local losers will spend at most $500,000.[30] Hence, one might well predict that the nonlocal winners from restoration will win the lobbying game, and that our bureaucrat will get to spend the $1 million, despite the fact that the total cost of restoration, $1.5 million (the direct cost plus the lost local development value), vastly exceeds the restoration benefits of $600,000.

One may well object that I have forgotten something in my example: the lobbying activities of people who pay the $1 million cost of restoration. But those people are all American taxpayers and, even if there are only 50 million such taxpayers, the cost of the restoration to each taxpayer is only $0.02. Hence, even if such taxpayers know about the actual $1 million cost of restoration, and they perceive no benefit whatsoever from it, no single taxpayer has any reason to spend any amount of time or money opposing the restoration. Only a massive and highly publicized series of such projects could generate large enough stakes for otherwise indifferent, nonlocal taxpayers to take action and lobby their Congressional representatives to do something to stop the spending. In the present example, there would need to be 5000 such projects—each with a net social loss of $1 million—before the cost of a species protection program reached $100 per taxpayer.

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[29] As Jason Shogren has elaborated, local economic costs of species protection include "reduced economic profit from restricted or altered development projects including agriculture production, timber harvesting, minerals extraction, and recreation activities; wages lost by displaced workers who remain unemployed or who are reemployed at lower pay; lower consumer surplus due to higher prices; and lower county property and severance tax revenue." Jason F. Shogren, *Economics and the Endangered Species Act*, ENDANGERED SPECIES UPDATE, Jan./Feb. 1997, at 4, *available at* http://www.umich.edu/~esupdate/library/97.01-02/shogren.html.

[30] Such lobbying contests have been modeled in various ways, from Tullock's contest model to more recent approaches that view lobbying as an all-pay auction. While it is not clear that people will spend right up to their value in such a contest, most models do predict that the side with more at stake will win.

What this little example explains is precisely why one cannot infer anything about either individual valuation or the net social value of species from the amount of money that federal and state bureaucrats spend on species protection projects. Such projects do not reflect market choice, or even individual choice, but rather the expenditure of public revenues derived from taxes.

While economists have not, to my knowledge, argued that ESA spending reveals people's nonuse valuation of species, they have studied how federal agencies (primarily the FWS) decide to allocate such public revenues across different species. Unsurprisingly—given that agencies have to attend, at least to some extent, to the political costs and benefits of their decisions—in their pathbreaking study in this literature, Metrick and Weitzman found that the FWS spends the most to protect so-called "charismatic megafauna" such as grizzly bears and bald eagles;[31] that is, the agencies protect species with a constituency. Indeed, the FWS data relied upon by Hsiung and Sunstein show the same thing: a major problem for them in the FWS data is the very large spending on salmon, a game fish much sought after by recreational fishermen, and a primetime celebrity in nature films depicting the challenges and drama of living its anadromous life.[32] More generally, a consistent finding in this literature is that annual agency spending on species recovery is not much influenced by current scientific assessments of the actual risk to a particular species, but instead by other factors that do not vary with the current risk of extinction.[33]

Just as there is evidence that political factors explain ESA spending, there are also indications that the FWS systematically understates

[31] Andrew Metrick & Martin L. Weitzman, *Patterns of Behavior in Endangered Species Preservation*, 72 LAND ECON. 1, 2 (1996). Metrick and Weitzman report that, based on the FWS federal and state data, between 1989 and 1991 over 50% of the money spent on endangered species recovery by such agencies was spent on the top ten species: the bald eagle, northern spotted owl, Florida scrub jay, West Indian manatee, red-cockaded woodpecker, Florida panther, grizzly bear, least Bell's vireo, American peregrine falcon, and whooping crane. *Id.*

[32] *See, e.g.*, U.S. FISH & WILDLIFE SERV., FEDERAL AND STATE ENDANGERED AND THREATENED SPECIES EXPENDITURES: FISCAL YEAR 2000, at 5 (2000), *available at* http://endangered.fws.gov/expenditures/reports/FY_2000.pdf (listing five species of salmon as garnering the highest reported expenditures for the 2000 fiscal year).

[33] *See* Deborah Dawson & Jason F. Shogren, *An Update on Priorities and Expenditures Under the Endangered Species Act*, 77 LAND ECON. 527, 531 (2001) (concluding that variation in variables like endangerment rankings and economic conflict have no significant effect on expenditures); Metrick & Weitzman, *supra* note 31, at 14-15 (finding that government spending is not related to the degree and role of scientific characteristics such as endangerment).

the true social costs of species protection under the ESA. As ably summarized by the Simmons and Frost study, upon which Hsiung and Sunstein rely for the final ESA expenditure numbers,[34] the actual report released by the FWS fails to consider administrative costs incurred by the FWS to implement the ESA, omits the species protection costs incurred by a large number of federal agencies, neglects to include the private costs of species protection imposed by the ESA, and is greatly at odds with many other government estimates of species protection costs.

My simple example of the incentives facing an agency such as the FWS, which is subject to pressure from competing local and nonlocal constituencies, predicts precisely such a systematic understatement of the costs of species protection. After all, while local losers from species protection might be expected to have a very good idea of what species protection will cost them, taxpayers in general probably do not. Nor do nonlocal beneficiaries of species protection have a very good idea of how much is being spent in their interest. Hence, an agency such as the FWS has no reason to inform people what its projects cost, since so doing angers and activates opposition, either from taxpayers (who think too much is being spent) or from species protection advocates (who think too little is being spent). In Hsiung and Sunstein's view of the world, by contrast, what the FWS spends on species protection is what people want, reflecting the net "revealed preference" for species protection.[35] Based on this point of view, however, the FWS should be more than willing to tell people what it is spending

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[34] *See* RANDY T. SIMMONS & KIMBERLY FROST, ACCOUNTING FOR SPECIES: THE TRUE COSTS OF THE ENDANGERED SPECIES ACT, at ii-iv (2004), *available at* http://www.perc.org/pdf/csa_costs.pdf (describing the limitations and inaccuracies of the FWS report).

[35] Hsiung & Sunstein, *supra* note 1, at 1731. Indeed, Hsiung and Sunstein seem to be completely in the dark about who wins and who loses from the ESA. Such lack of understanding is betrayed by their comment that the large ESA-compelled expenditure on salmon—$34 million per species—is "arguably the result of mixed use and nonuse value. One might question why commercial fish interests would lobby for endangered species protection rather than direct subsidies." *Id.* at 1735. While they are potential winners in the long run from healthy salmon runs, recreational and commercial fishermen have been severely harmed by recent cutbacks in, and even closures of, the salmon fishing season, *see, e.g.*, Tom Gentle, *Commercial Fishing*, *in* A SNAPSHOT OF SALMON IN OREGON (1998), http://eesc.orst.edu/salmon/human/commfish.html, and through their representatives in Washington have argued strenuously that bad water management and environmental degradation, not ocean fishing, are responsible for salmon decline, *see* Press Release, U.S. House of Representatives, Wu: Closure Is Not the Solution (Apr. 4, 2006), http://www.house.gov/list/press/or01_wu/pr04042006salmon.html.

on species protection; after all, it is only spending what people want it to spend.

B. *Hsiung and Sunstein Misunderstand and Misuse Contingent Valuation, and Contingent Valuation of Species Is, in Any Event, Unreliable for Aggregate Cost-Benefit Analysis of Species Preservation*

As noted above, economists who have studied agency behavior in general and spending on the ESA in particular have never seriously discussed the novel notion that FWS spending on the ESA measures people's willingness to pay for species protection. What economists have seriously worried about, however, is the possibility that—as in any system where government projects are financed out of general tax revenues—government spending on species protection might bear very little relation to actual net willingness to pay for species protection. What they have proposed to curb this problem is nothing less than cost-benefit analysis. But, of course, cost-benefit analysis cannot really work unless both the costs and benefits of species preservation are monetized. And when economists have examined the existing methods for monetizing both the use and nonuse benefits received from species protection, they have generally concluded that there is no reliable way to monetize either, at least not on the kind of global aggregate scale that Hsiung and Sunstein propose.

1. Current Contingent Valuation Surveys Do Not Yield Willingness-To-Pay Measures That Are Sufficiently Reliable To Be Used in Cost-Benefit Analysis

First, although federal regulations say that contingent valuation (CV) surveys may be used to measure natural resource damages,[36] there are many prominent economists who argue that CV surveys do not actually reveal people's willingness to pay for natural resources, and who essentially reject the CV technique. Contingent valuation involves using surveys in which people are asked hypothetical questions about how much they would pay to save or to protect a species, or how much they would have to be paid to consent to the loss of a species. A primary reason that many economists do not believe that CV studies actually measure willingness to pay is because even the most carefully

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[36] Interior Department regulation 43 C.F.R. § 11.83(c)(2)(vii) (2003) expressly authorizes the use of contingent valuation as a method of determining (A) the lost use value of natural resources and (B) lost option or existence value of such resources, but only if "the authorized official determines that no use values can be determined."

done CV studies have revealed a very strong embedding effect—a tendency for people to have the same stated willingness to pay regardless of the number of resources protected. Such insensitivity of value to quantity is inconsistent with economic models of individual value. In one survey, for instance, people expressed roughly the same willingness to pay to prevent the killing of 2000, 20,000, or 200,000 birds.[37] In another study, people reported almost the same willingness to pay for partial cleanup of a contaminated waste site as for a complete cleanup.[38] When asked whether their willingness to pay concerned just the specified cleanup or environmental causes in general, only 16.9% of the subjects said that they had reported their willingness to pay for the particular cleanup about which they had been asked.[39] Surveying this and other relevant evidence, Diamond and Hausman conclude that the evidence is not consistent with people actually revealing their individual willingness to pay in CV surveys; instead, the authors indicate that such surveys elicit general expressions of support for the environment (known as the "warm glow" effect)[40] or the results of people's own "casual benefit-cost analyses" rather than "an examination of their own preferences over resources."[41]

As Diamond and Hausman explain,[42] this distinction is crucial, for if CV studies do accurately measure individual willingness to pay, then basic economics says that by adding up individual willingness to pay, we get the total willingness to pay for a pure public good such as species protection; such aggregate willingness to pay may be used as a measure of nonuse values in cost-benefit analysis. But if CV responses represent either "warm glow" or "casual benefit-cost analyses," then it is inappropriate to use them in cost-benefit analyses. If such responses represent the warm glow of reporting oneself to be generally

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[37] *See* William H. Desvousges et al., *Measuring Natural Resource Damages with Contingent Valuation: Tests of Validity and Reliability, in* CONTINGENT VALUATION: A CRITICAL ASSESSMENT 91, 93-102 (Jerry A. Hausman ed., 1993) (providing an overview of the migratory fowl protection experiment, which tested the validity of CV studies).

[38] Peter A. Diamond & Jerry A. Hausman, *Contingent Valuation: Is Some Number Better Than No Number?*, 8 J. ECON. PERSP. 45, 52-53 (1994) (discussing a 1993 study conducted by William D. Schulze et al. regarding willingness to pay for partial and complete cleanup for particular contaminated sites).

[39] *See id.* at 53 (concluding that, given the outcome of the study, a vast majority of the respondents recognized an embedding effect in their own responses).

[40] *Id.* at 51 & n.10.

[41] *Id.* at 54.

[42] *See id.* at 56 (describing problems with accurately measuring willingness to pay through CV analysis).

supportive of the environment, then a reported value of protecting a particular species is really just the responding person's value of protecting at least *some* species, not that particular species. Under this reasoning, responses to various CV studies of the value of protecting different species would not actually provide us with a measure of people's willingness to pay to protect each species ($1000 for bears, $300 for wolves, for example) but rather sample measures of people's willingness to pay to protect species in general ($1000 in CV study number 1, $300 in CV study number 2, for example). If CV studies measure the warm glow value of species protection, then the value of species protection in general is the *average* value reported across different CV studies ($650 in our two studies, for example) rather than the *summation* of reported values across the population ($1300 times the number of individuals or households).

If CV studies do not measure the warm glow value of species protection in general, but instead represent informal cost-benefit analyses of individual species protection by the people interviewed, then once again, but for slightly different reasons, they cannot simply be summed across all households and then added in to the aggregate cost-benefit analysis. Such informal cost-benefit analysis would, by hypothesis, already capture people's estimates of all the benefits from protecting a particular species—that is, use plus nonuse. It would also include people's sense of the cost of protecting a particular species. And both estimates—of nonuse plus use values, and of costs—would have been obtained without any guidance or actual knowledge of the situation, and then weighed against one another in ways that may or may not correspond to the principles of cost-benefit analysis.

2. Even If CV Surveys Sometimes Yield Reliable Willingness-To-Pay Measures, Those Measures Are Highly Contextual and Are Valid Only for Particular Species Protection Measures in Particular Locations, and Cannot Be Used To Derive an Aggregate Willingness To Pay for Species Preservation

As observed above, CV studies are actually used to value natural damages in regulatory rulemaking and in litigation under laws such as the federal Superfund statute, and, at least among environmental and natural resource economists, contingent valuation is an accepted methodology. But it is a methodology that has definite limits, limits that preclude the kind of application employed by Hsiung and Sunstein.

In concluding that the reported willingness to pay for species protection from the Loomis and White CV study (one of two such studies used by Hsiung and Sunstein) appears to be "suspiciously high," Brown and Shogren reason that if

> one summed the stated preferences from various endangered species surveys as a crude measure of benefits, the average person was willing to pay about $1000 to protect 18 different species. Multiplying $1000 by the number of U.S. households suggests that we would be willing to pay over 1 percent of GDP to preserve less than 2 percent of the endangered species.[43]

In other words, when two environmental economists tried to do what Hsiung and Sunstein do with the contingent valuation data on species valuation—that is, use it to derive an aggregate willingness to pay—they concluded that something was seriously amiss, as there was no way that Americans really would be willing to spend almost 1% of GDP to protect eighteen species. For Hsiung and Sunstein, by contrast, only an estimate of aggregate willingness to pay for species that is three to seven times GDP is clearly implausible.

This distinction—between the use of CV studies to discover how people value particular resources in specific places and their use as a measure of aggregate value—is inherent in the limitations of the CV technique. Since CV questions are hypothetical and no one actually has to pay what they say they are willing to pay, people who want to see species preserved have an incentive to overstate their willingness to pay.[44] More generally, over the course of thousands of CV studies, economists have observed that people's responses are extremely sensitive to how questions are asked, but oddly insensitive to the scope of the environmental harm to be averted or natural resource to be protected (which is known as the "embedding effect").[45] Additionally, the payment that people demand to accept an environmental loss (their stated willingness to accept) is systematically higher in CV studies than

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[43] Brown & Shogren, *supra* note 25, at 12.

[44] No general theory concerning the cause of this bias, known as "hypothetical bias" in the CV literature, exists, but the bias is found in many CV studies and there is no reliable way to eliminate it. For support of this point, see James J. Murphy et al., *A Meta-Analysis of Hypothetical Bias in Stated Preference Valuation*, 30 ENVTL. & RESOURCE ECON. 313 (2005).

[45] For a discussion of these and other problems with CV studies by critics of the CV method, see Diamond & Hausman, *supra* note 38, at 50-54. For additional discussion by one of the method's most eminent practitioners, see W. Michael Hanemann, *Valuing the Environment Through Contingent Valuation*, 8 J. ECON. PERSP. 19, 34 (1994).

the amount that they say they would pay to prevent the environmental loss.[46]

Economists have tried a number of different ways to improve CV as a method of eliciting willingness to pay for species protection and preservation. They have varied the question format;[47] tried to measure and control for the fact that some people surveyed may have never heard of the species and thus may be uncertain about its value;[48] and fashioned surveys that attempt to measure the relationship between people's moral and ethical beliefs, their attitude about the environment, and their stated willingness to pay for species protection.[49]

As these attempts to overcome particular problems indicate, economists who administer CV surveys recognize their limitations. Indeed, CV studies are now generally done with a careful eye to the guidelines for such studies, established by a National Oceanic and Atmospheric Administration (NOAA) panel back in the early 1990s.[50]

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[46] For a discussion and experimental results pointing to perceived fault as perhaps accounting for the willingness-to-accept/willingness-to-pay discrepancy, see Jeffrey Rachlinski, Rachel Croson & Jason Johnston, *Punitiveness as an Explanation of the WTA-WTP Discrepancy in Contingent Valuation: Theory and Evidence* (Univ. of Pa. Working Paper, 2005), *available at* http://opim.wharton.upenn.edu/~crosonr/publications/research/%5B72%5D.pdf.

[47] There are three general ways of asking people how much they would pay, or have to be paid, in CV surveys: (1) open-ended questions, in which people answer with whatever amount comes to mind; (2) dichotomous choices, which ask whether people would pay a chosen amount, and then give a higher or lower amount and ask again; and, finally, (3) payment cards, which give a range of values and ask respondents to circle the one that best represents their willingness to pay. For a CV study employing all three formats to investigate how much people were willing to pay to restore red-cockaded woodpecker habitat after it was destroyed by a hurricane, see Dixie Watts Reaves, Randall A. Kramer & Thomas P. Holmes, *Does Question Format Matter? Valuing an Endangered Species*, 14 ENVTL. & RESOURCE ECON. 365, 371-77 (1999).

[48] *See* Catherine M. Chambers & John C. Whitehead, *A Contingent Valuation of the Benefits of Wolves in Minnesota*, 26 ENVTL. & RESOURCE ECON. 249, 259 (2003) (employing two alternative statistical tests for the meaning of "don't know" responses to questions asking people how much they would pay for two alternative wolf management plans); John Loomis & Earl Ekstrand, *Alternative Approaches for Incorporating Respondent Uncertainty When Estimating Willingness To Pay: The Case of the Mexican Spotted Owl*, 27 ECOLOGICAL ECON. 29, 31 (1998) (discussing methods for dealing with "respondent uncertainty").

[49] *See generally* Matthew J. Kotchen & Stephen D. Reiling, *Environmental Attitudes, Motivations, and Contingent Valuation of Nonuse Values: A Case Study Involving Endangered Species*, 32 ECOLOGICAL ECON. 93 (2000) (measuring environmental attitudes and stated nonuse values for a proposed recovery plan for peregrine falcons and shortnose sturgeons in Maine).

[50] Natural Resource Damage Assessments Under the Oil Pollution Act of 1990, 58 Fed. Reg. 4601, app. 1 at 4602-14 (proposed Jan. 15, 1993) (Report of the NOAA Panel on Contingent Valuation).

These recommendations stress that the results from CV studies are highly context and survey specific, and advise CV practitioners to attend carefully to the way that survey respondents are informed about the problem, the way that questions are posed, and how values are elicited.

The most general lesson from existing CV practice is that the results of CV studies are highly particular and context based, and that they most assuredly cannot be used to assign a value to aggregate species protection. Throughout their discussion and use of CV studies, Hsiung and Sunstein demonstrate a complete failure to understand the technique and its limits. When they find that people in a European survey attached a value to humpback whales an order of magnitude lower than the value assigned by a group of Americans surveyed, they call it a "troubling irregularit[y]."[51] But such differences are to be expected when two very different sets of survey respondents are asked different questions about a species that one group (the Americans) has probably had much more contact with than has the other group (the Europeans). Even worse, although Hsiung and Sunstein seem to understand that virtually all CV studies of willingness to pay for species preservation have focused on a very small number of very high-profile, high-value animal species such as wolves or songbirds,[52] and although their own methods force them to confront the large variation even in CV-reported value across species,[53] Hsiung and Sunstein still think it is somehow worthwhile to take an average value from the CV studies and use it as the value of preserving tens of thousands of unknown and unnamed (vertebrate) species. I venture to say that no economist would defend such a practice.[54]

All of this explains why the economic analysis of the costs and benefits of climate change has not explicitly considered species loss. As leading climate change economist Richard Tol concludes in a recent survey of current frontiers in climate change policy research, "[w]ide-spread change that is hard to detect and to attribute is beyond current [economic] valuation methods."[55] Indeed, rather than pro-

[51] Hsiung & Sunstein, *supra* note 1, at 1727.

[52] *See id.* (discussing a reporting bias where high-profile species are surveyed more often).

[53] *See id.* at 1730.

[54] Nor, given the highly contextual nature of all species valuation, would any qualified economist ever declare simply, as do Hsiung and Sunstein, that the difference between the valuations of domestic versus foreign species is "not significant." *Id.* at 1732.

[55] Richard S.J. Tol, *Why Worry About Climate Change? A Research Agenda* (Fondazi-

viding some means to value aggregate climate-change-induced species loss, economic valuation methods (primarily contingent valuation) have improved by recognizing that "values are heterogeneous and contextual" and by becoming very specific by "focusing on a single issue in a particular locality."[56] What Hsiung and Sunstein presumptuously call the economics profession's ignorance of the effect of climate change on species loss is actually the recognition by well-informed, trained economists that current methods cannot reliably be applied to the problem.

III. WHAT SCIENCE ACTUALLY KNOWS ABOUT GLOBAL WARMING AND SPECIES LOSS: ONE ECONOMIST'S VIEW AND RECOMMENDATION FOR HOW TO PROCEED WITH POLICY GIVEN INCOMPLETE INFORMATION

Biologists know a lot about how species respond to different climates. Indeed, the relationship between climate variation and species distribution and abundance is central to the field known as biogeography. Biologists are also very quickly learning how species are responding to the global warming that has occurred during the twentieth century. Lovejoy and Hannah, who have studied climate change and biodiversity for decades, have recently summarized the most important new findings from the field of "climate change biology" as follows:[57]

1. Range shifts, rather than either evolution or extinction, will be the "dominant response" to climate change, with species generally moving poleward and upslope to find a suitable climate.
2. Still, there is increasing evidence of rapid evolutionary adjustments of traits such as photoperiod (that is, light and day length) response and development time, adjustments that may be so rapid that "[m]ismatches in photoperiod as organisms move poleward . . . [are] unlikely to be problematic."[58]

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one Eni Enrico Mattei, Working Paper 136.2006, 2006), *available at* http://ssrn.com/abstract=945044.

[56] *Id.*

[57] Thomas E. Lovejoy & Lee Hannah, *Global Greenhouse Gas Levels and the Future of Biodiversity*, *in* CLIMATE CHANGE AND BIODIVERSITY 387, 387-88 (Thomas E. Lovejoy & Lee Hannah eds., 2005). The earlier volume was GLOBAL WARMING AND BIOLOGICAL DIVERSITY (Robert L. Peters & Thomas E. Lovejoy eds., 1992).

[58] Lovejoy & Hannah, *supra* note 57, at 388. For a synthesis of evidence that the dominant response of species to warming climate has been to shift their ranges north in latitude and up in elevation, and to begin breeding, nesting, flowering and other

3. Most generally, the response to climate change is likely to be highly species-specific. This implies that many vegetation communities and predator-prey and other competitive relationships will "be torn apart and reassembled in novel ways."[59] Still, when they look to the past (to a field called paleoecology), it is apparent that "[t]here is no reliable record of mass extinctions in the Pleistocene, so plants and animals have been able to survive huge regional changes by modern standards," and "biodiversity has survived these past rapid changes largely intact."[60]

These recent findings are fascinating, and they have very important implications for climate change policy, which I sketch below. But they do not generate the kind of precise probability-of-extinction number that Hsiung and Sunstein use. That number comes from a particular article in a very new and quite controversial application of quantitative ecology.[61] Criticism by other biologists suggests that the quantitative estimates generated therein should be taken at best as first steps, likely to be substantially revised as work in the field continues.[62] Indeed, one such critic, Oxford zoologist Owen Lewis, con-

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phonological events earlier in the spring, see Camille Parmesan & Gary Yohe, *A Globally Coherent Fingerprint of Climate Change Impacts Across Natural Systems*, 421 NATURE 37 (2003). For a more recent review of this literature, see Camille Parmesan, *Ecological and Evolutionary Responses to Recent Climate Change*, 37 ANN. REV. ECOLOGY EVOLUTION & SYSTEMATICS 637 (2006).

[59] Lovejoy & Hannah, *supra* note 57, at 388.

[60] *Id.* For further discussion of this latter finding, see Owen T. Lewis, *Climate Change, Species-Area Curves and the Extinction Crisis*, 361 PHIL. TRANSACTIONS ROYAL SOC'Y B 163, 169 (2006) ("Marked variations in climate over the last 10000 years . . . have had relatively little impact on extinctions; and where species have gone extinct the effect may have been to 'filter out' those species most sensitive to climate change." (citation omitted)). *See also* Mark B. Bush & Henry Hooghiemstra, *Tropical Biotic Responses to Climate Change, in* CLIMATE CHANGE AND BIODIVERSITY, *supra* note 57, at 125, 129 (noting that "in the intensively studied flora of North America only one species of tree, *Picea critchfieldii*, is known to have gone extinct in the last ice age" (citation omitted)).

[61] Thomas et al., *supra* note 7, at 145.

[62] Owen T. Lewis, *supra* note 60, at 167-69, criticizes the way that Thomas et al. use the species-area relationship (SAR) to come up with a probability of species loss due to climate change. His criticism contains a number of points that seem quite compelling, at least to my economist's mind:

First, models such as that presented by Thomas et al. (climate envelope studies) assume that the existing climatic distribution of species indicates species' climatic requirements, but in fact species almost surely occupy smaller areas than they might with a different assembly of local communities of plants and animals. This is very clearly shown by the ability of alien or exotic plants and animals to multiply when introduced to areas that have a very different set of predators and prey compared to their natural range. Climate change will generate new communities of species, but biologists cannot cludes his recent discussion of the Thomas et al. study by opining that the "logical simplicity" of the species-area relationship (SAR) method used by Thomas et al. "conceals a hotchpotch of assumptions, extrapolations, approximations and estimates that combine to generate considerable uncertainty," so much so that it is not the SAR technique that one should look to in the future for estimates of the impact of climate change on extinctions.[63] Indeed, in Lewis's view it will be difficult to come up with quantitative estimates at all, because while he is "more comfortable with estimates of extinction calculated on a species-by-species basis, . . . such estimates are hampered by our almost total ignorance of the minimum critical habitat required by most species, particularly the small, poorly studied ones living in the most diverse habitats on earth, the tropical forests."[64]

I am not alone in arguing that there is still far too much uncertainty in numerical estimates of species extinction probabilities such as those generated by Thomas et al. for those numbers to provide the basis for climate change policy analysis. Richard Tol, for example, has recently argued as follows:

1. Because quantitative ecology is "still in its infancy" and there are many species to model, the existing quantitative studies consist only of dynamic vegetation models that were built to study the carbon cycle and that ignore animals and have only a

predict how the growth or decline of any particular species will vary with the composition of hypothetical communities.

Second, even if predictions for the particular species and regions in the Thomas et al. study are accurate, that study is necessarily limited to endemic species—those that live only in the areas studied—and thus the study is necessarily limited to species with relatively small ranges, and it is "well known that species with small geographic ranges are particularly prone to extinctions." *Id.* at 168.

Third, the Thomas et al. study includes only a relatively small number of species from tropical forests, but such forests account for over 50% of the world's species and are likely to be less affected by climate change than habitats at higher latitudes.

Fourth, under the approach taken by Thomas et al., decreases in the size of a species range increase the estimated risk of extinction, but increases in species range due to climate change cannot lower extinction risk, despite the fact that climate change will push species north from species-rich equatorial latitudes to species-poor northern latitudes.

[63] *Id.* at 169. For an article illustrating the range of uncertainty in all such quantitative approaches at present, even those based on models other than SAR, see Wilfried Thuiller, *Patterns and Uncertainties of Species' Range Shifts Under Climate Change*, 10 GLOBAL CHANGE BIOLOGY 2020, 2024 (2004) (noting that large variation in species turnover rates shows the "strong variability of species turnover estimates from different niche-based models applied on the same data" but that "there is no way currently to assess which universal niche-based model is most appropriate").

[64] Lewis, *supra* note 60, at 169.

"crude resolution" for plants, while there are few studies that do take detailed looks at the impact of climate shift on species, and those that do so look only at small numbers of species.

2. Because species loss is caused not only by climate change but also by the "synergistic" changes in "land use, . . . nutrient cycles, alien invasions and acidification," it is very difficult to isolate the impact of climate change, and thus it remains very difficult to derive a quantitative model of climate change and species loss that can be tested on past observation and used to make future projections of species loss.[65]

In their quest to attach a numerical dollar figure to the potential species loss from climate change, Hsiung and Sunstein have overlooked what biologists are quite confident about when it comes to climate change and species loss, and instead pounced upon what biologists are least certain about. It is hard to see how this is consistent with sound policy analysis.

What is consistent with sound policy, I believe, is to look to biologists not for numbers that can be plugged into abstract cost-benefit analysis, but rather for concrete steps that may be taken to lessen the impact of global warming in causing species loss. The way to find such concrete policy measures is to focus on what biologists do know about species and climate change. Biologists tell us that although it is difficult to predict the impact of climate change on the genetic composition of species, because "[w]hat genetic properties determine the species' environmental limits, its adaptive niche, and the edge of its range is a very demanding question," it is "clear" that by remodeling population distribution and size, climate change will have some impact on the genetic composition of populations via the forces of evolutionary selection.[66]

A concrete example of how climate change differentially favors some genotypes is the impact of climate change on European great

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[65] Tol, *supra* note 55, at 10.

[66] Godfrey M. Hewitt & Richard A. Nichols, *Genetic and Evolutionary Impacts of Climate Change*, in CLIMATE CHANGE AND BIODIVERSITY, *supra* note 57, at 176, 178-79. As Hewitt and Nichols go on to explain, at the trailing edges of shifting ranges, "[p]opulations of many species will fragment into smaller and more isolated subpopulations." *Id.* at 183. But fragmentation into subpopulations may increase or decrease genetic variation within the species; if a species is divided into a large number of subpopulations with little migration among subpopulations, then genetic diversity within the species may well increase. Indeed, when range contraction proceeds in this manner, a species' genetic diversity may increase during range contraction but fall during range expansion with the opposite characteristics (in particular, high migration).

tits. These birds depend on caterpillars to feed their young; "[w]ith earlier springs, the caterpillars have been maturing earlier, before the tit chicks hatch," so that only those great tits whose genetic makeup allows them to vary their egg-laying date in response to an earlier spring have been able to maintain reproductive success.[67] The great tit population as a whole "cannot keep pace with environmental change," however, and is experiencing declining average lifetime reproductive success.[68] Bradshaw and Holzapfel say that as a general matter, "[s]mall animals with short life cycles and large population sizes will probably adapt to longer growing seasons and be able to persist; however, populations of many large animals with longer life cycles and smaller population sizes will experience a decline in population or be replaced by more southern species."[69] Still, even at their direst, Bradshaw and Holzapfel predict only that if we do not take effective steps to mitigate climate change, then "natural communities with which we are familiar will cease to exist."[70]

Thus what biologists are telling us, with considerable confidence, is that global warming will bring rapid genetic selection, range shifts, and hence the large-scale destruction and reassembly of biological communities. Crucially, they are also telling us that the preservation of biodiversity in this process will be seriously impeded by the loss of species habitat.[71] Habitat loss, which was the most important cause of species decline during the twentieth century,[72] is likely to be even more harmful in a rapidly warming twenty-first century. Recessive traits that are disfavored under current climate conditions but that would be well adapted to a warmer climate may not get a chance to increase in frequency if human land development activities split a species into small, isolated populations; similarly, successful long-distance population dispersal is dependent not only upon the size of the current population, but also upon the existence of relatively large and connected landscapes.[73]

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[67] William E. Bradshaw & Christina M. Holzapfel, *Climate Change: Evolutionary Response to Rapid Climate Change*, 312 SCIENCE 1477, 1477 (2006).

[68] *Id.* at 1478.

[69] *Id.*

[70] *Id.*

[71] *See* Lovejoy & Hannah, *supra* note 57, at 389 (describing the implications of climate change for biodiversity).

[72] *See* Parmesan & Yohe, *supra* note 58, at 41 ("In an absolute sense, land-use change has probably been a stronger driver of twentieth century changes in wild plants and animals than has climate change.").

[73] Lovejoy & Hannah, *supra* note 57, at 389.

Hence, what biologists are telling us about how policy needs to respond to global warming if we are to lower the risk of species extinctions and biodiversity loss is quite clear, and represents a very significant policy shift: the provision of isolated biological preserves, connected by corridors—the currently dominant approach to habitat conservation—needs to be replaced by an approach that focuses much more on the preservation of large, connected landscapes.

CONCLUSION

Designed ostensibly to provide some dollar figures on species loss that can be used to get a more accurate picture of the benefits of climate change mitigation, the exercise performed by Hsiung and Sunstein is instead a caricature of cost-benefit methodology, an exercise that ironically makes cost-benefit analysis appear more arbitrary and irrational than the regulatory process that it is supposed to discipline.[74]

Why, then, should one even take the time to read Hsiung and Sunstein's article, or to write the response that I have set forth above? Because climate change policy is important. Deciding when, whether, and how to mitigate climate change entails very real, human consequences. These decisions require careful, unbiased analysis. Yet more than in perhaps any other major public policy debate of our time, in the climate change policy debate, numbers, and numbers alone, have been used as a substitute for analysis: numbers on what temperature or sea level increase is to be expected from global warming, how many cities will be underwater if sea level rise is large, how quickly glaciers and ice caps are melting, how many people may be expected to perish or suffer disease, or how much wealth will be lost if we do or do not mitigate. But numbers cannot substitute for analysis; they result *from* analysis. And if the analysis underlying the numbers is weak, moving from questionable assumptions to logically flawed deductions derived from models patched together in order to reach certain preordained conclusions, then the numbers are worse than useless—they are misleading and dangerous.

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[74] Even more ironically, a coauthor of this study is one of the legal academy's most thoughtful and perceptive advocates of cost-benefit analysis. *See, e.g.*, CASS R. SUNSTEIN, RISK AND REASON: SAFETY, LAW, AND THE ENVIRONMENT (2002).