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**Valuation of Ecological Benefits: Improving the Science  
Behind Policy Decisions**

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Prepared by Alpha-Gamma Technologies, Inc.  
4700 Falls of Neuse Road, Suite 350, Raleigh, NC 27609

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## Summary of Keynote Address: The Economics of Ecosystem Services

Geoffrey Heal, Columbia University

Dr. Heal opened by saying, “I want to talk about what I think of as an emerging area, which I’ve loosely called “The Economics of Ecosystem Services,” not because that’s a really snappy title but because I couldn’t think of anything better. It’s an area that’s attracting an increasing amount of interest both in academia and in policy circles, and you’ve seen some evidence of that already so far today.” He referred particularly to three governmental committees that are examining the general area of economics in ecosystems, two internal to EPA and one external at the National Academy of Sciences, about which Mark Gibson had already given a presentation (see Session I). Dr. Heal said he has had the pleasure of serving on two of those three committees that are at work in this area of increasing concern.

Reiterating that this is basically a relatively new area of focus, Dr. Heal stated that it dates back, as far as he can see, “to 1997 with the publication of a book, edited by Gretchen Daily in the biology department at Stanford, called *Nature’s Services: Societal Dependence on Natural Ecosystems*.” Saying that “interaction between economics and ecologists goes back further than that,” he cited the [Journal of Ecological Economics](#) and “the Beijer Institute in Sweden, which also works on the economics/ecology interface and has been doing this since about 1990. However, neither the economics community nor the Beijer group, of which I’m a part, really focused on the concept of ecosystem services, and I’m going to argue during my talk that that concept of ecosystem services is really a very important one and is a rather powerful organizing concept. The introduction of the concept has really made a difference in the way we think about things.”

Dr. Heal went on to quote the following lines spoken by Teddy Roosevelt nearly a century ago: “The nation behaves well if it treats natural resources as assets which you must turn over to the next generation increased, and not impaired, in value.” He went on to ask rhetorically whether this was “the first statement of the importance of strict sustainability—by a Republican president no less?” (laughter) He continued, “It’s clear that Roosevelt, interestingly, was thinking about natural resources as assets, and in fact, as a form of capital, and that’s an issue I want to come back to.” Dr. Heal stated that this new field of ecological economics is “possibly even a new paradigm,” although he uses that term “with great caution because it’s hugely over-used, in many ways.”

He continued by enumerating the various components of “society’s capital”: physical capital (buildings, computers, etc.); human capital; intellectual capital; social capital; “and last, but not least, natural capital.” Dr. Heal said these all represent assets that yield a return to society, “and they’re all assets in which we can make an investment.”

Focusing on the concept of natural capital, Dr. Heal sought to identify its components. He stated, “Certainly since Hotelling’s 1931 paper on the Economics of Exhaustible Resources we’ve known that mineral resources are a form of capital. What Hotelling did

in that 1931 paper was essentially to take a capital theoretic approach to the management of natural resources, though I guess “capital theoretic” wasn’t a current phrase in 1931.” He went on to remind the audience that the famous Hotelling Rule that came out of that paper, which says that “the rate of capital gain on a resource should equal the rate of interest, is essentially an asset management rule—a rule for efficient management of assets which, incidentally, was developed by those researchers way before any general theory of efficient management of assets.” Dr. Heal identified “environmental systems, as a whole” as another more-intangible type of important natural capital asset, and he gave the example of lakes and rivers that are used to generate hydropower. He cited Sweden, in particular, which gets “about 75% of its electric power from hydroelectricity, so the Swedish system of lakes and rivers is a massive public utility and represent a large fraction of Sweden’s natural assets in the public utility area.”

Dr. Heal said, “Extending this line of argument more generally we can think of ecosystems as assets, as part of our natural capital stock.” He reiterated that all forms of capital provide services—they provide a return, “and the return that natural capital provides is the services of natural ecosystems.” He explained, “Now, there are two concepts coming together when I make that statement: there’s the concept of natural capital from economics, and there’s the concept of ecosystem services, which basically comes from ecology. Ecologists, I guess, developed this concept of ecosystem services as a way of characterizing *how* ecosystems matter to society, what *services* ecosystems *provide* to society.” Dr. Heal went on to identify some typical classifications of the nature of some of these services provided to society by ecosystems: climate stabilization, pollination and other assistances to food production, waste decomposition, recreation, etc. He added, “There’s a review of these in the National Academy of Sciences’ volume that Mark (Gibson) was talking about earlier,” and went on to summarize that “ecosystem services are the return on natural capital, and natural capital essentially consists of ecosystems. The economic value of natural capital is obviously the present value of the ecosystem services it provides.”

Stating that this idea could be taken in several different directions, Dr. Heal clarified, “What I want to do for the bulk of my talk, actually, is talk about the National Academy of Sciences report and how it develops some of these ideas, but let me first take a little digression into the area of sustainability, which has been an area of interest to me for quite a long time.” Allowing that there are a number of different ways of defining sustainability, he said that most of the definitions “revolve around the concept of natural capital, so I’m just trying to indicate that the concept of natural capital has applications in a variety of areas. One way of defining sustainability is to say that sustainable income is the interest on capital stocks—all of the capital stocks taken together.” Dr. Heal added, “That’s a Hicksian concept,” and reminded the audience that Hicks defined income as “the maximum amount you can spend today consistent with spending the same amount indefinitely into the future.” He pointed out that “There’s a concept of sustainability right there in that concept of income that Hicks developed back in the 1930’s, but if you think about what that means, it really means that income is interest on capital, broadly defined.”

Exploring more definitions of sustainability that support both weak and strong versions of sustainability, Dr. Heal pointed out one in which “the weak version of sustainability is policy that keeps the *total* value of *all* capital constant—preferably increasing, but at least constant. So, non-decreasing value of *total* capital stocks is what is sometimes described as weak sustainability. Non-decreasing value for natural capital *alone* is what is sometimes referred to as strong sustainability.” He stated that he didn’t wish to go into the merits or demerits of the various definitions, but was “just trying to emphasize the point that natural capital, whose value is the present discounted value of ecosystem services, is a key concept in discussions of sustainability.” He also added that “one of the interesting consequences of keeping a non-decreasing total value for all capital stocks is that it implies the present discounted value of future welfare is non-decreasing.”

Returning to the issue of ecosystem services, Dr. Heal commented that ecosystem services are frequently public goods (such as those he had mentioned previously: climate stabilization, pollination, etc.). Furthermore, he stated that “a great majority of them are non-market goods, so when it comes to valuing them, this raises some questions, but questions that are fairly conventional in the field of environmental economics—questions which are, in fact, the lifeblood of environmental economics.” He pointed out one aspect of ecosystem services which is “certainly rather distinctive, and that’s that there is frequently a considerable amount of uncertainty about the functional relationship between the *state* of an ecosystem and the *services* that it provides.”

Switching to a discussion of “the National Academy of Sciences report (the National Research Council report) and how it addresses some of these things,” Dr. Heal said that the report starts off by “classifying the various ways in which ecosystems and ecosystem services can have value.” He described this as a “conventional classification into use and non-use values, with a sub-classification of the use values into direct and indirect values” and added that “there’s a two-way classification which is central to the report. One is a classification of the types of values that ecosystem services can have. The second, obviously, is a classification of how you can go about valuing them.” Emphasizing that this is all fairly standard economics, he identified the optional ways to value them: “with revealed-preference techniques, with stated-preference techniques, or with some combination of the two.” He added that in writing the report, he and the others spent some time “trying to work out when one or the other is more appropriate and which of the various techniques is more appropriate for which particular types of services.” He also stated that “the discussion of these issues in the report does address some of the issues raised by the NOAA Blue Ribbon Commission on Contingent Valuation and some of the critics of the CV approaches there. I don’t think we have anything enormously original to say about that, but I think there’s quite a clear integration of the literature on that within that section of the report.”

Dr. Heal identified one of the key questions that they focused on in the report is “how the services provided by an ecosystem (i.e., the services provided by natural capital) change as the ecosystems are impacted by human activity.” He presented the example of how the extent of mangrove swamps and other types of coastal wetlands affect the productivity of offshore fisheries and identified the pertinent questions as: “What *exactly*

is the functional relationship there—how much will a change that we make in the extent of coastal wetlands affect fisheries and on what sort of timescale?” As another example, he brought up an issue that he has been involved with: New York City’s decision to conserve the Catskills watershed. The primary question they have dealt with here is: “How does the extent of a watershed and the nature of the vegetation in that watershed affect the watershed’s ability to provide ecosystem services?” He identified the two “critical ecosystem services” that most watersheds provide as water purification and stabilization of stream flow and said, “If you’re thinking about the conservation of a threatened watershed because of the value of those services, then it’s actually quite important to have some understanding how different ways of using that watershed and different levels of human impact on that watershed will affect the provision of those services.” Ideally, he said, you’re looking for some kind of functional relationship between the state of the watershed and the services it provides.

Dr. Heal went on to say that “we don’t have to answer that type of question if all we want to do is to value the current services of ecosystems, but if we want to value *changes* in the services that result from extended human activity or from policy intervention, then we *do* have to answer these sorts of questions about what’s the nature of the link from the physical characteristics of an ecosystem and the extent of the ecosystem and the human intervention in the ecosystem through to the services that it provides.” For emphasis, he repeated, “If we want to value the *change* in natural capital which comes from the destruction or the conservation of a system like a watershed or a wetland, then we have to be able to answer those kinds of questions.” He went on to state that “the biggest challenge that we face here is linking changes in the bio-geo-chemical state of an ecosystem to a change in the service flow,” and he said that the NAS report pushes quite hard for more of the integrated economic and ecological modeling that is required to address this.

He continued, “What we really need here, ultimately, is what I might loosely call an ecological/economic production function, which is a function that has ecological variables as its domain and economic variables as its range. Basically, you would then perform economic analysis on that production function—you want to be able to differentiate that production function and find the marginal productivity of this type of change in the vegetation, this type of change in the extent of the area, etc.” Dr. Heal stated that with this marginal productivity, you could then conduct policy analyses. He went on to explain that ecologists characterize ecosystems in terms of their structure and their functions, and he clarified structure as meaning “a description of the things that are in it—the species, the number of each species, the structure of the soil, the climate, the vegetation, and things like that.” He clarified functions as “the flow of energy through the ecosystem, the productivity of the ecosystem, and a range of variables like that” and he said that “the ecosystem, acting through its structure and functions, produces ecosystem goods and services, which are of importance to humans. As we said before, those services have use and non-use values, consumptive and non-consumptive uses and so on. Then, of course, human activities, in principle, have an impact on the structure of the ecosystem and therefore affect the ecosystem services.”



“What we really want to be able to do is to go right through that system from the top down to the bottom and say how a human action will affect the structure and function of an ecosystem and, in turn, affect the extent of the goods and services provided, and therefore the value of those goods and services provided. Then you can use that calculation in a cost-benefit analysis to compare it with the alternatives available.” Dr. Heal admitted that this can be quite a complex thing to do, and it isn’t easy to link the economic and ecological models. He characterized ecological models as having “a habit of being fairly complex,” often involving non-linearities, thresholds, and irreversibilities. He said that although these complications also existed in economic models, they seem to be “more dominant and more central to the true characteristics” in ecological models.

To provide an example of “what you run into when you try to do this type of stuff,” Dr. Heal brought up the case of Lake Mendota, a lake beside the campus of the University of Wisconsin-Madison, which he termed “the most widely studied lake in the world, by far.” He cited studies that looked at the eutrophication of the lake and estimated that 70% of the fertilizer applied to the farmland surrounding the lake actually ends up in the lake. The high level of phosphorous in the fertilizer causes the lake “to sort of switch states, biologically speaking, and become eutrophied. There’s a huge reservoir of phosphorous in the sediment at the bottom of the lake, and under certain conditions this phosphorous is released into the lake water, causing a sudden pulse in the water’s phosphorous level.” He went on to explain that while the amount of phosphorous leaving the lake by means of an outflowing stream is directly proportional to the concentration of phosphorous in the lake, the inflow is more complicated. There’s a basic rate of phosphorous inflow, which is set by the rate of fertilizer use by the farmers on the adjacent land and the rate of rainfall, but “once the concentration of phosphorous in the lake water reaches a certain critical level, phosphorous is released from the sediment into the water and you get a sudden increase in the rate of phosphorous inflow into the lake because of that. So, you end up with a sort of S-shaped relationship between phosphorous concentration and phosphorous inflow because of that pulse.”

Dr. Heal went on to identify different equilibrium points along the relationship curve. In particular, he pointed out a lower point, at which the lake was healthy and usable, and a higher point, at which the lake was eutrophied. He pointed out that a sudden heavy rainfall can “kick” the phosphorous concentration from the lower, normal equilibrium value up to the high-concentration equilibrium value, where the lake is eutrophied, and it can be very difficult to move the phosphorous concentration back once it has been elevated in such a way. He concluded, “The point here is not to give you lectures on lake ecology, but to illustrate the complexity of these ecological models and the complexity, therefore, of the linked economic/ecological models, because the services that this ecosystem provides depend on which of these equilibria we’re at. At the lower level, it can provide quite a high level of services; at the higher level, on the other hand, it provides a much lower level of services. The relationship between the inputs to the system and the ecosystem services it provides is actually given by a quite complex dynamic process where what’s happening today depends not only on the inputs today but on a whole history of past inputs. This makes it quite difficult to write down the kind of

production function I was describing before, and in ecology this kind of thing is quite common.”

Dr. Heal provided another example based on the responses of watersheds to oxides of nitrogen, citing a study done on the Catskills by researchers at the Institute for Ecosystem Studies. In this situation, the water bodies’ natural ability to buffer the effects of the deposition of oxides of nitrogen keeps the chemistry of the water at a steady state until the buffering capacity is exhausted—then there is a sudden change in the chemistry of the water, producing a relationship between the inputs and the outputs which is highly non-linear and which also depends on the history of past inputs rather than just on current levels of inputs. He summed up the situation by saying, “While I think we definitely need to link the economic and ecological models, it’s complicated and it’s understandable that it hasn’t been very extensively done to date. There are a small number of good examples, but that number really ideally should be much greater.”

Dr. Heal commented that Chapter 5 of the report presents some of the examples he has referred to and pulls together “a whole range of case studies which try to integrate ecological and economic thinking in the valuation of ecosystem services.” He further clarified that the chapter begins with “some relatively simple cases involving a single service provided by an ecosystem—the decision on policy issues is made on the basis of a single service, usually something to do with water,” for example drinking water, flood control, and fisheries. Then the report goes on to look at more complicated examples representative of ecosystems that provide many different services “all of which matter for the policy decision, and therefore you have to worry about valuation of *all* of the services and about the impact of human activity on the provision of all of the services.” Dr. Heal stated that there are some “really quite good case studies” that focus simply on single-service situations, but when you progress to the more common multi-service situations “there is regrettably a paucity of really well-worked case studies.” He cited the Lake Mendota example as one that “has been very well worked with some really effective integrative studies.”

Saying that the last topic he wanted to address was “the issue of uncertainty,” to which an entire chapter of the report is devoted, Dr. Heal said, “I think it’s implicit in what I’ve said so far that in any attempt to link economic and ecological modeling there will be a significant level of uncertainty in the final output.” Though this is always the case in the statistical analysis of economic studies, he said it’s “particularly pronounced” in the type of situations being discussed. He stated that’s one of the reasons why in the report they emphasize the need for a sensitivity analysis, and they recommend “both conventional sensitivity analysis and also Monte Carlo analysis when the data are sufficient and the opportunities are available for that.”

Dr. Heal said that in the report they also “talk at some length about option values, which are very important in this context.” This is because we’re dealing with ecosystems in which there are “potentially significant irreversible changes” due to human activity while at the same time being uncertain about the consequences of the changes. However, over time, we may learn something about these consequences. As Dr. Heal stated, “That’s a

classic situation for the existence of a quasi-option value.” He explained, “Quasi-option values (or just option values, for simplicity) are associated with situations where there’s a potentially irreversible change and you don’t know the full consequences of that change although you may learn about the consequences of that change over time. Then what the theory of option values tells you is that there is a real merit, or advantage, to maintaining a flexible stance and using the available time to learn more about the importance of the system that you’re thinking about conserving or changing.” Dr. Heal said he and his colleagues noticed that “there are actually no studies at all of the significance of option values associated with avoiding irreversible changes in complex ecosystems.” He added, “Let me emphasize the issue again, just in case I didn’t make this clear: When you’re looking at the costs and benefits of changing an ecosystem and making potentially irreversible changes, then on the benefits side associated with conserving the system you should enter a number which reflects this option value, a number that reflects the fact that if you conserve the system you can, in the future, revisit the decision on whether to damage it or not when you have better understanding of the consequences of that. That’s what we call the quasi-option value—that’s what Arrow and Fisher first analyzed in the QJE [*The Quarterly Journal of Economics*] paper back in the 1970’s.”

Dr. Heal went on to say that none of the studies cited in the report look at option values at all, and he added that he is not aware of any attempts by researchers in the field to compute option values for their ecological/economic studies. Stating again that he believes this is an important area for empirical research, he said it has left “a big gap in our understanding of some of the numerical issues in the conservation of these ecosystems.” He added that when you talk about this type of uncertainty, ecologists always raise the issue of adaptive management, which means “managing an ecosystem, if it’s possible to control it in some sense, in such a way as to actually *learn* about its behavior—in effect, experimenting to some degree with the ecosystem so as to get more information about the parameters of the system and how it responds in various ways.” Dr. Heal noted that the issue of adaptive management is dealt with in the report and went on to say that from an economic perspective it is interesting that “there’s an interaction between this ecologist’s concept of adaptive management and the economist’s concept of option value.” He clarified by stating that “one of the things that gives a flexible stance an option value in the face of a potentially irreversible change is that if you postpone making the change, you get a better estimate of the value of making or not making the change. If you can actually experiment through adaptive management, you can potentially increase the value that you get from learning in a situation like that, so there can be an interesting positive interaction between option values and adaptive management.”

A concept that “comes up naturally when you’re talking about uncertainty in this context,” and one of the issues that Dr. Heal and his colleagues “discussed at some length in the report is the issue of the precautionary principle.” He briefly reviewed the history of this principle, which was advanced in the Rio Declaration in the early 1990’s, became commonplace in European legislation on environmental conservation, and is often cited by NGO’s as an argument for not making certain types of change. Dr. Heal said, “I have to say that, potentially slightly controversially, the committee saw little value added in

the precautionary principle. It seemed to us that many of the issues that motivate people to talk about the precautionary principle and lead them to *advocate* the precautionary principle *are in fact* actually adequately captured in concepts that economists already have—namely the concepts of risk aversion and option value.” Dr. Heal said, “If you approach a decision from the perspective that society may be very risk averse, and particularly may be very risk averse about making irreversible changes (and this is captured in the concept of option value), then I think actually there’s little value added by using this so-called precautionary principle. Much of it is already there in the body of economic thinking about decision-making under uncertainty, but we haven’t done a terribly good job of articulating that connection.”

Dr. Heal returned at the end of his talk to why he believes it’s interesting and useful to think in terms of ecosystem services. He believes that the ecosystem services approach gives researchers a better handle on understanding why the conservation of natural environments matters from an economic perspective. He said there are currently “some big shortcomings in the way we go about this.” He acknowledged that “we’re very good at talking about why pollution is bad for people’s health, and a lot of the ways in which we *pitch* the conservation of our natural environments is in terms of the impact on human health.” He also stated that we know that people have a willingness to pay for conservation, for example on the issues of wilderness areas and threatened species, but he added that “we’re not particularly good at actually articulating in detail to a skeptic *why it matters* that we conserve the natural environment and *why it matters* that we conserve threatened species.”

Dr. Heal believes that “thinking in terms of natural capital, and in terms of natural capital as providing ecosystem services, which are a return on that natural capital, can give us a much better handle on explaining in detail why the conservation of the natural environment works.” He said that in his view, “One of the ultimate challenges in this area is explaining why biodiversity conservation matters and why extinction matters. Almost all environmental economists are personally concerned about the extinction of species—it matters to most of you in this room that species go extinct.” He raised the question: “Is this purely a moral judgment?—Is this purely an aesthetic judgment?—Or is there also a sense of an economic element in this as well?” He believes, “Thinking in terms of ecosystem services does *potentially* give you a handle for analyzing your concerns about extinction and about biodiversity loss in economic terms rather than in moral or aesthetic terms.” Dr. Heal was quick to add, “I’m not undervaluing moral or aesthetic thinking at all, but it often doesn’t have much impact on policy makers, I regret to say. Economic thinking, on the other hand, tends to have much more impact on policy makers.”

In closing, Dr. Heal stated, “If you think about ecosystems providing services and about the range of the services provided as a function of the biodiversity inherent in those ecosystems and of certain species in those ecosystems being key to the way those ecosystems operate, then you can get a different model of why it matters to conserve species and to conserve biodiversity. That extra way of thinking—having that extra

element in the economist's toolkit—I think is ultimately one of the most valuable contributions of this type of approach to environmental economics.”

“Thank you.”

## Summary of the Q&A Discussion Following the Keynote Address

*Nancy Bockstael (University of Maryland)*

Dr. Bockstael commented, “Geoff, you had a slide in which you talked about the bio-geo-chemical changes that might happen in the ecosystem and how they might affect ecosystem services. There was quite a bit of detail on that slide, and then there was an arrow that went around the corner, and it sort of stood for feedbacks. I think this arrow hides a lot and raises an interesting question that EPA has asked me over and over again in my work on land use, which is: If land use change affects ecosystems, what are the feedbacks from the ecosystem back to human’s decisions to change land use? My answer is that there aren’t obvious feedbacks that affect the demand for land use change. The resulting ecosystem changes affect people through different pathways. The *ways* in which we *benefit* from some of the *improvements* in these ecosystems or that we *lose* from changes in the land use hit different people in different ways – through water recreation or storm damage, for example. But there a logical feedback mechanism that causes the land use change decisions naturally to adjust. We develop areas, we affect stream health, we affect stream geomorphology—but none of that feeds back on the demand for housing and the development decisions, so the public sector has a role here I guess. I’m wondering if this issue of that feedback arrow and that the feedbacks aren’t clear came up in your discussions . . . and if they aren’t clear, is that a pervasive thing—and if so, are there any indications for what we do in this area? I know that’s not a very well-formed question, but . . .”

*Geoffrey Heal (Columbia University)*

Dr. Heal responded, “No, it seems a very *good* question, though it seems a very *hard* question—and a very *interesting* question. I guess part of what you’re saying there—and I’m more re-phrasing the question than answering it, really—is that the impacts that you and I and others have on ecosystems don’t come back directly to us.” Dr. Heal said that, instead, our impacts “occur as external effects imposed on other people,” who can potentially be a long way away. He used the example of people in New York City who “escape” on weekends to the Catskills and because of their activities while up there “impose a negative external effect on people a couple hundred miles away. You don’t see it. So, one thing that comes out of this is that you *need to choose* the scale for decision making very carefully. A lot of land use planning in the U.S. is carried on at a very, very micro scale—and these data are too small to capture for many of these effects. So, that’s another reason why I’m integrating the valuation of watersheds into a valuation of Chesapeake Bay, for example—it gives you a chance to operate on a scale big enough that you capture some of these effects and you can bring them back into your position paper.” He offered the further example of another study he was involved with which looked at pollutant accumulations in the Gulf of Mexico that came primarily from the Mississippi River, representing a drainage basin of almost half the continental U.S.

He continued, “The arrow that you were talking about was really designed to indicate that human activity impacts ecosystems . . . and that impact is *not* well understood. Even if



you *know*, for example, how much development has occurred in an otherwise pristine ecosystem, ecologists *can't* really tell us very much precisely about *how* that impacts the ecosystem's watershed population, for example. There's no simple functional relationship between the amount of pollutant in the Catskills and the quality of the water that New York City gets."

Dr. Heal concluded by stating that part of the underlying problem here is that "we just need a lot more research on *how* human transformation of ecosystems affects the services they can provide—but this has been a very complicated relationship" which is often not easy to see "because the cause and the effect are spatially quite separate."

*Nancy Bockstael*

Dr. Bockstael interjected, "I would add that sometimes they're *temporally* quite separate."

*Dr. Heal*

Dr. Heal responded, "Yes, you're quite right. With species extinction, for example, there are a lot of species around that the ecologists like to call the walking dead." He explained that these are species whose populations are low and population/genetics modeling indicates that they'll become extinct at some point "but they may be around another 50 or 100 years before the last one dies. So, there can be long time lags between the necessary conditions for extinction being in place and the actual extinction occurring."

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*Marca Weinberg (U.S. Department of Agriculture, Economic Research Service)*

Posing a follow-up question to Dr. Bockstael's, Dr. Weinberg commented, "What we struggle with a lot is the linking question that you started with—how do you *link* policies and outcomes?—in particular, the value of changes in the natural environment that are *initiated* by the policies or that *might* be initiated by hypothetical policies." Saying that she agreed that bioeconomic modeling and process modeling are really critical to understanding these systems, she asked: "Since most policy is at the federal scale, how do you *design* data collection efforts or modeling efforts to allow an assessment of the benefits or costs of national-scale policies?"

*Geoffrey Heal*

Dr. Heal answered, "I'm not sure that the relevant policies are always at the federal level. . . . To the extent that the relevant issues are land-use issues, they are often very locally controlled, on a surprisingly small scale. That sometimes makes it harder rather than easier because if you want to control the management of a watershed and it's a large watershed, you may actually end up talking to 10 to 15 independent sovereign entities in order to get their perspective on that." Dr. Heal continued by saying that in his view, "that's actually a significant weakness in environmental protection. . . . it would be desirable to have land use decisions made on the basis of larger entities. Land use could *really* be managed that way because there's a significant influence that way—there's the potential for disaster, but there's also the potential for somewhat more straightforward solutions . . ."

Addressing the other issue that was raised concerning linking policies to outcomes, Dr. Heal commented, “The point I was trying to make for part of my talk was that the link between the physical nature of an ecosystem and the services it provides is very weak—we don’t understand that well. It’s partly a question of collecting data, but it’s also a question of doing some modeling. There are actually quite a lot of data in the Heinz Center that Tom Lovejoy runs . . . a lot of data on the state of the U.S. ecosystems and the way these have evolved over time. But, no one has tried to map that into statements about services and to evaluate services to human communities. That remains to be done.”

*Marca Weinberg*

Dr. Weinberg said she agreed, but she thinks “that’s exactly the disconnect—the Heinz data, by-and-large, is national scale and so it’s *not* very helpful in informing decisions that happen at the *local* scale. . . . We do have a lot of federal policies that affect resource usage.” She concluded by saying that she believes we could benefit from “some deep thinking about how to develop models capable of informing those decisions.”

*Geoffrey Heal*

Dr. Heal responded by saying some of that is being done in the area of non-point source pollution, a major source of impacts on ecosystems.

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*Sasha Sud (Ontario Ministry of Natural Resources)*

Mr. Sud said that he is presently working on a project looking at road development and motors and how they affect ecosystem services. He stated, “Hypothetically, in trying to value the impact of developing a road and seeing the impact on ecosystem services, I’d say one of the services that we’re looking at is water purification, and you’re trying to value the impact of how much *less* water purification takes place when you develop a road over a wetland, for instance, and you disrupt the water cycle of that region. One of the ways to value it would be to see how much *less* water gets purified—put a value to it—and then value the ecosystem service based on the price of the water found in that region.” Saying that this price differs by region, he wondered what would be a good way to put a value to an ecosystem service in a situation such as this.

*Geoffrey Heal*

Dr. Heal responded that “values of ecosystem services are invariably geographically specific,” offering the comparison of the value of water in the Sahara versus the value in the Great Lakes area. . . .” He closed by saying, “If you can identify a relationship between road construction and the nature of the watershed services, I think you will have done very well. Of course, that’s not an easy thing to do at all.”

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*Avery Sen (National Oceanic and Atmospheric Administration)*

Admitting that he is not an economist but is starting to work on the economics in social sciences, Mr. Sen addressed Dr. Heal saying he enjoyed the presentation and that it seems



“the conclusion that you draw, or what you observe, is that economics is slowly being integrated into the rest of the natural sciences—physics, chemistry, and biology. As a consequence, what I see is that there are going to be inherent limits to growth. There are some people, I suppose, who won’t like the idea that there *are* limits to growth imposed by the physical world, and I’m wondering what obstacles you might see to your work” and how those obstacles might be overcome.

*Geoffrey Heal*

Dr. Heal responded, “I guess some bits of environmental economics are about the extent that we observe physical limits to growth. I think the standard economic response here is that if you price [changes focus here]—well, there are different types of growth: there’s environmentally intensive growth and there’s environmentally conservative growth. For instance, there are different ways of generating energy—there are those ways that are environmentally intensive and those that are not. Part of the problem we have at the moment is that we just don’t price environmental services right. You know, for the type of growth that we have and the general type of economic activity we have, it’s probably excessively intensive in the use of the environment and excessively intensive in the impact on the environment.”

He concluded by saying, “I don’t think that there are significant physical limits to growth that we’re about to bump up against—that is, that we *have* to bump up against and we’re *about* to bump up against—we don’t *have* to. I think the reasons that we may possibly bump up against them is not that there are real constraints on growth but that we’re simply not *steering* our growth in the right direction. . . . and we’re not getting prices right—we’re not *pricing* environmental services appropriately. . . . So, I don’t see physical limits as being a real issue. What I see [the need for] is thinking more smartly and growing more smartly, just by considering environmental constraints.”

*Avery Sen*

Mr. Sen clarified his position by saying, “I guess my question was more along the lines of what *perceptions* might be to limits to growth and what effects the perceptions may have as opposed to whether or not there will be limits.”

*Geoffrey Heal*

Dr. Heal responded: “Well, a large fraction of the population receives no benefits whatsoever from growth, as far as I can see.” [laughter] He stated that his concern was more with “getting people to start realizing that there *might* be limits to growth.”

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*Clay Ogg (U.S. EPA, National Center for Environmental Economics)*

Dr. Ogg commented, “One of the few successful T&DO’s (time and displacement optimization) of an agricultural watershed, where they actually are claiming that they reached their objectives, is in the Neuse watershed in North Carolina. They’ve basically tracked what it is that accomplished their objective and it seems to be buffers and following a nutrient recommendation, both of which would have been very relevant to the

example that you used here.” He went on to say, “The USDA, in its new Conservation Security Program, pays farmers approximately 5% of their rent in exchange for adopting a set of practices that are geared to reach a certain watershed objective or a certain set of local objectives. It’s a national program but it’s keyed in to reaching what I think we could call an ecosystem objective. What’s happening is that their people are identifying a very *small* set of changes that they ask farmers to make—very *focused*. . . . Your part of the job is very, very difficult. The choices that agriculture has in terms of practical options that they can actually carry out as part of the programs they have out there are very limited. So, I think that having the whole team together is kind of critical given the fact that, otherwise, the kinds of tasks you described here seem absolutely monumental. I think we have to ground it in terms of: Here are our choices—let’s try to figure out what are the ecosystem benefits of carrying out what we can do here.”

*Geoffrey Heal*

Dr. Heal replied, “I wasn’t aware of that North Carolina case—it sounds interesting. It all sounds pretty similar to what is being done in the Catskills watershed. They’re planning for . . . essential organic farming methods . . . and things like that. At some point it will be interesting, when we get enough data on these things, to use these as a study of what is the functional relationship between implementation measures like that and the impact on the water quality and the stream flow and things of that sort.”

*(Unidentified, U.S. Forest Service)*

Stating that the U.S. Forest Service routinely gets hit by lawsuits and challenges regarding the studies they do and the documents they produce, he said he understands very well the complexity of mapping ecological impacts or landscape impacts into ecological outputs. He continued, “One of the things from your talk that I have a bit of a quantitative issue with is that for us (the Forest Service), I don’t think it’s a question of overvaluing economic outputs versus non-economic outputs—it’s usually about jobs versus ecosystem services, and jobs in some markets constitute a non-market value if you look at it. My *main* question is: Given the complexity of some of these issues of trying to go through the whole contingent evaluation process or perhaps a cost-benefit analysis approach to decision making, there is an alternative model and that alternative model is public participation in a broader circle of choice model. It *can* incorporate ecosystem information into the social choice process. Given those two competing models, there might be ways in which they could support each other, but there also might be ways in which there apparently would be a conflict technological/technocratic models and social choice models. Have you guys looked at those issues?”

*Geoffrey Heal*

Dr. Heal answered, “No, we specifically *don’t* look at those issues in the report because the mandate of the report was to look at the economic valuation of ecosystem services for use in regulatory evaluation, cost-benefit studies, and things like that. I’m aware of what you’re saying—there are obviously two radically different alternative methods and . . .”

*The Questioner*

Interrupting, the questioner said, “Given the complexity of what you’re talking about, especially when you’re talking about project-level decision making and localizing the decision making process, what sort of implications do you think it has for the institutions?”

*Geoffrey Heal*

Dr. Heal continued, “I don’t really see them as alternatives—I see them as operating together. One of the things that studies of the type I was talking about here do is they provide data for the political discussion and the political process. If there’s a discussion about conservation of a particular wetland, and an economic study suggests this is very cost-effective or very cost-ineffective, then that study will impact the political discussion. At certain levels [of the decision making process], the economic analysis is dominant, but once you get to the very *top* of the decision making process it’s almost always a social choice political process. At that point, the economic variables are influential—it becomes hard for politicians to argue against a very convincing economic case—but they’re not determinant.”

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*Kerry Smith (North Carolina State University)*

Dr. Smith referred to Dr. Heal’s comments on “quasi options” and questioned whether there actually had been a measure of quasi options. He said he felt the raw material was there, and he cited Eric Helm’s talk from Session II, which involved a retrospective study which looked at scenarios designed to discover “what would happen *if* we did not take a particular action and what was the string of benefits that were associated with that action?” He said the reason he thinks that has the raw material to get at a quasi option value is because one has to “*pretend* that that decision would be irreversible—you can’t reverse that outcome. That’s one of the key elements—we want the *additional* speculative value of what we learn as a consequence of not taking irreversible action.” He continued by asserting that in and of itself that ability to go back and to reconstruct “what the past might have been . . . doesn’t actually help very much in thinking about *future* decisions”—it doesn’t *inform* future choices. Dr. Smith then posed the question: “Could we take the existing information that we’ve already developed in a range of situations and *design* these scenarios in such a way that we could identify . . . the attributes of the uncertainty that’s inherent in the decision process *for which we have already learned something*? Then we could go back and say, “Okay, these look to be important in that circumstance.” He closed by saying, “That would not be a valuation exercise when you’re talking to *any one person* but it *would* be a *diagnostic* evaluation of decision processes—and it seems to me that’s what you’re calling for.”

*Geoffrey Heal*

Dr. Heal responded, “Yes, that’s a very interesting point—I’d have to think about that a little bit, but that’s a very suggestive idea.” He said they’d have to go back and pry up some data from 1972-1977, but judged that that would not be impossible.

*Kerry Smith*

Dr. Smith continued, “Look at the information *base* at the time the decision was made, and then *compare* that information base with what we learned as a consequence of the activity and then design all the different *attribute* sets that would characterize the uncertainty.”

*Geoffrey Heal*

Dr. Heal responded, “You’re right, it would provide us with data on the past choice, but to me it would be interesting just to get *some sense* of the order of magnitude of these option values. One of the things I find frustrating is not knowing whether these are negligible or potentially quite significant, and I don’t actually even have an intuition on that myself. So, that type of exercise would be useful for that purpose.”

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END OF KEYNOTE Q&A