Commentary

Guide to Diplomatic Relations with Economists

During my sabbatical at NCEAS, I've been working on models for how to manage ecosystem services from an economic standpoint. In countless lunch meetings, people have asked me what it's like to work with economists, and have expressed skepticism that ecologists and economists are compatible. Although ecologists do use economic concepts in foraging theory, adaptive plant morphology, and so forth, mistrust, posturing, and a seeming absence of common ground often hinder our working together. From these recurring luncheon discussions, Jim Reichman asked me to develop an informal essay on how to approach a rapport with economists. So I offer some rules that might be used as a travel guide when visiting the land of economists.

Rule 1. Know who economists are.

Ecologists usually don't distinguish among the various types of people who talk money talk.

Developers and business executives talk about bottom lines, profits, and jobs, which sounds like economics. But just talking about dollars doesn't make one an economist. Business people typically have a background in accounting or business administration, and will have taken a few courses in economics. Business people hire economists as consultants.

Politicians also talk about growth, jobs, and prosperity, and can sound like they know some economics, too. But I was amazed to attend a dinner with economists a few years ago, and hear the dinner speaker complain that politicians never listen to economists. Politicians do the strangest things in the name of economic growth (remember voodoo economics?), and economists face a never-ending struggle to educate politicians about how the economy functions.

So, if economists are not developers and politicians, who are they? Well, they're just like you and me. They're academic or academic-like, and their favorite system happens to be the human economy rather than the tundra, the Everglades, or the rocky intertidal zone. Their system consists of two kinds of components, firms and households, which dynamically interact.

Although economists study systems like we do, there is one big difference. Economists like to tinker with their system. Our tradition is to see how a pristine ecological system works, and then maybe later consider modifying it. Economists though, want to control the economy. How the economy works is called descriptive economics, and how to manage the economy is called normative economics. Although somewhat interested in descriptive economics, economists become truly excited when devising policies to manage the economy.

Distinguishing among economists, developers, and politicians reminds us that a rapprochement between ecology and economics is only part of an overall program of environmental action. Financial clout and political acumen come in handy too.

Economists are reciprocally unaware of distinctions among members of the environmental community. They don't distinguish between ecologists as scientists and environmentalists as advocates. They think ecology is a social and spiritual movement, not a science, and are pleasantly surprised, though somewhat disbelieving, to learn that we do experiments, have mathematical models, and so forth. They think the Sierra Club and Greenpeace are our professional societies, and haven't heard of ESA. While most ecologists do support the Sierra Club and Greenpeace just as, I suppose, most economists are Republicans, there is a difference between what we do professionally and our political orientation. It helps to bring this distinction up if you encounter an economist who is afraid to talk with you for fear you might chain yourself to a nearby tree and create a scene.

Rule 2. Don't assume the moral high ground.

As ecologists, we know we're pure as the driven snow. Humanity depends on ecological systems, so we are the stewards of humanity.

Alas, economists do not genuflect before this lofty claim to moral superiority. To see why economists are not impressed, consider two nuns. Both work in a soup kitchen feeding the homeless. Both work with potatoes and onions. But one is slow at potatoes and the other tears at onions. By trading responsibilities, one nun can agree to dice the potatoes, and the other to slice the onions. More soup is then made and more homeless are fed. If Mother Superior arrives to impose a different division of labor based on her beliefs of fairness, however well-intentioned, the net result is more discomfort to the two Nuns doing the work, and an overall lower production of soup and relief of human suffering.

Thus, economists see the exchange that takes place in a market-based economic system as a way, indeed **the** way, to bring about good for people both individually and collectively. Intervening in the natural give and take of a market-based economy, regardless of how well intentioned, is thought to reduce, rather than increase, human welfare.

So, economists are not about to cede the moral high ground to ecologists just because humanity is contained in a giant ecosystem. In principle, economics deals with "ethical efficiency"—trying to achieve the most good for the most people given a "budget constraint" of either time or money. Of course, matters may not work out so ideally, but it's important to realize that the ethical starting points for both ecologists and economists are equally noble.

Rule 3. Get used to their idea of valuation.

Economic value is not the same as a dollar tag.

Economic valuation must refer somehow to an exchange—a seller with a supply and a buyer with a demand. Economic valuation does not measure quality, moral worth, or beauty, unless buyers happen to demand these characteristics.

Economists use the phrase, "consumer sovereignty" to refer to the idea that consumer preferences are a logical primitive. Economics takes no stand on what consumers should want. Hopefully, they will want good things, but establishing consumer preferences is outside of economics.

Environmental advocacy has a rightful place in an economic world—its goal is to inform the public so that their economic preferences come to support environmental values. For example, The Nature Conservancy buys land on the open market, and the general public is increasingly demanding organic produce at grocery stores.

Economic criticism of Bob Costanza and colleagues who have valued global ecosystem services illustrates the difference between economic valuation and putting a dollar tag on something. Bob Costanza's group enumerated the services supplied by the major ecosystems of the world, and concluded that the biosphere's services are worth 33 trillion dollars per year, a nice big number that is twice the human global gross national product. From these natural earnings one can, in principle, calculate the capital value of the biosphere as though it were a multinational corporation that supplies various utilities, including clean air and water. But economists complain that any capital value for the biosphere as a whole is meaningless, because no one is about to buy the whole biosphere. Indeed, economists think any finite price is too cheap. The economic value of the biosphere is infinite because life depends on it. As we chop the forests of the world down, the economic value of the remainder goes up, until the demand for the last acre becomes so great that it fetches any price, and becomes unmarketable.

From an ecological perspective, putting a large dollar tag on the world's ecosystems was a successful way to influence the preferences of politicians in favor of environmental awareness. Bob Costanza's group helped highlight the environment on the public's radar screen, as evidenced by the great media coverage they've received. Still, this illustrates how ascertaining economic value is different from putting a dollar tag on an item.

Economists view the market price of an item in language quite foreign to noneconomists. To me, price has always been an obstacle—standing between me and a bottle of Chanel No. 5. But to an economist, price is a "signal." A what? To an economist, an item's price indicates something about how many of the items there are, and how many are wanted. And price fluctuation is seen as good and natural, a reflection of the economy dynamically changing as it should.

Take nonalcoholic beer. When it first hit the grocery stores, it was heavily discounted. Then people tried it on a hot summer day, and wow, what a change from diet Coke! The demand increased, the discounts stopped, and the price rose. The high price then attracted other breweries to enter the market, and the price dropped again. Eventually the price stabilized when the supply and the demand balanced each other. Throughout it all, the actual substance of the beer never changed.

This attitude toward price as a signal can make economists reluctant to believe that environmental issues are real. If nature's goods and services are cheap, then what's the problem? If we're really running low on nature, then why aren't its goods and services more expensive? Well, if nature's goods and services are indeed cheaper than they should be, there is said to be a "market failure." And when this happens, economists have a tool kit of policy techniques, such as taxes, licenses, tradable permits, and so forth, to raise the prices up to where they should be.

Although markets may sometimes fail to value environmental goods and services properly, they don't always fail. Recently, a California town near Santa Barbara, called Carpinteria, placed taxes on new residential developments, in part to buy up open space. As land filled up, the public demand for open space increased to the point that the local government out-bid developers and purchased land to maintain as open space. The price of open space rose to a point exceeding what a developer would pay. This reflects the market correctly signaling the high preference people now place on open space. This scenario has played out in many other places, too.

Because many environmental goods and services are not traded on any market, there isn't any readily available economic value for them. What is the price of a sea otter? And if one is killed by an oil spill, what is the damage to be assessed? Economists have developed many techniques for finding the value of something that isn't actively traded. One method, called contingent valuation, relies on asking people what something is worth. How much would you pay to keep a sea otter alive? Economists worry that this technique yields inaccurate answers because people are merely responding to a hypothetical question rather than putting real money on the table. Another method, called hedonic valuation, involves tracing the item back to something that is actively traded. We know that otters eat sea urchins, and sea urchins are traded as seafood. Well, how many sea urchins per year is an otter worth? By finding the number of sea-urchin equivalents needed to support an otter, and knowing the market value of a sea urchin, one can arrive at the value of a sea otter. Also, tourists may pay to see sea otters. And so forth. All these techniques somehow connect environmental goods and services with market trading. There's a lot of active research among economists on techniques of valuation.

People from many disciplines have criticized economists over the years for relying on a market-based concept of value. For example, feminist scholars have observed that mothering can't be traded. Although one may hire a baby sitter, a child can't exchange its mother, nor a mother her child. Most of what mothering is about lies outside of economic valuation, implying that economic valuation is inherently sexist. I believe this criticism is true. But what a conversation stopper! Environmentalists, too, can easily ruin a party by noting how little the market helps with distributional equity, environmental justice, and intergenerational responsibilities, or deals with the possibility that species other than humans have existence rights too. But why bother making such a stink? There's more to life than economic value, and I feel we can leave it at that. We can achieve a lot of environmental good by working with economics as it is rather than deconstructing it.

Rule 4. Don't underestimate them.

It's tempting to suppose that the environment poses new problems that economists haven't begun to deal with. Yet this is less true than one might think.

Economics in the first half of the 1900s considered limits to growth. Land area was taken as a constraint in early agricultural economics. Economists can deal conceptually with limits to growth perfectly well. But they may not be convinced that the limits are where ecologists say they are.

Economists have long known how to fold into the price of an item all the costs of its production. A company that pollutes the environment can sell a product at an artificially low price because the public pays the cleanup. But the cost of the cleanup, called the social cost, should be fed back to the company with a special tax called a Pigovian tax. This topic is called "internalizing" an "externality" and has a long history of discussion. Economists are solidly behind making companies pay for any environmental damage that they cause. Economists are against subsidies. Economists always want the price of an item to present an accurate signal of its true supply and demand. Economists don't want the price of an item to suggest a distorted view of the demand, as occurs when a price is artificially low because a company is not paying its full costs of production.

Economists are also against subsidies that protect weak industries. Much environmental damage has been carried out by governmentally protected companies in timber, mining, and fishing. Economists are against such protectionism, not specifically because these companies have damaged the environment, but because the companies are inefficient and make the public pay more for their products than they would if free international trade were allowed. Paying an inflated price for a product from a protected industry steals money that could be used for other purposes and thereby inhibits overall economic growth. The protections and subsidies that weak industries receive exemplify laws passed by politicians in the name of jobs and the economy that are opposed by economists. From our perspective, weak industries are likely to be poor stewards of the environment, and we find ourselves on the same side as economists, although for somewhat different reasons.

Indeed, economists are ideologically against anything that limits consumer freedom of choice. We little people often feel manipulated by large multinational corporations. But with freedom of choice, an environmentally aware public was recently able to boycott Shell Oil in Europe, forcing them to change their environmental policies. In fact, economists have pioneered antitrust regulations that provide consumer choice, even though big business usually tries to control the markets through monopoly, as illustrated recently by Microsoft.

Dealing with ecology does pose some new challenges for economics, but it is polite to know which these are. It is rude to assume that economists haven't considered the environment at all. In fact, they are often on our side, so let's keep them there.

Rule 5. Explain how ecology promotes economic growth.

If you've gotten this far talking with an economist, you're probably friends by now and may even be invited home for dinner. To start the dinner conversation, you might say offhandedly that ecology promotes economic growth. "Oh really?" your host is bound to ask, "Please tell me how." That's your entree to explaining how ecosystem services relate to human welfare.

During the Christmas season in Santa Barbara, California, colored lights decorate offshore oil-drilling platforms. Fish congregate around the platforms, which are called "artificial reefs." The fish collectively provide two "ecosystem services." One is revenue from divers who travel to the oil platforms and nearby natural underwater out-croppings to watch fish and other marine wildlife. The fish are also harvested and sold as seafood, which is another ecosystem service. Both of these services have their own industrial trade groups to lobby on their behalf. Coastal zoning authorities and fishery regulators must decide how large to make the no-take zone, including oil platforms, within which no fish can be caught, and how many fish can be caught outside the no-take zone. This is a real problem that is receiving ongoing coverage in the local news media.

Can ecologists contribute to resolving this problem, and if so, how and in what form? Well, we could side with the divers, wave the banner of conservation, and advocate as large a no-take zone as politically feasible. This is what we would typically do; indeed, we wouldn't know what else to do. But there is another way.

We could use our knowledge of the ecology of fish to develop a model for how the combined revenue from both services depends on the area of the no-take zone and on the size of the harvest allowed outside of this zone. We could then find the combination of area and size of harvest that returns the most combined revenue. This could be our recommendation, as ecologists, for how best to promote economic growth in the Santa Barbara coastal area. The recommendation would be advisory only. Political give and take would determine the final outcome, but our recommendation might help to achieve a better outcome than otherwise. This path offers us a way to make ecological information relevant to improving human welfare without requiring that we take an advocacy position with one of the stakeholders.

I feel that combining ecological and economic theory to manage ecosystem services provides a new vision of how ecologists can interact with the public.

But by now, the dinner will nearly be over, and it would be diplomatic to change the topic of conversation before dessert.

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Biodiversity and Ecosystem Function: Alternate Hypotheses or a Single Theory?

Abstract. Here we present a theory that unites existing theories describing the relationship between biodiversity and ecosystem function. All reported findings can be described using a redundant species model, the exact nature of the relationship in each system depending on the scale of biodiversity being examined. Instead of further debating the exact nature of the relationship between biodiversity and ecosystem function, it would be more useful to examine many different systems in order to discern the ecosystem-level consequences of species loss.

Key words: biodiversity; diversity–stability hypothesis; ecosystem function; redundant species hypothesis; rivet hypothesis; scale effect.

Ecological research has been preoccupied with the topic of biodiversity for the better part of a decade, inspired by evidence of massive species extinctions in the last century. In particular, research has linked species richness with ecosystem functioning (Naeem et al. 1994, Tilman and Downing 1994, Tilman et al. 1996, Naeem and Li 1997, van der Heijden et al. 1998, Hector et al. 1999). Most recently, the debate has centered on whether the observed relationship between biodiversity and ecosystem function is, in fact, the result of species richness, rather than an artifact of experimental design (Huston 1997, Wardle 1999).

Regardless of mechanism, it is generally accepted that biodiversity is an important factor controlling ecosystem functioning. Four hypotheses have been proposed, describing the relationship between biodiversity and the rate of ecosystem processes (reviewed in Johnson et al. 1996).

1) The "diversity–stability" hypothesis predicts a linear relationship (Elton 1958). Here, the rate of ecosystem processes is maximum with the greatest number of species.

2) The "rivet" hypothesis predicts a positive, nonlinear relationship (Ehrlich and Ehrlich 1981). In this definition, ecosystems are equipped with more than the minimum required species richness.

3) The "redundant species" hypothesis predicts a positive, asymptotic relationship (Walker 1992). It stipulates that a loss of species richness is of little consequence to ecosystem functioning, because functional groups comprise many different species.

4) The "idiosyncratic" hypothesis predicts no relationship (Lawton 1994). This most recent hypothesis is effectively a null hypothesis. That is, the contribution of species to function is unpredictable, since both the identity and order of deletion will affect function differentially.

It is unclear which of these hypotheses best describes the relationship between biodiversity and ecosystem functioning. The relationship lacks clear empirical evidence, probably due to the difficulty in resolving the role of functional group richness vs. species richness. Nonetheless, what few species manipulation experiments exist have shown the relationship as positive and asymptotic (redundant species) (Tilman and Downing 1994, Tilman et al. 1996, van der Heijden et al. 1998), or positive and linear (diversity/stability) (Naeem et al. 1994, Naeem and Li 1997, Hector et al. 1999). In the only theoretical examination, Tilman et al. (1997) predicted a positive, asymptotic relationship between diversity and function in a modelled system.

Rather than debate which hypothesis represents the true relationship, we suggest that the alternate relationships are instead aspects of a single relationship. We use a hypothetical asymptotic relationship (Fig. 1a) to demonstrate this. In this example, 0–20 species are manipulated, and as a

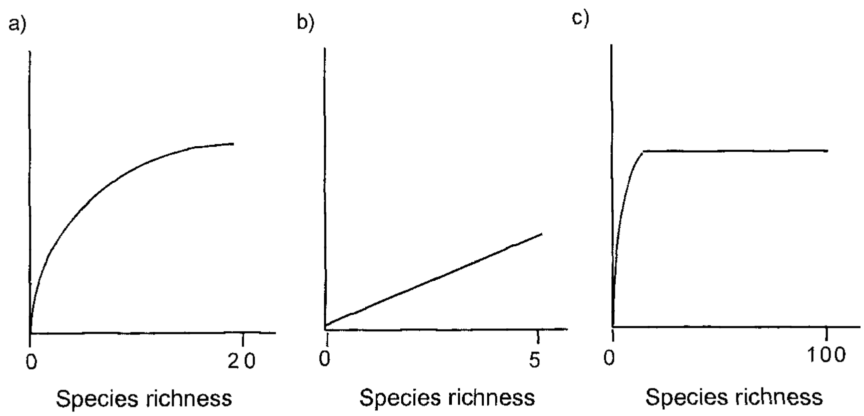

Fig. 1. Proposed relationship between species richness and an ecosystem function at three different scales of species richness. (a) "Rivet" hypothesis; (b) "Diversity-stability" hypothesis; (c) "Redundant species" hypothesis.

result, productivity increases asymptotically, reaching a threshold at about 20 species. In this case, loss of a few species might not greatly impact productivity, but further losses might seriously limit productivity. This best supports the rivet hypothesis. If the same experiment were performed with only 0–5 species (Fig. 1b), the relationship would be positive and linear, supporting the diversity–stability hypothesis. If 0–100 species were used (Fig. 1c), the relationship would quickly reach an asymptote, supporting the redundant species hypothesis.

This hypothetical example suggests that the support of any single hypothesis may be due to the extent of species richness. That is, the observed relationship between diversity and ecosystem function may depend on the physical and biological constraints of the experiment, and the shape of the curve may be determined by the scale of the species richness axis. Thus, support for one hypothesis does not eliminate the existence of the others, making the concepts nonoperational (Peters 1991).

It is important to note that the effect of scale has previously been the subject of debate in ecological studies (Moore and Keddy 1989, Reich 1993). It is unlikely that there is an "optimal" scale of species richness with maximum predictive powers for ecosystem function. Rather, systems will show unique variations throughout different ranges, ecosystem types, and species richness.

Instead of attempting to support one of the hypotheses, we should instead characterize the relationship between diversity and ecosystem function for different ecosystems. There are more interesting questions. What determines the position of the species threshold? What factors determine the slope of the initial incline? What is the maximum possible rate of a particular ecosystem process? It is likely that the maximum rate of an ecosystem process is predetermined by abiotic constraints. Thus, the "redundancy" threshold would then depend on several things. First, the presence of "super" functioning species would determine at which species richness maximum functioning is achieved. Further, synergistic relationships between species, whereby functioning increases more than the additive effects of each species individually, may affect the redundancy threshold. Finally, mutualisms may also determine the redundancy threshold by increasing functioning of species. Recently, Klironomos et al. (2000) showed that the presence of arbuscular mycorrhizal fungi (AMF) increased the initial slope in the relationship between plant diversity and productivity. In this example, treatments with AMF reached a threshold in productivity more quickly than non-AMF treatments. Also, the species composition of AMF influenced the maximum plant biomass achieved: one species of AMF reached a plateau at half the plant biomass of another AMF species. They suggested that the difference could be explained by differences in the carbon cost for plants maintaining symbioses with different fungi. In this example, both the initial slope and the species threshold depended on factors that influenced how plants contributed to function (productivity). This suggests that the maximum rate of ecosystem function may depend on both total amount of resources available, and also the ability of the species to access those resources in other systems, but this remains to be tested.

Instead of defining the "authentic" relationship between biodiversity and ecosystem function, researchers should focus on much-needed empirical studies in many different systems. Existing theories describing the relationship between biodiversity and ecosystem function may, in fact, describe aspects of the same generalized theory, as we have suggested. However, variation among communities may limit the accuracy of predictions based on a generalized theory. In practice, information from different systems may prove more valuable for predicting the effects of species loss on ecosystem functioning.

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Public Access and Use of Electronically Archived Data: Ethical Considerations

Ecologists today are increasingly expected to electronically archive their data sets and make them publicly accessible. For example, NSF now requires that LTER sites have major data sets documented and available on-line within a reasonable time of collection. This is generally interpreted as 3–5 years, a lag designed to allow those who collected data a reasonable period in which to publish results. The expectation that data will be archived and shared may well spread to all NSF-sponsored research. Indeed, NSF's Grant General Conditions state that NSF "expects investigators to share with other researchers, at no more than incremental cost and within a reasonable time, the data, samples, physical collections and other supporting materials created or gathered in the course of the work."

Although some ecologists have made their data available following publication, making data available before they are published, or possibly even before they are analyzed, makes many ecologists uneasy and raises some ethical issues. Although fears of being scooped or contradicted by one's own data may be unwarranted, such fears could promote hiding or poor documentation of data, or hasty and premature publication, therefore undermining progress in the field. In addition, unpublished data, particularly unanalyzed data, often contain data entry and other errors, errors that are usually discovered during analysis by those who collected them. Public access to such data could result in erroneous conclusions by others if those who collected the data were not consulted.

We believe that making more data accessible to more ecologists has the potential for greatly increasing communication, collaboration, and synthesis within the ecological community. However, for the latter to occur, it is imperative that the ecological community develop, and individual members abide by, a set of ethical guidelines that promotes data sharing, collaboration, and scientific advances, while at the same time acknowledging and respecting those individuals whose time, energy, and intellectual efforts produced the data. Currently, no ethical code of conduct exists within the ecological community governing the access and use of archived data. Thus, we strongly encourage ESA to develop such a code, by which all members of the ecological community would be expected to abide. Ideally such a code would be developed collaboratively with the ecological societies of other countries, since the ecological community is global, and electronically archived data can be accessed from anywhere in the world.

Currently, ESA has a general code of ethics <http://esa.sdsc.edu/codeofethics.htm>. This code lists several principles of conduct that are relevant to the issues we have raised concerning the electronic archiving of data. These include:

- Researchers will not submit for publication any manuscript containing data they are not authorized to use.

• ESA assumes that the principal investigator(s) of a research project retain the right to control use of resulting unpublished data, unless otherwise specified by contract or explicit agreement.

We believe ESA needs to clarify whether these principles are also intended to apply to the use of electronically archived data. Specifically, we believe that ESA needs to address the issue of electronically archived data in its code of ethics and/or develop a code specifically addressing this topic. In order to encourage the development of such a code (whether a supplement to the current code of ethics or a separate code), we offer the following working draft that ESA could use as a starting point for such an effort.

A Proposed Code of Ethics for Access and Utilization of Archived Data

Science is a community enterprise that prospers most when there is open dissemination of ideas and data. Thus, The Ecological Society of America supports the archiving and public accessibility of ecological data and urges all ecologists to make their data accessible in this way. It is expected that raw and summary data will be made available promptly following any publication of the data. In addition, all summary and raw data, published or not, normally should be made publicly accessible no more than 5 years following their collection or determination. Should further delay be necessary, reasons for this delay must be publicly provided, along with an expectation of the release date. It is expected that those who gathered the data will document the archived data sets sufficiently to permit their use and interpretation by others. Furthermore, all individuals who access and use data gathered by others are ethically obliged to respect and acknowledge the time, energy, and intellectual effort expended by those who produced the data. Any individual who analyzes or presents archived data, or any portion of the data, in any form or fashion, is required to have contacted those who produced the data and to have thoroughly discussed with them issues of data quality, interpretation, acknowledgment, recognition, and authorship before any dissemination of ideas, results, or conclusions based on the data occurs.

If such a code of conduct were to exist, then individuals and research teams archiving data sets could post a copy of the code to their archive web site reminding users of their ethical obligations. Authors of manuscripts submitted to ESA journals, and authors of posters or oral presentations at ESA-sponsored events, could be required to indicate whether any archived data sets other than those of the author(s) were used in the papers or presentations. If so, the authors could be required to provide the names of those individuals whose data sets were used and to indicate how they had resolved issues of data interpretation, acknowledgment, recognition, and authorship. This could be accomplished via a standardized form provided all authors by the editors or ESA. Should questions remain, editors and meeting organizers could then contact the individual(s) whose archived data sets were being used to obtain additional information and perspective. Although ESA could require such information only for its own journals and meetings, it would be expected that ESA members would abide by the ethical code of conduct no matter where or in what form any dissemination of ideas, results, or conclusions based on another's archived data occurs.

We believe that such a code of ethics would provide the assurances that both data gatherers and data users need to make data sharing a win–win situation. By providing leadership in developing and implementing such a code, ESA could help the ecological community adapt to, and benefit from, the newly emerging culture of open data sharing.

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Managed Ecosystems Deserve Greater Attention

The current debate regarding the relationships between declining biodiversity and ecosystem processes as they relate to aspects of the Earth's support system has garnered much recent attention throughout the scientific community and in the general media (Naeem et al. 1999, Huston et al. 2000, Kaiser 2000). Inconsistent results from a variety of experiments highlight the complexity of interactions among species and their environment. This is particularly true in natural ecosystems. We suggest that understanding the relationships between species diversity and functioning will benefit from greater attention to managed ecosystems. We also suggest that more ecological research in managed ecosystems is necessary for both the conservation of biodiversity and the sustained production of goods and services that we depend upon.

Within the ecological and conservation communities, managed ecosystems have repeatedly suffered from an inaccurate characterization as the root of ecosystem degradation through declining biodiversity. This has led many ecologists and conservation biologists to ignore managed ecosystems in the study of biodiversity and ecosystem processes, and to reject managed environments as conservation priorities because they have been modified by human intervention, and thus are no longer "natural." Certainly, poor management, or lack of management, can lead to ecosystem degradation, which may or may not be caused by a change or loss of species. A more accurate characterization of managed ecosystems is as replicated experiments in the manipulation of biodiversity to achieve specific functional goals. These real-life experiments offer great scientific potential to the ecological community, and in return ecologists can more directly contribute to the achievement of sustainable land use and conservation of biodiversity.

One of the reasons that many ecologists shun managed ecosystems results from a misunderstanding of what management entails. It has been argued that humans have impacted the entire planet, and thus no area is truly wild (Janzen 1995). But not all landscapes impacted by humans are managed. Managed ecosystems require human inputs to maintain a desired function. Often, ecosystem management is a prescription for manipulating biodiversity to assure particular functions that are vital for people and the human environments that support civilization. Ideally, managed ecosystems are under the care of professionals who follow management plans based on science. Managing ecosystems requires application of knowledge from social, biological, and physical sciences (Johnson et al. 1999, Sexton et al. 1999, Szaro et al. 1999). Food and fiber production, water quality assurance, flood control, rehabilitation of damaged lands, and buffering of human activity are but a few examples of situations that require properly managed ecosystems.

Many manipulations of ecosystems fail, usually because of insufficient understanding and/or poor applications. This is where ecologists can make important contributions to the conservation of biodiversity in managed landscapes, and to the ultimate sustainability of management activities. Sustainability of management activities benefits society and indirectly contributes to biodiversity conservation by decreasing the need to exploit new lands. Collaboration between managers and scientists to apply the principles of adaptive management (Bormann et al. 1994) is likely to help achieve these goals. Management failures should not to be confused with ecosystem exploitation, conversion, or misuse. There are many examples of polluted, over-exploited, or converted ecosystems that have not been managed.

A challenge to our civilization is to conserve biodiversity while maintaining humans on Earth. To do so, we must manage ecosystems to derive products and services that are vital to our well being. While management often requires the manipulation of biotic communities, it is counterproductive to assume a priori that managed ecosystems are detrimental to the conservation of biodiversity. Pimentel et al. (1992) estimated that a significant fraction of the world's biodiversity resides in managed landscapes. They suggested that a large part of the success or failure to conserve biodiversity depends upon how we deal with species in managed ecosystems.

Demographic and economic trends require more, rather than less, human control of biodiversity. Ecologically engineered ecosystems will become increasingly important in the future as the need for higher yields and environmental quality force us to apply science for the purposeful design of new ecosystems. This will require greater understanding of how ecosystems—managed or natural—function. We can improve understanding of ecosystems by testing our ability to use ecological knowledge to manipulate and manage biodiversity for the control of ecosystem functions to meet specific human needs (Ewel 1987). Better communication and increased collaboration between those land management professionals and ecologists will accelerate the rate of knowledge acquisition and improve the effectiveness of ecosystem management for both the conservation of biodiversity and the production of goods and services.

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A History of the Ecological Sciences: Early Greek Origins

Editor's Note: Frank Egerton, a well-known science historian, has been working on a history of ecology for some time. He has agreed to provide the history to the ESA Bulletin, *in readable-sized units, as he finishes them. This installment is the first of several.* —A. M. Solomon

Introduction

Ecology is the most comprehensive and diverse of the sciences. Its scope is enormous, and it may be the most important science for managing the earth as an abode for humanity and for what is left of our natural environment. Yet ecology is also one of the youngest sciences, and its history is not well known. Histories of ecology already published attempt to describe the origins and development of some basic ecological concepts. That was a sensible way to begin, but it is time to move on to a more comprehensive history.

In doing so, we must recognize organizational realities. On the one hand, ecology is organized around certain concepts and perspectives. On the other hand, because it is such a diverse science, most ecologists think of themselves as belonging to a more narrow specialty, such as marine ecology, limnology, plant ecology, or animal ecology. They write textbooks for these specialties and teach courses in them. Many of these specialized fields arose before the umbrella science of ecology did, and members of some of these specialized sciences prefer to maintain their separate identities. Parasitologists and bacteriologists would perhaps find it presumptuous for anyone to place them under the ecology rubric. Nevertheless, the history of these subjects is still part of the history of ecology in a way that is not true of the history of physical sciences, however essential these latter are as foundations for ecology. Advances in physical sciences must still be noticed as they become relevant.

Observations and interpretations of ecological interactions extend back to the origins of science, but the term "oecologie" was not coined until 1866, and steps to organize the science were not taken until the 1890s. So where should we begin the history? If the ancient writings that now seem relevant had been forgotten and the science had been built only upon observations and interpretations made during the 1800s, it would be unnecessary to look back in history before 1800. However, the balance of nature concept was the earliest ecological notion, and it remained a fundamental ecological idea until recent times, even though reinterpreted in different ages. The problem was that ecological ideas got more or less lost within the framework of a broader science called natural history. Natural history included not only ecology but also botany, zoology, and geology. The other sciences (physics, chemistry, and astronomy were included in many of its components) were taken from natural history, but it has also drawn upon the already organized ecological sciences of biogeography, evolutionary biology, parasitology, bacteriology, virology, entomology, plant physiology, and so on. In this situation, it is appropriate to entitle this book *A History of Ecological Sciences* rather than *A History of Ecology*.

Science is a product of critical thinking, and some early Greek critical thinking included ideas that we consider ecological. The transition from mythopoeic to critical thinking was gradual; someone could have a mix of mythic and critical thoughts. Thales (c. 460–c. 547 BC) believed that all things come from water, which thought seems to have both mythic and critical aspects. Miletos was on the Aegean coast, beside the Menander River; water was the only substance known to the Greeks in solid, liquid, and gaseous forms. He also believed that all things have souls, which is a mythic idea. If Thales were a lonely voice, he would now seem quaint. But he initiated critical thinking, which means that Anaximander (c. 610–c. 545 BC) and others were interested in the cogency of his arguments (which mostly do not survive), and they were not intimidated by his wealth and prominence. Thales focused on substance as a way to explain change. If water can change into both ice and air (*pneuma*), then perhaps under some circumstances it changes into a tree (apply water to a planted seed) or a rock. Anaximander, a younger contemporary, disagreed. He thought water was only one of several pairs of "opposites." In contrast to Thales, he focused on process. He imagined that life came from the sea and that humans evolved from some species that matured more rapidly than we do.

Anaximenes (flourished c. 545 BC) pondered the ideas of his predecessors and concluded that water could not be the most basic thing in nature because one cannot get fire from water. He decided that *pneuma* is basic, because one can rarefy it by blowing on combustible material and coax a flame, but also *pneuma* condenses into rain, and water can condense (or expand) into ice, and so on. What we see in this small sample of the earliest natural philosophers is a progression in thought by "conjecture and refutation." The philosopher of science Karl Popper studied the ideas of early natural philosophers and concluded that this is the way science should progress. Popper said that scientists do not actually prove their conjectures, but that a conjecture can persist until refuted.

However, the intellectual ferment that Popper found at work among some early natural philosophers did not prevail among all. Soon after the Milesian philosophers began their debates, Pythagoras (c. 560–480 BC) began teaching a natural philosophy that focused on quantities and patterns rather than on substance and process. He believed that there are numerical harmonies in nature, and that mathematics is the key to finding them. When chemists assert that water is made of two parts hydrogen and one part oxygen, they are vindicating the faith of Pythagoras and his followers. Chemical formulas are whole-number ratios, and these philosophers believed that all of nature could be expressed in such ratios. When chemists speak in terms of whole-number ratios, they are talking about elements; but when the Pythagoreans did, they had only numbers in mind. That was reasonable in astronomy and music—sciences that particularly interested them. Astronomical bodies could be thought of as mathematical points, and musical harmony does not seem tangible. However, neither in mathematics nor in real-world measurements do quantities always appear as whole numbers. There is a story told about the Pythagoreans that may not be true, but it seems to capture their bias. Someone measured the diagonal of a square having sides of one and discovered what ever since have been called "irrational numbers." The story is that they all agreed to keep secret this discovery, but someone told the outside world and was then expelled from their commune.

The idea of scientific proof undoubtedly comes from Pythagoras' idea of mathematical proof. According to tradition, Pythagoras developed the proof of the geometrical theorem that, in a right triangle, the two sides squared is equal to the hypotenuse squared. In some sense, Pythagoreans may also have "proven" that musical harmony is achieved when harp strings are in whole-number ratios of length, but in other aspects of science, they depended on faith, not proof.

Pythagoras began teaching on his native island of Samos, but later took his followers to Crotona, on Italy's southern coast. They recruited a local scholar, Alcmaeon (born c. 535 BC), who applied the Pythagorean notion of harmony in nature to medical thought. Alcmaeon had the idea that there are body "forces" (hot and cold, sweet and bitter, and so on) that are in a proper "balance" with each other when one is healthy, and that illness occurs when these forces fall out of balance. After 500 BC, Greek physicians began to synthesize this idea, known later as the balance of "humours," with Egyptian empirical surgery and medicine, to create classical Greek medicine. Greek medicine then became part rational—the balance of humours—and part empirical. The way in which the rational ideas and empirical medicine came together is illustrated by physicians' concern that people live in healthy environments, eat healthy diets, and get an adequate amount of exercise. Physicians learned that living near marshes caused fevers (malaria) in summer, and that people get colds mainly in the winter.

There are more than 50 brief medical works written around 350–250 BC from a rational and/or empirical perspective. These writings are known as the *Hippocratic Corpus*, because they were later attributed to Hippocrates (460–c. 370 BC), a respected physician who might have written one or more of them. *Airs, Waters, and Places* had an ecological goal of correlating diseases in a community with changing weather conditions (paragraphs 1–11). The author also attempted to identify environmental factors that determine racial characteristics (paragraphs 12–20). Greek physicians used the stars to keep track of the seasons, but they did not consider the stars as environmental influences. Although they knew three kinds of parasitic worms found in human intestines, this knowledge did not lead to a theory of germs and contagion, and without such a theory, an environment vs. health research program could achieve little. Furthermore, there was no institutional support for medical research of this kind. Nevertheless, the *Hippocratic Corpus* represents a significant advance over the writings of early natural philosophers, because the latter only reasoned from commonplace evidence. They did not, therefore, bother to describe evidence in any detail (as far as we know). In medicine, however, physicians needed more details than commonplace knowledge, and thus the *Corpus* as a whole (but not individual treatises) meets a loose definition of science: it provides observational evidence, interprets the evidence, and draws conclusions based on the evidence.

Natural philosophy influenced not only Greek medicine, but also Greek history. Herodotos (died c. 425 BC) is called the father of history because, like Homer's *Iliad,* his *History* gives both a Greek and a foreign perspective. For Herodotos, the foreign perspective included especially Persian recollections of the Greco–Persian Wars. Herodotos was not a natural philosopher, and his *History* is a mixture of old and new thinking. He was a traveler, visiting Egypt, Phoenician ports, and other places in the eastern Mediterranean, Black, and Aegean Seas. His interest in plants was substantial, though mostly practical, and included reports on pollination of date palms and the fig trees. His reports on animals included the natural history of wild species and some accounts are ecologically significant. His discussions of geography are also sometimes ecologically relevant.

Herodotos spent about 4 months in Egypt, which fascinated him. Egyptian experience with rivers was virtually limited to the Nile, which they viewed as a gift from the gods. Their concern for it was religious, not scientific. The Greeks, however, were familiar with a number of rivers, and the Nile was the only one they knew that flooded in summer instead of spring. Other Greeks had speculated about the cause, and Herodotos attempted to find the most plausible natural explanation. He found the evidence for north-blowing winds as the cause of the flooding to be very weak, although his own speculation—a change in the pathway of the sun from summer to winter—was no better (II, 24-25). The Nile crocodile was conspicuous and dangerous, and therefore of great interest. It was the largest creature known to him that began as a small egg. (An elephant is fairly large at birth, and mammalian eggs were unknown.) He reported that when crocodiles come ashore, they open their mouths and allow sandpipers (Egyptian Spur-winged Plovers, *Hoplopterus armatus*) to eat leeches from inside, without ever harming the birds in appreciation for this service (II, 68). Such a relationship (if true) is what ecologists now call mutualism, and this was the earliest report for what we now call the balance of nature concept.

Perhaps Herodotos never got to Arabia, but he came close enough to collect Arabian evidence for his balance of nature concept (III, 108-109):

> *The wisdom of divine Providence. . . has made all creatures prolific that are timid and fit to eat, that they be not diminished from off the earth by being eaten up, whereas but few young are born to creatures cruel and baneful. The hare is so prolific, for that it is the prey of every beast and bird and man; alone of all creatures it conceives in pregnancy; some of the unborn young are hairy, some still naked, some are still forming in the womb while others are just conceived. But whereas this is so with the hare, the lioness, a very strong and bold beast, bears offspring but once in her life, and then but one cub; for the uterus comes out with the cub in the act of birth. This is the reason of it: when the cub first begins to stir in the mother, its claws, much sharper than those of any other creature, tear the uterus, and as it grows, much more does it scratch and tear, so that when the hour of birth is near seldom is any of the uterus left whole.*
>
> *It is so too with vipers and the winged serpents of Arabia: were they born in the natural manner of serpents no life were possible for men; but as it is, when they pair, and the male is in the very act of generation, the female seizes him by the neck, nor lets go her grip till she has bitten the neck through. Thus the male dies; but the female is punished for his death; the young avenge their father, and gnaw at their mother while they are yet within her; nor are they dropped from her till they have eaten their way through her womb. Other snakes, that do no harm to men, lay eggs and hatch out a vast number of young. The Arabian winged serpents do indeed seem to be many; but it is because (whereas there are vipers in every land) these are all in Arabia and are nowhere else found. (Godley translation)*

Although there is superfetation in hares, most of this account is incorrect; the winged serpents cannot be identified. If Herodotos had applied quantitative reasoning to his account of lions, he would have found that the situation he describes would lead to rapid extinction. Nevertheless, the differential reproductive capabilities of predators and prey became a permanent part of balance of nature concepts.

Herodotus was a free spirit, but most Greeks felt strongly bound to their city state. The Greco-Persian Wars were at a time when the Greek states had united and achieved a glorious victory. Fifty years later, however, these states polarized into opposing alliances and fought the destructive Peloponnesian War. Thucydides (c. 460–c. 400 BC) was a general for Athens who arrived at a besieged city too late to save it from the Spartans, and for that he was exiled. While living in exile, he collected information from participants on both sides of the conflict and wrote his *History of the Peloponnesian War*, which is more critical and sophisticated than Herodotos' *History*. One famous episode that he described was the plague of Athens. Although Greece endured malaria and other diseases, it never had an epidemic until the Spartans invaded Attica in 430 BC. Pericles' strategy was to let the Spartans ravage the countryside while he kept the people safely within the walls of Athens. However, with so many people crowded together, an epidemic erupted. Thucydides' account of it is so detailed that some historians speculate that he may have gained insights from reading contemporary medical writings, even though none of these dealt with epidemics. If one wonders why physicians did not also leave accounts of it, he provides a clue: the ones who were there to treat the sick also died from the epidemic. He said that it spread from Ethiopia or Egypt, it was contagious to both people and animals, and he gave detailed descriptions of its symptoms from early appearance to death, with few survivors. (There has been much discussion by historians of medicine on what the disease was, but with no consensus.) In 429 it killed Pericles, which was a major blow to the Athenian cause.

Athens finally surrendered in 404. Recriminations followed, but peace returned. Plato (427–348/47 BC) founded the Academy in Athens around 385 BC. He used the dialectical method of his teacher, Socrates, to organize his *Dialogues*, the most widely read work in the history of philosophy. Plato was strongly influenced also by Pythagorean mathematics, and the conviction that numerical patterns provide a key to understanding nature. Although a few mathematicians and astronomers were associated with the Academy, it more closely resembled a sectarian college than a modern university. When one left the Academy, one was prepared to be a member of the ruling class, which meant that one could answer any questions raised by the lower class. In *Republic*, Plato developed an elaborate metaphor of the cave (VII, 514–517), the purpose of which was to discredit sensory observations. If one understands that collecting data is pointless, then one can gain an understanding of the world and society in the only reliable ways left open, mathematics and dialectics. This is where myth comes in; one discusses the possibilities and then develops a scientific myth that is as close to an understanding of nature as one can get. Popper claims (p. 38) that, "historically speaking all—or nearly all—scientific theories originate from myths, and that a myth may contain important anticipations of a scientific theory." Let us test Plato's myths against this claim. He tells us two different creation myths in different dialogues. They need not be seen as contradictory, however, since the one told in *Protagoras* can be seen as providing details about one aspect of the myth told in *Timaeus*. Timaeus, the scholar for whom the dialogue was named, asserts (30b-c) that "this Cosmos has verily come into existence as a Living Creature endowed with soul and reason owing to the providence of God." He then asks a rhetorical question: "In the semblance of which of the living Creatures did the Constructor of the Cosmos construct it?" To us, this is a loaded question (since we do not believe that it is in the likeness of any animal), but at the Academy, it seemed plausible. A sampling of Timaeus's reasoning can help us to understand the thinking involved: "We shall not deign to accept any of those [answers] which belong by nature to the category of 'parts'; for nothing that resembles the imperfect would ever become fair." Therefore, God "constructed it as a Living Creature, one and visible, containing within itself all the living creatures which are by nature akin to itself," (30d, Bury translation).

This mythic answer may sound irrational today, but it became the source of two related concepts: the superorganismic balance-of-nature concept and the microcosm–macrocosm concept. The first concept asserts that living beings are actually organs of a super "being" which is nature, and the second asserts that the parts of the human body correspond to different parts of the universe. This, of course, was metaphysics, not science.

Protagoras of Abdera was a sophist who presumably did not take myths seriously; Plato nevertheless has him tell a creation myth in the dialogue named for him: the god Epimetheos designed all the species of animals (320d-321b): "he attached strength without speed to some, while the weaker he equipped with speed; and some he armed, while devising for others, along with an unarmed condition, some different faculty for preservation." (Lamb translation) The main point of the myth was that when Epimetheos finished, he had forgotten to leave any physical advantages for humans, and his brother, Prometheos, had to step in and give intelligence to humans. We notice that Epimetheos' creations are mythic generalizations of Herodotos's balance of nature concept, which he described using particular species as examples. Both Herodotos and Plato contributed to what we might call providential ecology: God created permanent species with traits that mesh in such a way that no species ever becomes extinct.

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The Ins and Outs of the ESA Annual Meeting: Eight Things You May Not Have Known

For nearly 5 years, I have been a consultant working with the Ecological Society of America, planning, organizing and running the Society's meetings. With an undergraduate degree in ecological science, and 25 years of fund-raising and meeting-planning experience, I have the requisite background for the job. But nothing could really prepare me for the overwhelming decency of ESA members and the downright Byzantine complexity of an Annual Meeting which, every summer, attracts between 2,600 and 3,100 attendees, costs the Society over $450,000, and generates 2,200 to 2,500 scientific abstracts. After 85 years of ESA Annual Meetings, there is a wealth of history to honor, while at the same time striving to understand the needs of a new generation of members living in a cyber-age. It's a great job! As ESA's point person, I have heard a fair share of complaining and I have also gotten plenty of pats on the back. The Society's Annual Meeting, however, is a real team effort, a working partnership between volunteers and headquarters and Ithaca-based staff, local convention and visitors bureaus, sales representatives, vendors, and sometimes even local elected officials. It generally all takes place behind the scenes. All the activity is focused on making certain that the Society's Annual Meeting represents the best we can provide, and that attendees have a productive, professionally enriching, and personally satisfying meeting experience.

The questions for this article were inspired by conversations with members, and by the Annual Meeting evaluations I have reviewed.

1) How do ESA meeting locations get selected?

In order to guarantee that ESA has sufficient meeting room space, favorable hotel rates, and dormitory housing, any group as large as ours has to start between 7 and 10 years before the meeting actually takes place. This has not always been the case, but as the ESA meeting has grown in size from 1,100 people less than 10 years ago to more than double that number today, the Society has had to get more proactive.

The process starts by looking at the location of previous meetings and reviewing places we haven't been, or places where we have been that were popular with attendees. We look for geographic balance between east and west, north and south, and we keep tabs on locations constructing or opening up state-of-the art convention facilities in second-tier (smaller) cities. ESA headquarters maintains a library of background information and contacts. In addition to a good central location with sufficient meeting rooms and a range of affordable midrange and economy lodging—preferably within walking distance—important criteria in our review process include ease of airline and driving access for travelers, a location's "Green" consciousness, plenty of nearby eateries and microbreweries, a pleasantly relaxed and casual environment, and the potential for exciting, varied field trips.

The Future Meetings Committee, one of ESA's volunteer standing committees, also has a primary role in this process. For the past 9 years, Emory University professor Donald Shure, who has attended more than 30 consecutive years of ESA Annual Meetings, served very ably as the chair of the Future Meetings Committee. Don stepped down as Chair this August.

The Nature Conservancy's Steve Chaplin, long-time Future Meetings Committee member, has accepted the Governing Board's invitation to serve as Committee Chair for a 3-year term. At Steve's request, ESA Headquarters is conducting preliminary research on several potential sites for the Society's next open meeting date, the 2005 Annual Meeting, as well as Annual Meetings for 2007 through 2010.

Once information about each of these destinations' convention centers, hotels, dormitory rooms, transportation, features, and rates has been reviewed, Steve and I will schedule a site visit to the most promising locations. The Future Meetings Committee will review our reports on these locations, make comments, express concerns, and then the ESA Governing Board will receive a recommendation on which to act. ESA Executive Director Katherine McCarter generally also visits preferred locations. The selection process can take as long as three years before ESA signs contracts.

Steve has indicated that eventually he would like to use an electronic survey to find out more about the memberships' views on the Annual Meeting and about holding supplemental regional or thematic meetings.

2) Who develops the overall meeting theme and the scientific program?

The Governing Board's Vice President for Science recommends to the Board an individual who will serve as the volunteer Annual Meeting Program Chair for two consecutive meetings. The assignment brings with it a tremendous amount of responsibility and almost no compensation. Nonetheless, ESA has been fortunate to have had a number of exceptional members who have been willing to take on this role, bringing their own vision and organizational skills, humor, experience, and scientific expertise to the meeting.

The current Program Chair for the Madison (2001) and Tucson (2002) Annual Meetings is University of Wisconsin professor Paul H. Zedler. The Program Chair's first assignment was to recommend a meeting theme. After reviewing 20 possible versions, Paul settled on a quotation from one of Wisconsin's legendary ecologists. The theme for this meeting—from a line by Aldo Leopold—"Keeping All the Parts: Preserving, Restoring and Sustaining Complex Ecosystems"—was approved by the ESA Governing Board in March 2000.

After settling on a theme, the Program Chair works on developing the scientific program—issuing calls for Symposium proposals, as well as proposals for workshops, discussions, and evening sessions. The Program Chair normally receives many more proposals than can be accommodated during the Annual Meeting, so he turns to a Program Committee composed of the chairs of ESA's Sections, where the proposals are reviewed and ranked.

The Program Chair can also decide whether there will be a Scientific or Policy Plenary, or whether there will simply be symposia. Often the quality of the symposium proposals are so high that there is little need to assemble yet another group of speakers.

Once the symposia are placed in the schedule, the Program Chair, usually with a graduate student assistant, turns to the abstracts of the oral and poster presentations. ESA members tend to procrastinate, and in no area is this more visible than with the submission of abstracts. The deadline for submission is 31 January. Usually a few hundred abstracts have been received electronically by 28 January, and then, like a metaphysical phenomenon, 1,800 abstracts come roaring in over a 4-hour period . . . occasionally crashing servers and fraying nerves.

Over the next 3 months, the Program Chair pores over the 2,200 to 2,500 abstracts—rejecting a few and returning some for improvement—and placing each in an oral or poster slot. The Program Chair's assistant puts the titles, authors, and text in a standard format and tries to make certain that errors or omissions are picked up.

By mid-April, presenters whose abstracts have been accepted and placed in the program are notified. After considerable juggling, the specific sessions of the program and the abstracts are put on-line and are also prepared for proofing and printing. The Program Chair also lines up oral session presiders, communicates with symposium organizers, and ultimately fields lots of e-mails from those who forgot the deadline, want to change their abstract, or need to cancel their presentation.

For more information about abstracts, readers are encouraged to look at the Abstract Guidelines on the ESA Web Site.

3) Why don't we meet on college campuses anymore?

For more than 40 years of ESA's history, our Annual Meeting took place on college and university campuses. All lodging was in dormitory rooms; all sessions were in classrooms; the ESA banquet took place in a dining hall—many were not air-conditioned. The American Institute of Biological Sciences (AIBS) handled all arrangements, registration and logistics. ESA's Annual Meeting took place in concert with a number of smaller, related scientific societies. Total attendance was between 1,000 and 1,800. The number of papers presented at a University-based meeting numbered between 400 and 800.

The last ESA meeting to take place on a University campus was at the University of Wisconsin in 1993; the last ESA Annual Meeting run by AIBS was in Baltimore in 1998.

ESA's Governing Board has had to move beyond history to face today's realities and tomorrow's possibilities. As ESA's meetings have grown larger, and its programs have expanded beyond sharing research findings to encompass subjects such as applied ecology, education methodology, computer modeling, policy implications, public affairs, diversity and environmental justice, international ecology, and community outreach, there is no doubt that the intimacy and collegiality of earlier, smaller meetings has been, to some degree, sacrificed. The Board had to move ahead to open the meeting up to new members, undergraduate and graduate students, and exhibitors.

While there are some large universities with the potential to handle a meeting our size, the distances between classrooms and auditoriums would make it exceedingly difficult to move freely between oral and poster presentations. With attendees who now include older members as well as younger people with families, offering only the option of dormitory housing with shared baths would be unpopular. And, as a society, we have become more sophisticated in terms of our expectations about internet access, AV projection, and food service.

There is, understandably, some nostalgia for a meeting where "you knew everybody there," the fun of keg-parties and the affordability of chips and dips. Our continuing challenge is to try to find settings and opportunities where those values are still possible, and at the same time, where we are able to put on meetings, which showcase first-class science to an ever-widening audience.

4) Why can't we have more free coffee? And while you're at it, how about free beer?

More than any other single gripe, what I hear is "why can't we have free coffee? Or 7/24 coffee or free continental breakfasts, or round-the-clock snacks? I sometimes think that offering intravenous coffee as a registration option would be popular.

Nobody likes to be a Grinch, but what is at issue is simple economics. At the Albuquerque Annual Meeting in 1997, the coffee service cost $25,000. In Baltimore in 1998, it was $33,000. At most hotels or convention centers, the cost to ESA of a single 6-oz. cup of coffee (or tea) is between $1.95 and $2.25. Shade coffee, more ecological to be sure, is also more expensive. Soft drinks per bottle or can will cost us between $2.35 and $2.85 apiece. With five mornings and four afternoons of sessions, if we factored that cost into the Annual Meeting registration fee, the fee would need to go up between $15 and $25 in all registration categories just to cover coffee and sodas.

It's no secret that ESA meeting attendees love beer. We have an almost countrywide reputation for our affection for brew. Convention beverage managers actually tell stories about ESA's legendary levels of consumption. And not only do we at ESA like our beer, but also in general the attendees don't prefer low-cost, domestic beer. A bottle of microbrew or imported beer ends up costing ESA about $4.85, plus possible bartender charges. This turns out to be about the same price as a glass of wine. Add a free beer or a glass of wine to a mixer ticket, and suddenly you are looking at $5 extra for each ticket.

We know that some members wouldn't even notice if we rolled in these perks. But ESA's meeting registration cost has been kept low to encourage attendance and participation. The total increases since 1996 have been no more than 8%—less, in fact, than the rate of inflation. As a matter of policy, the ESA Governing Board wants to keep meeting registration affordable. In 1999 and 2000, we were able to serve complimentary coffee and tea at the morning break because generous exhibitor/sponsors underwrote the cost. Naturally, they are eager to get steady traffic at exhibit booths. Assuming that exhibitors can point to our members' interest and our Society's ability to attract sponsors increases, we may be able to offer attendees more "perks."

5) Do we have to have all those exhibitors?

We tend to forget how much exhibitors add to an ESA meeting. Not only does the revenue from exhibits make it possible for ESA to keep the meeting registrations low, but also ESA exhibitors publish the books and journals that our members write, sell the textbooks that our members use in the classroom, expand the technology for exploring and conducting ecological research, and offer face-to-face information about grant programs and employment opportunities. The materials that exhibitors pay to have placed in registration tote bags covers about 50% of the cost of those bags. The advertising that exhibitors place in the Annual Meeting program helps to defray the cost of the printed program. More than that, many Annual Meeting exhibitors are, themselves, very knowledgeable ecological scientists and editors. For all of these reasons, ESA continues to work to make exhibits an integral part of the Annual Meeting experience.

6) Why doesn't ESA use more high-tech equipment at its meetings?

ESA's Annual Meeting now utilizes three meeting rooms for symposia and 10 rooms for oral sessions—all going on concurrently. Occasionally, workshops and discussions also occur during these same time slots.

When it comes to technology, the issues are not only economic, but also staffing and technological compatibility. Rental costs for LCD projectors have remained high. Daily rental can cost ESA as much as $800 per projector. Rental of smaller projectors can be as high as $500 per day, but often these are not of sufficient quality to project well—even in oral sessions.

And, at least until recently, there have been compatibility problems with different versions of PowerPoint utilizing one central LCD projector. With back-to-back 15-minute presentations in oral sessions, and volunteer student projectionists, ESA has been cautious about introducing new technology.

The current meeting equipment in each meeting room includes a podium with microphone and light, a screen, a slide projector with remote control, an overhead projector, and sometimes an easel and flip chart. Each room set up in this fashion costs ESA about $350 to $400 per room per day. Professional projectionists can add $45 per hour to the cost.

Even using student volunteers as projectionists at oral sessions, ESA spends between $16,000 and $20,000 on audio-visual rental and services.

We have introduced the use of computer-based presentations in stages. In Spokane, for the first time, we used professional technicians in all symposia. At Snowbird, the symposia and evening sessions included, for the first time, PowerPoint capability. And in Madison, presenters at symposia and, for the first time, at oral sessions, will be able to use PowerPoint.

7) Why does everything cost so darned much?

One of the things most people who don't plan meetings for a living don't know about is how or why things are priced.

Every place ESA meets, in a hotel or a convention center, and even, these days, in a university hall, we have to deal with something called cost plus–plus. In effect, what this means is that the cost of a food or beverage item, or a piece of AV equipment, or a technician, bartender or carver, is multiplied by a service charge, and then the total of those two items combined is multiplied by the state sales tax. The three things added together (cost + +) ends up being the actual cost.

The service charge (which takes the place of a gratuity) varies from facility to facility, but it is never less than 18% and, in some locations, it is now as high as 28%. So, if the base price for a can of soda is listed in the facility's menu as $2.00, then multiplying by 18% adds 36 cents. Now the can of soda costs $2.36. And then, if the state sales tax is, for instance, 6% (and most places the tax is considerably more), 14 cents is added and then the cost to ESA of one can of soda ends up being $2.50.

Using ESA's status as a 501.C.3 nonprofit organization, ESA's finance folks always apply to be exempt from the state sales tax. For many recent meetings, we have been fortunate to receive this exemption. But in some meeting locations, state tax law precludes the exemption.

Either way, it's important to remember that virtually everything at one of our ESA meetings—whether you eat it, drink it, or view it—includes a service charge, and possibly a state sales tax. We always work to get our attendees the most for the money we are charged without having to pass it on in terms of increased meeting fees or ticket costs, but it is a balancing act.

ESA underwrites a portion of the costs of the Welcome Mixer and the Graduate Student Mixer to keep the ticket prices low. But we can never order enough food to make these early evening gatherings a substitute for "dinner," and those people who pile up their plates are denying others the opportunity to get anything. One of the strategies we have used recently is to phase putting out the food so that the hordes descending on the buffet tables can't eat it all. So, next year in Madison, if you get to the Tailgate Party (the ESA Welcome Mixer on Sunday evening) and there are no more "brats" to be found, be patient. The next round will be on its way.

8) How do I get the most out of my Annual Meeting registration?

One important way to get value is to put aside enough time to read the advance materials. A tremendous amount of staff time is spent answering questions when the information is already available on line or in print.

One of the people who responded to this year's evaluation complained that there was no description of the natural environment and no information about hiking trails. In fact, both the preliminary program and the official program included four pages of natural history, plant and animal identification, and a very detailed map and description of hiking trails. Another person was upset that there was no child care at Snowbird, when, in fact, Camp Snowbird offered a wonderful, professionally supervised program.

The preliminary meeting program and the ESA Web site will provide you with plenty of information to plan an itinerary for the meeting—not only what sessions and mixers to attend and which workshops and field trips would be of interest, but also where to find good restaurants, what food is being served at the ticketed events, and how to arrange for child care or for transportation from the airport. ESA's pre-meeting materials include information about what to expect in terms of poster and oral presentations, what to bring on field trips, what the weather will be like, and what sorts of local attractions you might sample.

Also, don't delay. Either in sending in your abstract or registering for the meeting. Not only do late registrations cost more, and field trips, workshops and special sessions (especially no-cost opportunities) fill up quickly with more than 2,500 registrants—but it is always possible to end up getting lost in the shuffle. We don't mean for it to happen—but it does.

Another strategy for making your meeting more satisfying is to come in time to participate in a workshop or field trip. These smaller groups enable attendees to get to know each other. In some cases, participants will have the opportunity to learn from leading field ecologists and educators.

Yet another idea is to make certain to attend section and chapter business meetings so that you can meet others in your field and have an opportunity to network. Students are always welcome at these meetings, and relationships forged in your section or chapter can last personally and professionally over your lifetime. Not only that. Several sections offer scholarships or stipends, which can help to defray student costs for Annual Meeting attendance.

ESA usually brings almost the entire headquarters staff and several of the Ithaca staff to the Annual Meeting. We relish the opportunity to get to know our members better, and we usually have been on-site a few days before you arrive, so we may know good places to get cheap food or great beer.

Make time for fun and reflection. With morning-to-night scientific sessions, Annual Meetings can result in information overload. In Madison, where they lay claim to being the bicycle capitol of the United States, you can rent a bike for a pedal around Lake Monona, or go up on the roof garden of Monona Terrace to zone out between sessions. This year, as we did last year, we are organizing an early-morning Fun Run, and there is usually an ultimate Frisbee game.

Finally, we want to hear from our meeting attendees. We want to know your questions and observations about what worked and what needs attention. We hope you will respond to next year's postmeeting evaluation. Never hesitate to communicate your ideas.

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Keeping All the Parts:
Preserving, Restoring
& Sustaining Complex
Ecosystems

THE ECOLOGICAL SOCIETY OF AMERICA
86th ANNUAL MEETING
MONONA TERRACE MADISON WISCONSIN
AUGUST 5–10, 2001

Two Ways to Be an Invader, But One is More Suitable for Ecology

Ideally, all terms in ecology will have the same general meaning to all ecologists. This has not been the case for the term *invader* and its derivatives: *invasion* and *invasive*. Recent articles by Davis and Thompson (2000) and Richardson et al. (2000) have both proposed criteria for calling a species an *invader*. Unfortunately, these criteria differ. I argue that both definitions will generally point to the same set of species, but that of Richardson et al. (2000) is preferable because the definition of Davis and Thompson (2000) includes a subjective criterion and is dependent on human values that vary substantially from person to person.

Both definitions agree that an invasive species must be novel to a region (biogeographic criterion). With this agreement, we have moved closer to a common concept of *invader*. In the past, native species arriving and spreading during natural succession were sometimes referred to as *invaders*. The need for a term that refers specifically to species new to a region has emerged from the large research focus on unprecedented rates of human-facilitated introductions between regions. Beyond the biogeographic criterion, the definitions part ways. According to Davis and Thompson (2000) an *invader* must have a great impact on its new environment (impact criterion). The reasoning behind this criterion is that most English definitions of *invader* have negative connotations. Common synonyms for invader include "attacker" and "aggressor" (Davis and Thompson 2000). In contrast, Richardson et al.'s (2000) definition lacks the impact criterion. Instead, they use natural reproduction and spread in its new environment as the criterion for being an *invader*.

Do both definitions refer to the same set of species?

To meet the impact criterion for being an invader, a species must have a "great" impact on its environment, and this impact is usually ecologically or economically undesirable (Davis and Thompson 2000). Richardson et al. (2000) estimate that 50–80% of invaders (as defined by the spread criterion) have "harmful" effects. If we equate harmful effects to great impacts, then we have up to 80% overlap in the species pool identified by both definitions. But whether a spreading introduced species has a "great" or a "negligible" environmental or ecological impact (Davis and Thompson 2000) depends on a combination of the variable being studied, the scale of the study, and personal values (Ewel et al. 1999). To claim that many "extremely common" introduced plants have "no discernible impact on the environment" (Davis and Thompson 2000) seems unreasonable, given our knowledge of the complexity of direct and indirect interactions among species, as well as the myriad types of ecological impacts (Parker et al. 1999). If we consider all kinds of ecological impacts (Parker et al. 1999), the fraction of *invaders* defined by the spread criterion that also have an ecological impact (perceived to be great by someone), must surely be higher than 80%, and probably approaches 100%.

Impact or spread?

Although both definitions may refer largely to the same set of species, use of the "spread" criterion is preferable, because the impact criterion is more subjective and dependent on individual values. Furthermore, the degree of impact depends on the variable being studied and the scale of study. Minimizing subjectivity and maximizing consistency is important, because we will have little chance of identifying trends or generalities among any group if inclusion or exclusion is largely based on subjective opinions. The spread criterion also includes some subjectivity, but it requires measuring two variables, population growth and distance of spread, both of which are relatively easy to measure (Parker et al. 1999). Richardson et al. (2000) provide specific suggestions on how to determine if a species meets the spread criterion. In contrast, how to best measure impact, and then classify impact as great vs. negligible, is controversial.

Curiously, Davis and Thompson (2000) never address the issue of whether a species must spread after colonizing (taken to mean establishing a population). Using their impact-based definition, a non-indigenous species could be considered an *invader* even if it doesn't spread (as in a *Eucalyptus* planting that replaces itself and greatly impacts the planted area, but does not spread beyond the introduction site). Most ecologists would not consider this situation an invasion.

Defining an ecological invader based on the "spread" criterion somewhat divorces the term from its negative connotation in common English. Yet, many terms in ecology do not match their common English definitions. For example, the term *ruderal* in ecology refers to a plant that is adapted to growing in frequently disturbed habitats, but common English definitions of ruderal are "growing in rubbish" or "growing on rubble." Neither of these English definitions captures the ecological meaning. Likewise, common English uses of the term *chaotic* to mean "completely confused" and "in a state of disorder" do not capture the meaning of *chaotic* in theoretical population ecology. We should not be too concerned if our ecological definition of *invader* does not precisely match that used by non-ecologists. If we wish to convey a (subjective) negative connotation, we can use terms like "weed" and "pest" (Richardson et al. 2000).

Is time important?

Davis and Thompson (2000) argue that, over time, all invaders become natives. Referring to European plants introduced to North America a century or more ago, Davis and Thompson (2000) suggest that "continuing to refer to them as alien invaders . . . is beginning to make little ecological sense." They do not consider the point that many major questions in invasion ecology involve trying to identify and understand patterns. For example, what factors promote invasions, or what traits increase invasiveness? In searching for general patterns, it makes little sense to exclude an invader from analysis simply because humans happen to have introduced it at an earlier date.

Conclusion

Clearly, not all non-indigenous species in a given environment should be considered invaders. Most non-indigenous species exhibit minimal or no population expansion beyond their site of introduction; they do not meet the spread criterion. All species that meet the spread criterion probably have ecological and environmental impacts, although for most non-indigenous species, these impacts have not been adequately quantified. Whether these impacts are great or small, harmful or beneficial, depends on your personal perspective. Some invading species have greater ecological impacts than others, but defining *invaders* as those species with the largest impacts is an exercise in subjectivity that will be unlikely to contribute to clarity. For ecology, defining *invader* based on population growth and spread in a new region is preferable. It captures a general ecological process that can be confirmed with simple measurements, leading to greater agreement among ecologists, and greater progress in understanding invasions as ecological phenomena.

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Is Ecology a Profession and is it Certifiable?

In the October 2000 *ESA Bulletin*, Dale et al. (2000) highlighted the need for professional certification for ecologists. The article was a strong narrative for the certification of ecologists, but the following excerpts from the article were personally disturbing. So I thought I would follow the article's advice and "speak up on this issue through the *ESA Bulletin*."

Excerpt 1: *Professional certification in medicine, engineering, geology, and other fields has undoubtedly helped them be recognized as legitimate professions. Should we not aspire to have similar recognition for ecology?*

Excerpt 2: *When Home Economics programs around the country renamed their departments and colleges "Human Ecology," where was the professional ecology group to protest loudly? You can bet engineers would have never allowed a title of "Human Engineering."*

I would like to examine the excerpts individually. The first quotation, with the rhetorical question, begs the following nested questions.

1) Is ecology a profession?

2) If so, what is "ecology"? Can it be defined as a profession in clear and uncertain terms?

3) Does "ecology" need recognition/certification, or do "ecologists" need it? If the former is the case, isn't certification yet another administrative hoop that ecologists have to jump through?

The dictionary definition of "profession" that is relevant in this context is, "a vocation requiring knowledge of some department of learning or science." By such a definition, academic, impact assessor, and researcher may be deemed to be "professions," while ecologist (literally meaning a student of ecology) certainly would not qualify as a profession. I am inclined to say that ecology per se is not a profession. In fact, some have argued that ecology is still in the process of trying to becoming a science (Peters 1991). Either way, we need to establish what ecology is, or, as Popper would have it, what it is not, before we can delineate it as a field/ profession distinct from others, thereby requiring and justifying certification.

I read the ESA's Code of Professional Ethics, published in the same issue of the *ESA Bulletin* (81[4]: 272–273). The section titled "Certified Ecologists" dwells on the expectations of ecologists who receive certification through the ESA. I am aware of many uncertified ecologists who adhere to most, if not all, of the criteria laid out in the code. So does the definition of ecology as a profession mean, "those who adhere to the ESA code of professional ethics"?

I personally feel that unless we are able to address the above questions convincingly, certification as an ecologist means little more than a few extra letters after one's name.

To examine the second excerpt: the rhetoric can almost be interpreted as a blanket insult to the home economics departments of yesteryear, who have changed their names to incorporate ecology as an ethos. While some institutions may have jumped onto the ecology bandwagon to acquire a green label, I would like to believe that at least some did so because they saw a need to amalgamate disciplines and emphases. To ask whether engineers would have allowed a use of their field's title is both pedantic and elitist. It is pedantic in that "home economics" cannot be directly transformed into "human engineering," while the change of name to "human ecology" is logically conceivable. Economics is the study of resources and their uses, as ecology is in some ways. So the study of human use and interactions with resources can be labeled "human ecology." If the change was made by this logic, is the use of "human ecology" a bad thing? After all, doesn't "oikos" mean "home"? In fact, the only people who can claim to be doing "Human Engineering" are biologists (genetic engineers and biotechnologists) and not home economists. The tone of the excerpt is elitist, in that, as people who are ecologically inclined, we are proposing to claim ownership of the word "ecology" by asking such a question in this context.

So what is ecology, if it is hard or impossible to define as a field, or a profession, or a science? I believe ecology is an orientation. The ecologically inclined tend to look at whatever systems they work on (human and otherwise) as an integrated whole of interacting components. For example, I work on insects, tephritid fruit flies to be precise. I study them from the perspective that they are organisms interacting with plants and bacteria and are influenced by other biotic and abiotic variables. My approach, therefore, is to try to understand the nature of such interactions and their outcome. My orientation is different from that of a tephritid taxonomist, whose principal objective is to devise a suitable method to identify individuals of a species and to differentiate between species. There are taxonomists who have an ecological leaning, or ecologists who have a taxonomic leaning. Either way one is an entomologist, as entomology, unlike ecology, has a clear demarcation as being the "study of insects." There are too many gray areas and no clear (or even partially clear) demarcations as to where being an ecologist ends and being a taxonomist begins. Elton (1927) captured this confusion in his satirical and cynical definition of ecology: ". . . the science which says what everyone knows in language that no one understands." Most ecologists face the confusion of precisely what "ecology" constitutes, at some time or other. This is probably part of the reason why fewer than 5% of ESA members (346 out of over 7500 in 1999 [Dale et al. 2000]) are certified ecologists.

I am not raising the above objections merely as a semantic obstacle to the claims of Dale et al. (2000). These are questions I ask myself as a doctoral student. In light of the above concerns, I think ecology could be better served by not following the paths of relatively clearly defined disciplines, such as engineering and medicine, purely for a piece of the "me too" pie.

Note: I apologize to those who find the accidental pun in the title offensive. It is neither an insult to ESA-certified ecologists nor to ecologists in general. I only realized the pun on second reading.

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