Science and Restoration Under a Big, Demon Haunted Tent: Reply to Giardina et al. (2007)

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Abstract

In a recent editorial, I discussed how the culture of science, heterogeneity of nature, and real-world human complexities can limit the practical relevance of formal scientific research and argued that less formal approaches might often be more efficient and effective. Giardina et al. criticized this editorial and argued that formal science has and increasingly will play a central role in ecological restoration in particular and human progress in general. Here, I respond to these arguments and expand upon the ideas presented in my previous editorial. I further illustrate how despite superficial appearances the utilitarian value of formal science may often be largely indirect. I also argue that the complexities of ecological and human systems combined with the subjective values and political beliefs underlying restoration make transforming this discipline into a unified "hard science" virtually impossible. Because values and politics also underlie most environmental conflicts, and scientific inquiry is inherently unsuitable for resolving these kinds of disputes, the future success of restoration may depend more on political support than scientific progress. Dogmatic, nonfalsifiable faith in the universal superiority of "rigorous" scientific knowledge and methodologies can foster arrogance and intolerance and blind us to the ephemeral nature of scientific "truths" and the double-edged sword of scientific "progress." My hope is that Society for Ecological Restoration International (SERI) will remain a big inclusive tent that embraces a healthy diversity of foci and approaches that emulate the extraordinary diversity we find within the natural ecosystems and human cultures we strive to preserve, restore, and reconnect.

Key words: ecological restoration, Hawaii, inclusive restoration, philosophy of science, politics, practical relevance, reductionism, trial and error experimentation.

Introduction

> … the public has to be more suspicious about what is claimed in the name of science, and scientists themselves need to be less naïve about the impact of their own ideological beliefs or value commitments on their scientific theorizing. What is called science can be far from an objective and dispassionate attempt to figure out the truth entirely independent of theism and naturalism, or of political and moral convictions …. It is the conflation of these elements that gives the false impression that science can be one's religion … the truly scientific mind must instead be conscious of the limitation of the scientific enterprise, and also allow forms of truth and knowledge which lie beyond the scope of the sciences (Stenmark 2001).
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> Formerly, when religion was strong and science weak, men mistook magic for medicine; now, when science is strong and religion is weak, men mistake medicine for magic (Szasz 1973).
>
> Not everything that can be counted counts, and not everything that counts can be counted (Albert Einstein).

In a recent editorial (Cabin 2007), I explored the question of whether formal, "rigorous" science is necessarily an effective framework and methodology for designing and implementing ecological restoration programs. Based on my experience with the culture of science, heterogeneity of nature, and real-world complexities of implementing resource management practices, I argued that a less formal, more trial and error/intelligent-tinkering-type approach might often be a more efficient and effective means of accomplishing ecological restoration.

Giardina et al. (2007) disagreed with much of my editorial and offered an alternative perspective. I appreciate this thoughtful critique from my good friends and colleagues in Hawaii and welcome the debate. Subsequent communications with Giardina et al. have also suggested that my editorial was interpreted by some as being "anti-science" and/or has led to increased tensions between the Hawaiian research and the resource management communities. Although these outcomes were actually antithetical to my intentions, I am nevertheless deeply sorry for any counterproductive results my editorial may have caused in Hawaii or elsewhere. In this article, I respond to Giardina et al.'s criticisms as well as expand upon some of the ideas

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presented in my previous editorial. Once again, my goal is to facilitate better restoration science, better ecological restoration, and better relations between these two still often distinct cultures.

Practical Contributions of Formal Science to Ecological Restoration

Giardina et al. (2007) maintain that I greatly undervalued the past and present practical contributions of formal science to ecological restoration projects. They also seem to have inferred that my previous editorial was at least an implicit argument against the general merit of *all* formal scientific research programs. My response to this is 3-fold: First, what I actually believe was explicitly stated in that editorial: "In my opinion, the pursuit of pure knowledge is sufficient justification for research; whether or not, it ever intentionally or serendipitously leads to anything of practical value is a separate issue." Second, much of the work of many of the ecologists I know is motivated more by a basic intellectual curiosity about and love of nature than a desire to solve applied problems per se. These scientists would be the first to admit that their research may never have much practical value because that is not even their intention. Third, the indirect benefits to restoration programs that may flow from formal scientific research programs (detailed in Cabin 2007) are often substantial and should be encouraged and rewarded rather than marginalized and discounted.

Although I appreciate Giardina et al.'s (2007) kind words regarding the practical value of my own research program within degraded Hawaiian dry forests, I would again argue that whatever practical contributions my colleagues and I may have made have been largely indirect. For example, despite their claim that our research on the effects of ungulate exclusion has been "widely adopted by land managers and restoration practitioners" in part because it was "scientifically rigorous and available in peer-reviewed outlets," I remain unaware of any past or current restoration efforts (including within our own research site) to actually apply it directly. There is an important difference between citing a scientific publication to gain "legitimacy" and political support for a preferred management objective such as ungulate exclusion (an indirect yet important benefit of the research) and using the specific technical data and analyses of the research itself to guide and facilitate a particular restoration program (a direct benefit that would be a true case of "science-driven restoration").

In this case, the devastating ecological effects of ungulates in the Hawaiian Islands have been well known for over 150 years (e.g., Tummons 2002*a*, 2002*b*), extensively documented by both technical and popular publications (e.g., Stone 1985; Stone & Stone 1989; Cuddihy & Stone 1990; Mehrhoff 1998; Pratt & Gon 1998; Warshauer 1998; Gagne & Cuddihy 1999; Liittschwager & Middleton 2001; Ziegler 2002), and painfully obvious to even a causal observer concerned with the preservation of native biodiversity. As a senior research scientist recently put it to me, "We probably could have done what has made the biggest difference in conservation in Hawaii just by following the advice of local, on-the-ground people who said fence here, weed there … we didn't need all this science to see the effects of the ungulates, hotels, and habitat alteration." Thus, I would argue that the reason their effects remain "controversial" is largely due to politics (particularly the hunting and ranching lobbies), and it is naïve to believe that ever more science will eventually resolve this issue.

Some might argue that the practical value of our research was more a result of rigorously testing, documenting, and disseminating the results of what actually happened under various restoration treatment combinations. Yet if this had been our primary motivation (as opposed to the more formal, hypothesis-testing-type science detailed in our previous technical publications), I would argue that a less formal methodology would have been far more efficient and relevant to restoration practitioners. For instance, instead of spending the countless hours required to meticulously record the height and biomass of hundreds of individually tagged experimental plants, more quick and dirty qualitative assessments would have allowed us to test additional, more practically relevant treatments and/or track variables of more interest to resource managers and practitioners than scientists (e.g., the time and money required to administer each treatment combination).

As a contrast to the difficulties I encountered trying to perform practically valuable research within Hawaii's dry forests, Giardina et al. (2007) cite the "diverse and successful" research of Scowcroft and colleagues within the relatively simple, well-studied, high-elevation rainforests of the Hakalau National Wildlife Refuge on the island of Hawaii. Yet ironically, my appreciation for the power of trial and error restoration programs largely developed over my years of research and observations within this Refuge.

The on-going restoration of Hakalau's thousands of hectares of degraded montane pastures back to native rainforests is in my opinion the most successful and inspiring restoration program in all of Hawaii. Yet although excellent formal scientific research has and continues to be performed there, I believe the success of this program is primarily because of the skillful application of trial and error/intelligent-tinkering-type approaches combined with an extremely effective volunteer and outreach program. For example, Jack Jeffrey, the Refuge's Biologist, told me that although he was very supportive and appreciative of formal science in general and the specific outside research performed at Hakalau in particular, he stressed his reliance on "seat-of-the-pants" trial and error methodologies and learning by doing. He also pointed out that "the theoretical stuff is real nice on a small scale, but as soon as you go to a larger scale … When the final scientific papers or

reports come back to the Refuge, they are almost always focused on one or a few species. Often they are quite interesting, but because we are managing the Refuge for the ecosystem as a whole, they're worthless as far as management recommendations."

I would also argue that Hakalau's restoration program has been much more a case of trial and error–driven restoration revealing interesting subsequent research questions than science-driven restoration revealing concrete management goals and techniques. For example, early in their program, Jeffrey discovered that frost was killing a substantial number of their native transplanted trees. After extensive informal experimentation testing the effectiveness of a wide variety of frost protection devices, he finally discovered a counter-intuitive method that was both effective and economically and logistically feasible for large-scale implementation. Jeffrey then collaborated with Scowcroft and other researchers to perform more formal scientific studies (e.g., Scowcroft & Jeffrey 1999; Scowcroft et al. 2000) to investigate the underlying causal mechanisms behind the results he observed in the field.

Despite superficial appearances and claims made by some scientists and even resource managers, at least in Hawaii, I have consistently found that other successful restoration programs are in reality also driven largely by trial and error methodologies. Similarly, I have not found the results from formal scientific research to necessarily be more generalizable than those obtained from less formal approaches. Although I have little doubt that there are times and places in which formal science *is* a practically relevant and/or more transferable methodology, my argument is simply that we should evaluate and compare different approaches on the basis of objective empirical evidence rather than blind faith or personal ideologies.

Science and the Future of Restoration Ecology

Giardina et al. (2007) argue that the future success of restoration will largely be driven by increasingly powerful and sophisticated formal scientific research programs. In contrast, I believe that science is only one of many strands that make up the complex web of ecological restoration, and that this strand has not necessarily been nor necessarily will be of overarching central importance.

In many ways, our different perspectives mirror the philosophical and technical debates within academic ecology. For instance, McIntosh (1987) began his review of the arguments within and among the numerous and often acrimonious factions that comprised this discipline at that time by writing that "Ecologists are in a period of retrenchment, soul searching, 'extraordinary introspection' …. This follows on nearly three decades of the heady belief on the part of some ecologists … that communities are structured in an orderly predictable manner, and of others that information theory, systems analysis, and mathematical models would transform ecology into a 'hard' science." Although much has changed in the 20 years since this review was published, the "soul searching" and "extraordinary introspection" over the relevance and rigor of the myriad competing approaches remain (e.g. Weber 1999; Kareiva 2000; Turchin 2001; Hansson 2003; Botkin & Cummins 2005; Egler 1986).

As intractable as the above debate may be, I would argue that its difficulties are trivial compared with the challenge of transforming restoration ecology into a unified "hard science." This is because in addition to grappling with many of the same messy ecological problems of academic ecology, restoration scientists must also contend with the even greater complexities created by the even messier world of humans. Moreover, deciding to "promote ecological restoration as a means of sustaining the diversity of life on Earth and reestablishing an ecologically healthy relationship between nature and culture" (the SERI [2004] Mission Statement) requires a commitment to a set of personal, subjective values, and political beliefs that lie outside the scope of science (Davis & Slobodkin 2004; Winterhalder et al. 2004).

I eventually realized that many of my attempts to help resolve disagreements within restoration programs with rigorous science were naïve because these controversies were in reality largely personal values/political disputes (even within the scientific community), and, as eloquently summarized by Sarewitz (2006):

> Scientific inquiry is inherently unsuitable for helping to resolve political disputes. Even when a disagreement seems to be amenable to technical analysis, the nature of science itself usually acts to inflame rather than quench the debate … Science seeks to come to grips with the richness and complexity of nature through numerous disciplinary approaches, each of which gives factual, yet always incomplete, views of reality …. 'More research' is often prescribed as the antidote, but new results quite often reveal previously unknown complexities, increasing the sense of uncertainty and highlighting the differences between competing perspectives.

Although members of the environmental community often argue that resource management decisions should be resolved by the "best science," what I think they actually want is not so much the science as the personal value systems of the scientists. This is because scientists who study ecological systems also tend to love and care about them much more than the public in general and the politicians in particular. These personal values in turn tend to predispose us (I would readily put myself in this group) toward "objectively" interpreting our technical data and observations as justifying more environmentally friendly policies and procedures. Thus, in my view, what is of central importance to the future success of ecological restoration is not the technical progress of the science as much as the development of broad political support for the values implicit in the above SERI mission statement.

A Candle in a Demon Haunted World?

Finally, Giardina et al. (2007) conclude with a broader discussion of the central role of science in improving human welfare in general and end their paper by referencing Sagan's (1996) admonishment to "better apply that science-based recipe that has been at the base of human progress for millennia." This argument reflects the view of many prominent and influential scientists. For example, Stenmark (2001) notes that "Some scientists seem to have an almost unlimited confidence in science—especially in their own discipline—and about what can be achieved in the name of science." However, he points out that "Crick's [1994] claim 'We are nothing but packs of neutrons,' Sagan's [1996] 'The Cosmos is all that is or ever was or ever will be' and Dawkins' [1989] 'Every living object's sole reason for living is that of being a machine for propagating DNA' are extra-scientific or philosophical claims." That is, although these statements were made by brilliant scientists, they are more religious than scientific claims because they are based on nonfalsifiable personal convictions.

My own nonfalsifiable personal conviction is that such dogmatic faith in science is dangerous and myopic. I also believe this worldview can blind scientists and the public to the ephemeral nature of scientific truths; the double-edged sword of scientific and technological "progress;" and to other ways of interacting with the "demonic world" that lies beyond the flickering light of science's candle.

The development of agriculture is a good illustration of just how double-edged science-driven enterprises can be. Giardina et al. (2007) argued that the intelligent tinkering approach that I employ in my own garden (Cabin 2007) is actually made possible by my standing on the "shoulders of the giants" of the agronomic sciences and argued that "science is absolutely the foundation on which day-to-day agricultural decisions should be made." However, a more holistic analysis reveals the many unintended horrors that have accompanied the undeniably impressive accomplishments of science-based agriculture. For example, the same science that delivered ever-increasing agricultural yields has also delivered ever-increasing malnutrition, starvation, epidemic diseases, social inequities and oppression, and population explosions (Cohen & Armelagos 1984; Diamond 1987). These phenomena, combined with the corresponding environmental disasters agriculture created or exacerbated, have led some scholars to consider the invention of agriculture in general (Diamond 1987) and the modern, high-technology, industrialized agricultural sciences in particular (Manning 2004*a*, 2004*b*) as being the "worst mistakes in the history of the human race."

The net result of the combination of the mixture of this science and the "free market" is that today we live on a planet in which (1) there is more than enough food to make all six billion of us fat, yet every day about a billion people go hungry and malnourishment directly or indirectly kills tens of thousands of children; (2) developing countries export much more food than they import, and most of these exports go to wealthy developed countries like the United States (where obesity is arguably the most pressing public health problem); and (3) a few multinational corporate giants control an ever-increasing majority of the world's food production, processing, and distribution systems. In addition, these corporations (often in the name of "scientific progress") continue to replace small, diversified, highly productive, ecologically sustainable, locally controlled, indigenous agricultural systems (developed in the absence of western science) with ever larger genetically engineered monocultures that displace the local human community, require many calories of fossil fuel to produce one calorie of food, and contaminate the land and water with synthetic fertilizers, herbicides, and pesticides (e.g., Lappe et al. 1998; Gliessman 2000; Lappe & Lappe 2002; Nestle 2002; Manning 2004*a*, 2004b; Pimentel et al. 2005; Pollan 2006). Can ever more powerful and sophisticated science get us out of this mess?

Although the immaturity of the science of restoration ecology can often be frustrating, it also affords us the major advantage of being able to learn from the experiences of other, more established sciences like academic ecology and agronomy. Perhaps one of the most important lessons we can learn is the value of humility, holism, and tolerance. Realizing that our present scientific understandings and methodologies will eventually be radically modified if not completely replaced by new ideas and approaches can help us avoid the arrogance and hubris that historically has accompanied the development of increasing scientific and technological knowledge and power.

This humility can also help us to see the limitations of formal reductionist science and the potential value of other forms of scientific inquiry and/or embedding our research within broader, more flexible and holistic frameworks. For instance, almost 70 years ago, Sir Albert Howard foresaw many of the problems that would result from the over-zealous application of formal science to the vast biological and social complexities of agroecosystems. As summarized by Pollan (2006), Howard (1940) argued that "the problem is that once science has reduced a complex phenomenon to a couple of variables, however important they may be, the natural tendency is to overlook everything else, to assume that what you can measure is all there is, or at least all that really matters." Although Howard's warning was and still is largely ignored by mainstream agricultural scientists and the academies and corporations that support them, perhaps it will be heeded by restoration ecologists and practitioners.

I hope that this humility and holism can also foster a healthy dose of tolerance. For example, I love the diversity and "big tent" inclusive atmosphere of SERI meetings. Even though there are always some parts that I do not personally value, agree with, or even relate to, I still hope that they will be retained as long as they are meaningful to at least some of the other participants. Similarly, rather than endlessly bickering about the "right" way to

define, justify, research, fund, implement, certify, and/or assess ecological restoration programs, why not attempt to emulate the extraordinary diversity we find within the natural ecosystems and human cultures we strive to preserve, restore, and reconnect?

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