# On the Cusp of Restoration: Science and Society

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## Abstract

**Habitat restoration has reached political respectability at many scales across the Earth and represents a serious reversal of some entrenched social views regarding the environment as a strictly exploitable resource for private gain. Science helps improve restoration by bringing clarity in the form of order, understanding, and descriptions of uncertainty. But scientific ideas and experience must be offered in a timely manner and welcomed to be a useful and accurate part of restoration. These ideas may be adopted or fail to be influential for vastly different reasons. Valid ideas may be untimely or be packaged too poorly to be acceptable, or an idea may be erroneous, but still be acceptable (and lead to poor decisions) where the ability to convince or superior networking skills compensate for an inadequacy of facts, logic, or intentions. The most desirable outcome is to fairly weigh all relevant ideas during decision-making, and without confusing accuracy and clarity with consensus or deliberative inclusivity. Project scale influences these outcomes because social and policy complexity increases with project size. Ideas, of whatever origin, must be applied in the imperfectly comprehended landscape and "policy-scape" of policies and personal preferences influencing the spatial productivity, richness, and uses. Successful habitat restoration will have the science welcomed and developing in well-ventilated and professional ways, while simultaneously participating in the world of the larger policy-scape. Judgments will be made and mistakes occur, of course. But, if done well, we may end up restoring habitats, institutions and parts of society.**

**Key words: restoration, science, society.**

### Definition:

> "Cusp…: definition b. The fixed point on a curve at which a point tracing the curve would exactly reverse its direction of motion."
>
> "When human beings lose their connection to nature,… then they do not know how to nurture their environment. Healing our society goes hand in hand with healing our personal, elemental connection with the phenomenal world."
>
> Chögyam Trungpa,
> Founder, Naropa University

### On the Cusp of Restoration

The industrial view of the natural environment as an almost exclusively economic resource was institutionalized by the seventeenth century in Europe and spread into the New World with its colonization. The effects of this colonization on the New World's natural resources by the end of the 1800s were chronicled especially well in *The Earth as Modified by Human Action* written by Marsh (1885). Marsh was a linguist fluent in 20 languages, ambassador to Italy, and traveled widely. He could see the broad picture of change from an intellectual point of view, within cultures from personal contact, and in landscapes. And changes were happening quickly for him. He saw the U.S. landscape transformed radically: virgin forests were cleared, the newly invented Deere plows turned Big bluestem prairies into farmland, and ecosystems became unsustainable or unavailable for the people of the First Nations. He clearly would have been a proponent of restoration as a logical next step in social development ("…Man, who even now finds scarce breathing room on this vast globe, cannot retire from the Old World to some yet undiscovered continent, and wait for the slow action of such causes to replace, by a new creation, the Eden he has wasted" [Marsh 1885:228]). Individuals were experimenting with a variety of restoration efforts in the past century, including the wildlife biologist–turned conservationist Aldo Leopold, who began restoration of his farm in Sand County, Wisconsin, and wrote a wonderful book that still inspires people (Leopold 1949).

Successful examples of habitat restoration are now found throughout the world as personal or local restoration efforts have been transformed into national and even international programs. This conclusion is evident in recent scientific publications, legislation, and programs funded. For example, the United Nations is involved in restoring the marshes of southern Iraq—the 10,000+ year–old home of the Ma'Dan or "Marsh Arabs" (Thesiger 1964; UNEP 2001). The rationale for this restoration effort is largely based on a human rights issue—it is explicitly recognized that the Ma'Dan culture depends entirely on "their" wetland ecosystem. Restoration has, in other words, achieved political respectability at many scales, and represents a serious reversal of some social views—not that this is, at all, sufficient in a qualitative or quantitative sense.

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Some legislative expressions of caution and prevention were underway as Marsh and Leopold were writing. Siry (1984) traced the development of a coastal conservationist ethic in the United States and concluded that social commentators, artists, and writers had more to do with the political results than did the developing national cadre of professional naturalists and scientists. Scientists followed, more than led, these earlier initiatives. Today, however, scientists guide many environmental restoration efforts through direct involvement in a project, or indirectly through the incorporation of research results and development of "best management practices," empirically defined outcomes and predictions, or even theoretical constructs. Their (our) progress in these endeavors has been nonlinear and embedded with obstacles. There have been twists and turns in the priorities, methods, and perceived factual basis for conclusions. The generalizations about restoration trajectories among and within ecosystems have been sparse. Because the science of restoration is so young, we should not have expected anything but this result. The practice of restoration is not yet the same as when building a bridge that taxpayers cross daily, whose weight, structural integrity, and load capacity, etc., are well defined in manuals and textbooks used in hundreds of classrooms. Although habitat restoration is supported by individuals and public entities, it is clear that there is also much to learn that would help meet the stated and unstated objectives.

This paper is concerned with how science is useful and used in restoration (a definition used herein that includes what some may call rehabilitation) and the reciprocal role of restoration scientists—many of whom are in academia—and society. Our professional obligations are to know not only the parts of what is being restored—the area, the ecosystem processes, the species, etc.—but also the context of why and how it is being attempted. I explore the relationships between science and restoration within a social context. I do this because sometimes knowing the facts and numbers about the project area is not sufficient to generate and complete a wholly successful restoration effort. The "just the facts, ma'am" or strictly "rationale" approach, by omission, diminishes just how much scientists are social creatures and influenced by social institutions, and that individuals and groups develop ideas in ways that can be encouraged or stymied, that ideas must be communicated effectively to other individuals to be effective, and that the work of scientists flourishes or shrinks within a network of public priorities that may restrict or enhance the possibilities for clarity and success. Both the "natural sciences" and the "social sciences" are essential components of restoration and are included in the discussion of "science" that follows. Habitat restoration is embedded in the larger landscape that affects the imperfectly comprehended downstream environments and also in a kind of "policy-scape" of policies and personal preferences influencing decisions. Estuarine scientists, for example, find themselves crawling up the watershed to influence policies that affect water quality. Habitat restoration must have the locally relevant science welcomed and developing in well-ventilated and professional ways, while simultaneously participating in the world of the larger policy-scape. I hope to encourage ongoing professional discussions of some aspects of a successful restoration program, which I see as being reciprocally coupled to society's well-being.

### Indices of the Involvement of Scientists in Restoration

To find out more about the involvement of scientists in habitat restoration over the past few decades, I conducted a search for the word "restoration" in the Science Citation Index (SCI) Web of Science citations for 1970–2003 (conducted on 2 September 2003). The word restoration appeared for the first time in the SCI keywords listing in the 1980s for the science journals Estuaries, Journal of Ecology, Limnology and Oceanography, Nature, and Science. The keyword restoration appeared first in the 1990s for the journals Conservation Biology, Ecology, Ecological Applications, and Wetlands, and first in 2001 for Ecological Monographs. In all journals in the SCI, the keyword restoration appeared together with the words "estuary," "forest," "lake," or "pond" for the first time in the 1970s, with "prairie," "seagrass," and "wetland" in the 1980s, with "aquatic," "coastal," "estuarine," "grassland," and "stream" in the 1990s, and with "coastal" and "coral" in 2000–2002. The percentage of articles in Estuaries that have the keyword restoration indexed in SCI climbed from none in the 1970s to 0.5% in the 1980s, 3.1% in the 1900s, and 7.2% from 2000 to 2002. The journal "Restoration Ecology" was initiated in 1993.

The same methods were used to trace the development of interest in wetlands science and then the "applied" science leading to restoration (Fig. 1). The number of references to a scientific article discussing wetland and "restoration" by

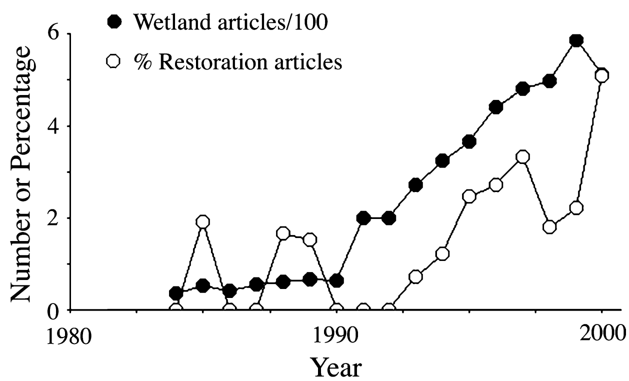


Figure 1. The development of interest in wetlands science and then the "applied" science leading to restoration. The number of references to a scientific article discussing both "wetland" and "restoration" by year of the article's publication date is from the SCI, and the percentage of wetland articles concerned with restoration was calculated from this dataset (adapted from Turner & Streever 2002).

year of the article's publication date is from the SCI; the percentage of "wetland" articles concerned with "restoration" was calculated from this dataset (adapted from Turner & Streever 2002). The percentage of articles on wetlands that are also on restoration lags a few years behind the rise in the number of wetland articles, and is climbing.

Thus, the scientific literature increasingly appears to be focused on restoration in the past three decades, and this interest is accelerating. A cynical interpretation of these indicators is that scientists are merely opportunistic scavengers following funding opportunities. I would like to think that the trends reflected in this brief analysis are, at least partially, the result of their sustained social engagement and quiet leadership in an area they care about as much as the lay public that funds much of restoration.

## Who Authors Professional Articles on Restoration?

An index of who is contributing to the new field of restoration science is revealed in the authorship of articles appearing in the SCI. Articles appearing in Estuaries that have "restoration" in a keyword search (3 September 2003; for articles appearing from 1970 to 2003) are dominated by first authors from educational institutions. There were 55 articles from 1970 to 2002, of which 67, 14, 9, 5.5, and 3.6% had authors from universities, federal agencies, state agencies, nonprofit laboratories, and private organizations, respectively.

The numerical distribution of citations of these articles in Estuaries was conducted using the same data described above. Eighty percent and 13% of all citations to all "restoration" articles published in Estuaries from 1970 to 2003 were citations of articles written by authors from universities and state agencies, respectively. The affiliations of authors for 10 articles received 69% of all citations (representing 18% of all papers). Eight and two of these 10 papers were by authors at universities and state agencies, respectively. Three papers in Estuaries receiving the most citations were authored by university scientists and had 35% of all citations. If there are any university scientists feeling a little competitive or smug as a result of this comparison with their governmental colleagues, then I'd like to point out that the 76% of the papers with no citations were also authored by university scientists. Compared to university scientists, government scientists have equivalent citation rates, but author fewer articles.

Reviews of the sources of all papers and the highly cited papers, or "classics" in ecology and oceanography also show that the address of authors has been overwhelmingly from educational or nonprofit institutions, and are not from government or industry (Officer et al. 1981; Garfield 1987; McIntosh 1989; Turner & Schubel 1994).

## A Role for Science in Restoration: Is Science Necessary?

> "To accept a conjecture as a solution is pseudo science. Science begins when we subject conjectures to critical evaluation and experimental tests that have the potential for refuting them."
>
> (Harper 1990)

> "True science teaches us to doubt and, in ignorance to refrain."
>
> (From Bernard [1957], quoted by Harper 1990)

A scientist's role is, in part, to reveal significant details by observation, experiment, and insight and by using exploratory models. In this way the scientist contributes to quantitative and critical thinking skills that may lead to useful predictions. The science that results brings clarity to a situation, and clarity in restoration efforts brings efficiency in the use of public funds, trust in the outcomes proposed, a broader acceptance of the uncertainties, and a higher probability for doing additional projects. Clarity might come in the form of accurate descriptions, but these descriptions may or may not be explanatory. Clarity may also be revealed in the discovery of causal relationships. When speaking favorably of the role of science in society, H. T. Odum (1924–2002) often said: "the shortest path to a solution is understanding." Together the new descriptions and understandings may add only a few details to our view of how things "work," but substantially alter our perceptions and change conclusions with the piece-by-piece accumulation of details (Fig. 2).

Although clarity can be added, uncertainties will persist because we may never know enough about a problem within the time frame of a restoration project implementation schedule. But even in the absence of sufficient accuracy (accuracy should not to be confused with precision), science can make predictions of uncertainty or even chaos. The uncertainty might be quantified as a "bounds of expectation" for a restoration trajectory (Weinstein et al. 1996) or ensconced within a wetland mitigation permit that includes a requirement to attempt to build more wetland area than lost to compensate for probable mitigation failure, thus increasing the likelihood that there is no net loss of wetland area.

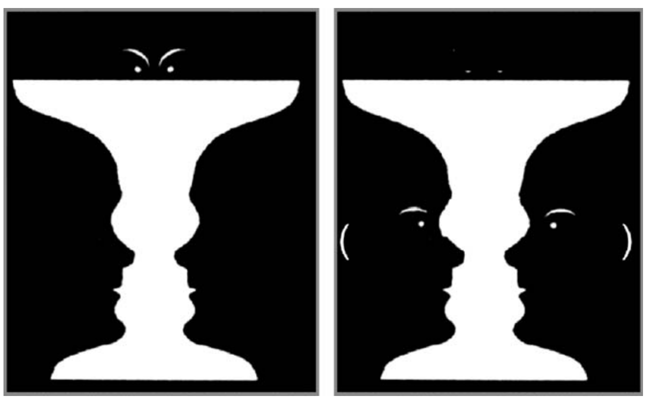

Figure 2. The addition or subtraction of only a few details covering less than 1% of this picture drastically affects perceptions. The conclusion does not, however, reveal definitive details, but only broad outlines of familiar (symbolic) constructions.

The above material is not meant to imply that scientists are the only ones bringing clarity to a restoration program and who can be auditors of logic. Science, however, has proven particularly useful, not because scientists are better people or more objective than others, but because of the methods used and training that leads to an enhanced willingness to ask penetrating questions. These methods implicitly and explicitly actively incorporate the indulgence of doubt and skepticism. The hypothetical-deductive (HD) method, for example, is primarily about testing ideas in a way that can lead to their falsification, if false. The acceptance of a hypothesis is an interpretation occurring after these tests. Acutely precise and accurate descriptions are communicated in a way that allows for others to repeat the process(es) leading to an author's conclusions. It is a public ventilation that retains tolerance for a certain amount of the arm-waving and self-promotion. That professionals can conduct thoughtful peer reviews and build professionalism even while disagreeing is something valued as essential within the scientific community, and something that can thrive in any professional environment under the right conditions. Scientific efforts, at least the healthy efforts, support a process of discovery that is more expansive than the numbers, the statistics, and the equipment used by the practitioners. Indeed, well-funded laboratories occupied by poorly administered and frustrated scientists may contribute much less than a lesser-equipped laboratory of inspired individuals that think clearly.

One way to illuminate some of the qualities of scientific enterprises is by contrasting them with others to show what they are not about. Scientists, for example, are interested in ideas, whereas, as Parkinson (1962) described in a humorous way many times, politicians and, to some extent, bureaucrats are interested more in reducing conflict, opposition, etc., to a position taken. Understanding and revealing immutable fundamental relationships is the province of scientists, whereas compromises are a means to develop political consensus. This may seem a simplistic outline, but in practice, at meeting after meeting, one sees the attempted compromise of how nature works, by legislation, argument, and attempted agreement. Nature, however, sets her own laws independent of a legislative body. In the interest of compromising to reach a policy agreement, the truth may be subsumed to an irrational set of assumptions. Science, at least healthy science, is concerned with quantification, predictability (accuracy and precision), and doubt. Of these, doubt is the last thing a politician wants to hear about or assume responsibility for, and the first thing an engineer wants to eliminate. Furthermore, a science culture may view failures as a learning experience, but a management culture views them as mistakes. These "mistakes" may demonstrate the range of possible ecosystem behaviors, so that we know how the system "works" and is sustained. Cost is probably of lesser concern to scientists, because truth (presumably) is the primary target. The interests in outcomes for scientist and manager are not the same, and so the pressures for professionalism are different (Bella 1996; Mattson 1996; Zemansky 1996). Although the essential roles and strengths of science are fundamentally different from those found within the social structure of government, private industry, or politics, they give essential value in discussions of how public resources are managed, used, misused, abused, and restored. Rykiel (2001) said it this way: "The work of scientists is to understand *what is* and how what is can lead to what might be. The work of policymakers is to wrestle what is and what might be into what ought to be."

## Ideas

> "You are like a mouse who wishes to impregnate a tiger, and the tiger is not even in heat."
>
> St. Aquinas

Many useful ideas will be new because habitat restoration is a relatively new field and needs the application of accurate ideas, and has room for general guidelines and principles. For ideas to be a useful and accurate part of restoration, ideas must be welcomed and timely, and neither hoarded nor dismissed before testing because they are threatening. The quality of ideas may be deficient in some way and still be acceptable, if not useful, when they provide accurate predictions. Science certainly should attempt to slaughter ambiguous ideas and diminish uncertainty. I am persuaded that, for better or worse, the success of ideas varies in a way that is sometimes chaotic, and that it is dependent on our sensitivities to the qualities of the intended audience to whom the information is presented, and on the social network from laboratory to editor, and from panel review to rejection/success. Ideas may also fall prey to entrained or rigid behaviors, of course. Scientists are, like everyone else, subject to the personal and societal vanities and graces of being human.

Ideas, whether partially useful or not, may either fail or be influential for vastly different reasons. If we think about what our fundamental intentions are with regard to the role of science, then we may sometimes see reasons why we want to, and need to, improve our level of professionalism, which, when accomplished, will simultaneously improve prospects for the utilization/testing of ideas. Four categories of how ideas become part of decisions are outlined in Table 1 (adapted from Elzinga 1997). On one extreme, valid ideas may be untimely or be packaged too poorly to be acceptable. For example, the labor organizer Alinsky (1972) suggested that if one "were organizing in an orthodox Jewish community, I would not walk in there eating a ham sandwich" because it would be unnecessarily offensive, though unintentionally so, and so one would be shunned. On another, more onerous level, ideas may be dismissed because a dominant minority (inside and outside science circles) finds them unacceptable for strictly political reasons. For a second set of reasons, decisions may be made when ideas or data are not presented,

**Table 1.** Closure of debates on scientific efforts—four approaches and one to support (adapted from Elzinga 1997).

| *Approach* | *Main Reasons for Closure of Debate* |
|---|---|
| 1: Social structure | dominant political structure (control) or lacking social acceptability |
| 2: Group politics | superior political/economic/social resources (based on need to effect closure, and not on knowledge; e.g., perceived time limitations) |
| 3: Sociology of networking | superior persuasiveness or scientific networking knowledge, ability in the micropolitics of the scientific community and funding controls, hence superior knowledge (e.g., the "tobacco lobby" approach, a.k.a. "good-ole boys club" and the politics of exclusion) |
| 4: Positivist | superior knowledge (an open process that includes skeptics, strangers, and ambiguities). Characterized by an allegiance to complete knowledge and understanding, and to include risks, ventilation and inclusivity in discussions |

perhaps because of superior networking skills but also because of time limitations. An idea may be erroneous, but still be acceptable (and lead to poor decisions) for several reasons. For example, an erroneous idea may succeed over an alternative because of the quality of communication skills when the ideas are discussed, or because the politics of exclusion prevent a full ventilation of facts, logic, or intentions. A third approach to making decisions is to test, or fund to test, a limited set of predetermined and acceptable conclusions—the so-called Tobacco Lobby approach—which is a kind of "policy of exclusion" or "limited entry" into the decision-making process. A fourth "positivist" approach is to actively encourage the development of fundamental understanding and choices before the tyranny of consensus or time limitation forces premature closure. The lesson from the discussions leading to the Global Climate Change documents is that the most desirable approach is to be inclusive, especially with skeptics or doubters, and in an open and well-ventilated way (Elzinga 1997). Those that purport to want the best science in their management program might think about how to explicitly address uncertainty when making decisions. Doubt, after all, is a signature characteristic of the HD method and experimentation.

Does project size influence the introduction of ideas and the administration of restoration projects? The size range of restoration projects in the United States is four orders of magnitude and may affect the way science is conducted within projects. Most restoration projects tend to be small, although some are relatively large (>10,000 acres; e.g., Kissimmee River, Hackensack Meadows, Florida Everglades). For example, Mager (1990) provided data on 2,009 wetland dredge and fill applications made between 1981 and 1990 processed by seven U.S. Army Corps of Engineers districts. The average size of the permit issued was 172.6 ha, for permits varying between 0.3 and 1,310 ha. Mathews and Minello (1994) reviewed the success of 69 wetland restoration and creation projects on the Atlantic and Gulf of Mexico coast. The average size of projects was 1.5 ha (± 3.7 ha; ± 1 SD; $n$ = 69). The National Research Council (NRC 2001) conducted a meta-analysis of 13 state wetland mitigation programs that had data on project sizes. The average size of all studies was 23.6 ha, and ranged from 1 to 110 ha.

Peterson (1993) described his experience with how scientists work in small and large research projects (Fig. 3). He hypothesized that the individual creativity of people is

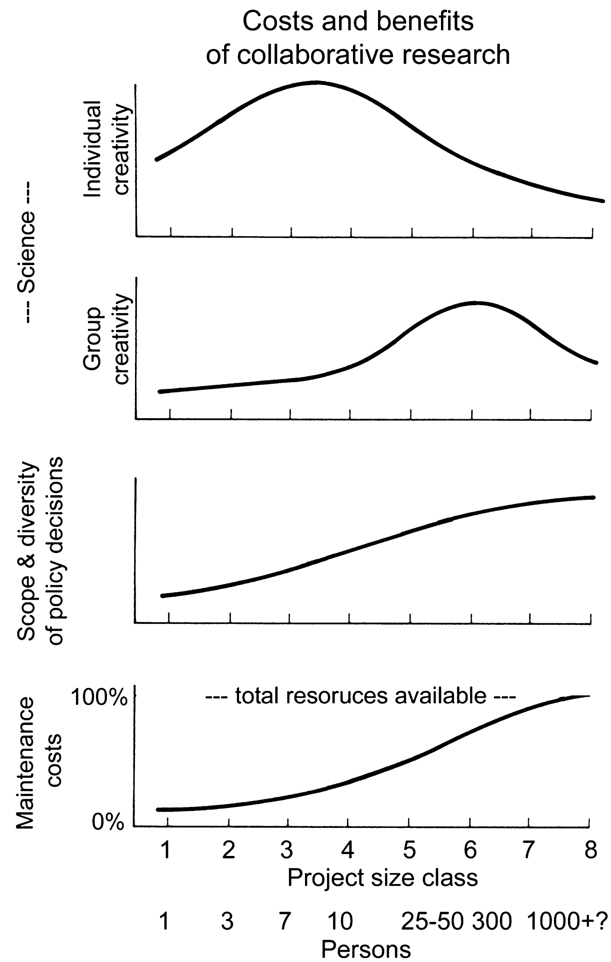


Figure 3. Changes in individual and group creativity, the scope and diversity of policy decisions, and of maintenance costs with increasing project size. My estimate of persons involved with each project size class is included. Adapted from Peterson (1993).

higher when they are in small focused groups than when they are in larger groups. One can appreciate that smaller groups, compared to larger groups, may be able to manage some of their own affairs with greater intimacy and effectiveness, and thus improve chances to create a healthy intellectual environment. Larger groups face a greater diversity of policy decisions and require a relatively higher commitment to maintenance (i.e., funds). His interpretations are consistent with an analysis of some coastal restoration projects in Louisiana, whose cost per habitat gained rises exponentially with increasing project size (Turner & Boyer 1997). One implication of this aspect of restoration is that introducing science into large, compared to small, projects will be more difficult, if only because ideas are developed at the individual level, and the organizational structure tends to demand more of the group effort as size increases, especially if the administrative hierarchy is a "command and control" unit unaccustomed to tolerating serious debate.

## Reciprocal Societal Interrelationships

What makes for a successful restoration program when viewed at a societal level? Are there good predictors of success (and failure)? LaPeyre et al. (2001) addressed both of these questions in an interesting and straightforward way, using a traditional scientific analysis, and with results that nonscientists might appreciate. They conducted a statistical analysis of factors influencing wetland protection and management in 90 nations. The measure of success was an amalgam of several indicators of wetland protection, including the number of Ramsar sites and when they received designation, the total wetland area protected, and the percentage of wetland area protected. Various social and economic factors were examined to see how much they influenced the dependent variable (wetland protection). The independent variables included national indices developed by others on (1) social capital (e.g., health and education); (2) economic indicators (economic growth, trade, per capita earnings, investment); (3) governmental characteristics (various indicators of shared governance and openness); (4) environmental characteristics (air and water quality, government actions in protection treaties, and citizen participation); and (5) land pressure (primarily agricultural development).

The essential points of what they found are outlined in Figure 4. The factors that had a positive influence on the quality of wetland protection and management were the quality of the environment, the openness and inclusiveness of government, the quality of the nation's social development, and, lastly, the expansion of agriculture. A negative influence was the degree of economic capitalization. I interpret these results as support for the following conclusions. First, the scarcity of wetlands brings appreciation for their losses and value, so that when agricultural expansion results in a regression of wetland area, then people and governments tend to respond with a heightened sense of the need for wetland protection/management. Second, this response is more likely to occur when citizens appreciate environmental quality and also have the means of responding. But this favorable response is more likely to happen when the governmental structure is receptive to these reactions through all types of interactions, including those through local, regional, national, and nongovernmental organizations. The negative relationship between wetland protection and indices of economic capital is due to the pressures for using the wetland area or capturing the social services of wetlands (a public benefit) for private gain. Greed, in other words, is not known as being an altruistic social attribute, or, to put it more benignly, economic activity is an imperfect measure of the general welfare.

These conclusions lend support to the idea that there are reciprocal interactions between restoration of habitats and ecosystems, and the society's interests or appreciation for them. If social capitalization is necessary to initiate and sustain restoration, then isn't there a positive feedback between restoration and the health of a society (and I will leave the definition of "health" for the readers to interpret in their own situation—I am asking only for one to think about it)? It was only a few hundred generations ago that our ancestors lived without written communication, having evolved to that state in intimate contact with the natural world by using all of their senses (Abram 1996; Chapter 1). This inheritance has brought with it individual and group preferences that are subtly hidden in the social matrix, e.g., an aversion to unequal rewards for equal work (Brosnan & de Waal 2003), decisions about cooperation or defectors in group dynamics (Semmann et al. 2003), and changes in altruism as population density rises (Levine 2003). I think it a reasonable conclusion that the restoration of a few hectares of habitat is, potentially at least, also a project about societal renewal and health. In the process of restoring ecosystems, individuals and society are reestablishing their relationships with the larger environments they live in, depend upon, learn from, and which many believe must be nurtured if the much-used term "ecosystem sustainability" has meaning.

## Conclusions

> "It is not necessary to 'go back' in time to be the kind of creature you are. The genes from the past have come forward to us. I am asking that people change not their genes but their society, in order to harmonize with the inheritance they already have."
>
> (Shepard 1996)

> "In speaking of a natural thing most men assume a natural law. All things in nature are governed by this law. Man begins by saying, 'of course,' before any of his senses have a chance to come to his aid

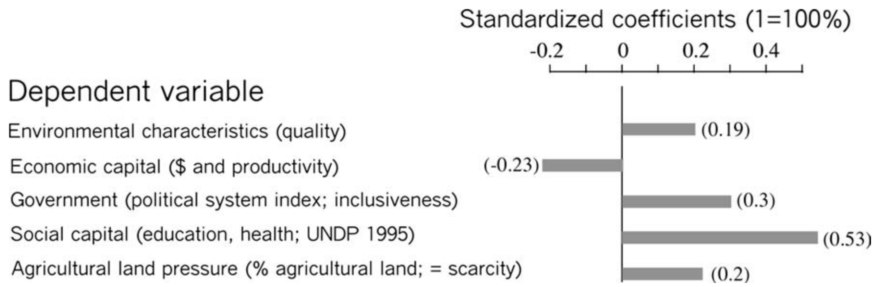


Figure 4. A statistical analysis of factors influencing wetland protection and management in 90 nations (conventions, area, participation). Values greater than 0 or less than 0 indicate positive (direct) or negative (indirect) relationships with the independent value. Adapted from LaPeyre et al. (2001).

> with wonder and surprise. The result is that he dies and his neighbors and his friends murmur with the wind, 'of course.' The love of bird or shell which might have restored his life flies away carried by the same wind which has destroyed him."
>
> (from the journals of Walter Anderson, quoted by Sugg [1985:82])

One strong conclusion that I see flowing from the above discussion is that the inclusivity of all of society has a better chance to build strong restoration programs than a narrowly supported program. Both good science and social capital are essential elements of restoration success (here I disregard how "success" is defined). Scientists will recognize this reciprocity and their own professional strengths and weaknesses while engaging management interests in a socially responsive way. But to be effective, scientists must be competent and have access to the tools, skills, resources, and time to adapt to changing conditions. If there is an electrical problem in your business, then you won't hire a plumber, but will want to hire a competent electrician with knowledge of the local building codes and a working knowledge of the wiring within your building. Conversely, a dysfunctional apprenticeship program for young electricians (or scientists) hinders social progress.

Some conclusions or recommendations come to mind, as a way of crystallizing how science and restoration are interrelated to affect positive policy developments that are also unprecedented societal developments.

- Support for curiosity-driven science is not a luxury, but an essential part of management and governance. It is the seed of successful adaptation to change, and requires long-term support. A parallel argument can be made that management should be flexible enough to adapt to changing conditions and understandings. Exposure to, and training in, interdisciplinary studies is strongly recommended.
- The existence of regional science resources means that it is possible to have self-reliance in public discussions about the restoration of natural resources, which usually are public resources and restored in small chunks. It is, therefore, essential to build and maintain regional science resources.
- Natural scientists, social scientists, engineers, and managers should work toward a professional ethos of encouragement throughout all aspects of restoration, from experimental design and information exchange, to the inclusion of multiple approaches. This professionalism extends beyond the science, the dollars generated, and the number and quality of publications to the whole of the person, in the same way that restoration of habitats is about more than just the ecosystem, but also society.
- A strong sense of inclusivity and egalitarianism in science and management reflects the practical aspects of natural resource management, the way ecosystems work, and the aspirations of the humans living among them, and studying and managing them.
- Restoration is more than putting habitats on a shelf or trophy case—the "we have one of those in the park" attitude—and extends to our relationship to the whole, including water quality, species survival, etc., and also how we reject or modify the seventeenth century industrial model of viewing the natural world as something to exploit.

Costanza (2001) posited that there were two contrasting cultural species in the past century, *Homo economis* and *Homo naturalis. Homo economis* valued individual preferences reflecting strong interests in economic efficiencies, and was more persuasive than *H. naturalis*, which was concerned more with sustainability, ecosystem integrity, and group preferences. Restoration is a social construct and argument that *H. naturalis* might find acceptable and then essential as projects are successfully and widely implemented in this century. It has possibilities for bringing rise to some balance, if not agreement, out of the debate between the two species, which is a complicated engagement that includes all kinds of obvious, subtle, and hidden interrelationships mingled throughout society.

A general point, then, is that being involved in restoration is a great way to restore not only the environment but also society. Being involved in restoration engages participants in several broadly defining ways (Table 2). Doing so makes it natural for the participants to ask not only "what" can be done, but "why," thereby moving from an emphasis on the tools or technical abilities, to the critical thinking of the toolmaker, and from competition

**Table 2.** Summary of some positive aspects of involvement in restoration projects and programs.

| From | To |
|---|---|
| What to do (tools) | why to do (the education of the toolmaker and tool user) |
| Fixation on outcomes (ends) | emphasis on ideas, means, and path |
| Top down (boss) and competition | shared governance, professional-level cooperation, acknowledgment |
| Presumed (illusional) net gain (the "no limits to growth" scenario) | zero sum gain (sustainable) |
| Temporary, false sense of accomplishment or stability | long-term maintenance; some headaches, but fulfilling |
| Introduction to the "real world" comes later | present situation is as good a place as any to be involved in restoration; the sooner the better |

to cooperation. The venues, means, and approaches involved will not result in homogeneity among projects and programs and will experience continued changes. It will be healthier, I think, to promote diversity rather than hierarchy, controlling oversight (boss or hero-worship), or competition.

The facts are that equability, fairness, inclusivity, etc., benefit our day-to-day interests in ecosystem restoration, a healthy society, and in our own lives. We can neglect or sustain these connections, and they will evolve. We have a choice to participate in that evolution, or to let external influences push us along to what is going to be a less desirable outcome. The same is true, I think of the academic scientists and their institutions involved in restoration. It is sometimes said at graduation ceremonies that students will now enter into the "real world" and find out "what it is really like." What does that say about their experience with higher education? That it is "unreal"? An alternative hypothesis is that institutions of higher education, which the majority of young adults now enroll in, may be a distinguishable sector of society, and that every moment spent there has the same potential to affect how we relate to the larger world, and that this effect extends as deeply into waste recycling, governance, personal relationships, corrective actions, etc., as any other sector. There can be restoration of all of the natural world and society, and I think this must be done simultaneously, because that is the only way that it will end up being sustainable. Getting involved in restoration only makes this conclusion that much more obvious and is a great way to fulfill educational goals.

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## LITERATURE CITED

Abram, D. 1996. The spell of the sensuous. Random House, Inc., New York.

Alinsky, S. D. 1972. Rules for radicals: a pragmatic primer for realistic radicals. Random House, Inc., New York.

Bella, D. A. 1996. The pressures of organizations and the responsibilities of university professors. BioScience **46:**772–778.

Brosnan, S. F., and F. B. M. de Waal. 2003. Monkeys reject unequal pay. Nature **425:**297–299.

Costanza, R. 2001. Visions, values, valuation, and the need for an ecological economics. BioScience **51:**459–468.

Elzinga, A. 1997. From Arrhenius to megascience: interplay between science and public decision making. Ambio **26:**72–80.

Garfield, E. 1987. Which oceanography journals make the biggest waves? Current Contents **48:**3–11.

Harper, A. E. 1990. Critical evaluation—the only reliable road to knowledge. BioScience **40:**46–47.

LaPeyre, M., I. A. Mendelssohn, M. A. Reams, P. H. Templet, and J. B. Grace. 2001. Identifying determinants of nation's wetland management programs using structural equation modeling: an exploratory analysis. Environmental Management **27:**859–868.

Leopold, A. 1949. A Sand County almanac and sketches here and there. Oxford University Press, New York.

Levine, R. V. 2003. The kindness of strangers. American Scientist **91:** 226–233.

Mager, A. Jr. 1990. National Marine Fisheries Service habitat conservation efforts related to Federal regulatory programs in the southeastern United States. National Oceanic and Atmospheric Administration, Washington, D.C. NOAA Tech. Memo. NMFS-SEFC-260.

Marsh, G. P. 1885. The earth as modified by human action: a last revision of man and nature. Charles Scribner's & Sons, New York.

Mathews, G. A., and T. J. Minello. 1994. Technology and success in restoration, creation, and enhancement of *Spartina alterniflora* marshes in the United States. Volume 2. Inventory and Human Resources

Directory. NOAA Coastal Ocean Program, Decision Analysis Series No. 2. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Washington, D.C.

Mattson, D. J. 1996. Ethics and science in natural resource agencies. BioScience **46:**767–771.

McIntosh, R. P. 1989. Citation classics of ecology. Quarterly Review of Biology **64:**31–49.

NRC (National Research Council). 2001. Compensating for wetland losses under the Clean Water Act. National Research Council. National Academy Press, Washington, D.C.

Officer, C. B., L. E. Cronin, R. B. Biggs, and J. H. Ryther. 1981. A perspective on estuarine and coastal research funding. Environmental Science and Technology **15:**1282–1285.

Parkinson, C. P. 1962. In-laws and outlaws. Houghton Mifflin Co., London, United Kingdom.

Peterson, B. J. 1993. The costs and benefits of collaborative research. Estuaries **4:**913–918.

Rykiel, E. J. Jr. 2001. What is, what might be, and what ought to be. BioScience **51:**423.

Semmann, D., H.-J. Krambeck, and M. Millnski. 2003. Volunteering leads to rock–paper–scissors dynamics in a public goods game. Nature **425:**390–393.

Shepard, P. 1996. The only world we've got: a Paul Shepard reader. Sierra Club Books, San Francisco, California.

Siry, J. V. 1984. Marshes of the ocean shore. Texas A&M Press, College Station.

Sugg, R. S. Jr, editor. 1985. The Horn Island logs of Walter Inglis Anderson. University Press of Mississippi, Jackson.

Thesiger, W. 1964. The Marsh Arabs. Penguin, Harmondsworth, United Kingdom.

Turner, R. E., and M. E. Boyer. 1997. Mississippi River diversions, coastal wetland restoration/creation and an economy of scale. Ecological Engineering **8:**117–128.

Turner, R. E., and J. R. Schubel. 1994. Research and development funding for coastal science and management in the United States. Pages 155–164 in National Research Council. Environmental science in the coastal zone: issues for further research. National Academy Press, Washington, D.C.

Turner, R. E., and B. Streever. 2002. Approaches to coastal wetland restoration: Northern Gulf of Mexico. SPB Academic Publishing, Den Hague, The Netherlands.

UNEP. 2001. The mesopotamian marshlands: the demise of an ecosystem. Early Warning and Assessment Technical Report. H. Partow, editor. UNEP/DEWA/TR.01–3 Rev. 1. United Nations Environment Programme, Nairobi, Kenya (available from: www.unep.org).

Weinstein, M. P., J. H. Balletto, J. M. Teal, and D. F. Ludwig. 1996. Success criteria and adaptive management for a large-scale wetland restoration project. Wetlands Ecology and Management **4:**111–127.

Zemansky, G. M. 1996. Ethical tensions in technical consulting. BioScience **46:**778–782.