New Natures and Old Science:
Hands-on Practice and Academic Research in Ecological Restoration

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Ecological restoration is a growing field in many parts of the world. Although it started as a field of practitioners in the Midwest of the USA, restoration is currently growing rapidly as an academic discipline. In this paper the development of ecological restoration is discussed by relating it to the propagated Mode 2 for the dynamics of science and research in contemporary societies, that is, the shift from traditional discipline-based research (Mode 1) to a problem-solving and transdisciplinary form of science (Mode 2). It is argued that ecological restoration as understood here at times includes the elements that have been claimed to indicate a Mode 2 form of science, but the historical extrapolation of the development of restoration discloses a social shifting of boundaries back-and-forth on an ongoing recursive loop between the two forms of science. This suggests a recursive interdependence between the two Modes, including phases of 're-traditionalization' back to Mode 1, rather than a general replacement of discipline-based research.

Keywords: ecological restoration, boundary work, Mode 1 and Mode 2, new production of knowledge

Ecological restoration is a rapidly-growing but controversial practice. The idea of the restoration of ecosystems is normally understood as a step beyond one-sided conservationist and preservationist strategies of traditional environmentalists and attempts at protecting nature. It is regarded as a development away from the ideal type of a 'hands-off' strategy on the part of the environmental movement designed to protect nature from human influence, to an active attempt to re-create, invent, design, or restore ecosystems (cf. Baldwin *et al.*, 1994; Jordan *et al.*, 1987; Stevens, 1995). A distinctive feature of ecological restoration is that the human influence on the landscape and the shaping of nature is not always perceived as bad.

Although the terms restoration and ecological restoration have come to play an important role in discussions relat-

ing to the environment and environmental policy over the past decade, especially in the USA, there is still no generally accepted definition of the terms, and different authors and groups understand them quite differently. The *Society for Ecological Restoration* (SER) defines ecological restoration as "the process of assisting the recovery and management of ecological integrity. Ecological integrity includes a critical range of variability in biodiversity, ecological processes and structures, regional and historical context, and sustainable cultural practices."[1] Many of the practitioners in the field of ecological restoration employ strategies of adaptive management with major parts of the work and planning undertaken by lay people and community organizations. Beginning in the late 1970s, the core strategy was that hands-on practitioners, although they may have little or no formal training in academic ecology, often achieve insights that contribute to and even challenge existing ideas about the ecology of the system being restored (Jordan, 1994). The effect of this is that the academically-based scientist becomes just one of a number of participants involved in restoration. Thus, ecological restoration from its beginnings was practice-oriented and was carried out by amateurs who learned as much ecology as they needed for restoring ecosystems. In attempts to restore nature the hands-on practitioners try to mimic the forces of nature, and in doing this they are in a position to achieve a peculiarly intimate relationship with nature that one cannot get by academic training.

Thus, for some authors this stream of environmental activism has – at least implicitly – been treated as a new kind of science that is on its way to transforming traditional disciplinary boundaries. Practitioners and observers of ecological restoration alike have applied various labels indicative of its novelty. Some talk of a new and sensitive natural science (Helford, 1999), a community science (Lee & Roth, 2001), a nature-healing science (Packard, 1988), a merging of science and artistic creation (Turner, 1987), or simply of a new paradigm and a new communion with nature that shakes our traditional understanding of science (Jordan, 1991; 1994; 2003). With surprising unanimity, these descriptions veer towards the same conclusions as those arrived at in recent social analys is of science that proclaim a general change in science in the form of a new mode of knowledge production that is emerging and will have profound implications for our understanding of science in the future. These consequences would be for instance a future of transdiciplinary science (Gibbons *et al.*, 1994; Nowotny, 1999; Nowotny *et al.*, 2001), a loss of natural scientific authority (Yearley, 1997), or even the general declaration of a new age of post-academic (Ziman, 1996) or post-normal (Funtowicz & Ravetz, 1993) science.

Although restoration started as a field of practitioners in the Midwest of the USA, it is currently undergoing dramatic growth as an academic discipline (Young, 2000). While none of the self-descriptions of practitioners and the analysis of ecological restoration mentioned above should be regarded as misplaced or wrong, a long-term perspective on the development of ecological restoration over the last quarter of a century shows a 'smoother' picture; that is, of a recursive development between academically

oriented research and practice oriented research that at times includes the 'ingredients' of a new form of science, e.g., citizen involvement, lack of disciplinary or academic context, or the solution of defined 'social' problems. In the following I will scrutinize the developments of ecological restoration by relating them to a propagated Mode 2 for the dynamics of science and research in contemporary societies, that is, the irreversible shift from traditional discipline-based research (Mode 1) to a problem-solving and transdisciplinary form of new science (Mode 2) as propagated most prominently by Gibbons *et al.* (1994).

By way of an illustrative example, I will show that ecological restoration – as understood here – at times includes all the evidence that has been claimed to indicate a Mode 2 form of science and thus might seduce observers and participants into believing that a fundamental and radical change is on its way. Restoration, due to its orientation, at first sight appears to be an example *par excellence* of an in-context mode of knowledge production, the so-called Mode 2. The historical extrapolation of the development of restoration ecology suggests, however, a prolific recursive process between the two forms of science with shifting boundaries (cf. Gieryn, 1995; 1999), rather than a radical replacement of discipline-based research.

To begin this task I will first outline briefly what is implicated by the buzzwords Mode 1 and Mode 2 as well as the talk of a new production of knowledge and how the theory of boundary work can be knit together with the latter. Then I will relate the field of ecological restoration to this debate in order to show that an extrapolation over the last 25 to 30 (if not 70) years of restoration work – rather than picking one spot or project at a certain time – suggests that ecological restoration is a field that has evolved in a process of "recursive learning" (Krohn, 1997) between Mode 1 and Mode 2 knowledge production, where the perimeters dividing science from non-science are in a process of continuous negotiations or 'boundary work' (Gieryn) with the goal of gaining 'epistemic authority.' This suggests an understanding of restoration as a recursive procedure where academic research and hands-on practice both feed off each other and become better defined and refined in the process. The thesis of recursive development and shifting – and sometimes blurring – boundaries, is underpinned by outlining the current perplexity of academic scientists about the social embeddedness of restoration projects. The conclusion of this paper tries to come to some preliminary assessment of this perplexity.

A New Mode of Knowledge Production and the Boundaries of Science

The "new production of knowledge" propagated by Gibbons *et al.* (1994) has received a lot of attention in recent years, both supportive and dismissive.[2] Recently some of the authors of *The New Production of Knowledge* have even proclaimed a Mode 2 society (Nowotny *et al.*, 2001: 47), where one of the contexts that indicates a Mode 2 society is that "it has become increasingly difficult to establish a clear demarcation between science and society". The relevant contrast in this proclaimed shift of the dynamics of science and research in today's societies is between problem-solving (which

is carried out following the codes of practice relevant to a particular discipline – Mode 1) and problem solving which is organized around a particular application, so called Mode 2. In the former, the context is defined in relation to the social norms that govern academic science. This, as the authors suggest, has tended to imply knowledge production carried out in the absence of some practical goal. In the new Mode 2, by contrast, knowledge results from a broader range of considerations. Such knowledge is intended to be useful to a certain group in society and this imperative is present from the beginning. It is generated and sustained in the context of application and not developed first and then applied to that context. Knowledge thus produced is always produced under an aspect of continuous negotiation with all groups involved, including those that have non-scientific, that is, non-discipline-specific or academic interests.

The pivotal point in Gibbons *et al.* (1994: 11) is that the world is witnessing a dramatic shift both in the institutional context of knowledge production and in the kind of knowledge that is being produced. The authors contend that this process is well under way and is in fact "irreversible". Traditional research is Mode 1, in which there are narrow fields of study and separate roles, with academics developing the knowledge and passing it on to the practitioners. Understood in this way, Mode 1 science had no interactions with broader societal concerns. Knowledge in Mode 2 is produced in the context of applications characterized by a problem-solving approach to specific social goals and social usefulness, as opposed to a context governed by the interests of an academic community. In Mode 2 knowledge is produced by a transdisciplinary team that also includes practitioners and other interest groups. The learning is immediate for all and it is part of the discovery process. Solutions to problems generated are beyond the resources of practitioners within a single discipline and "knowledge will not be produced unless and until the interests of the various actors are included" (Gibbons *et al.*, 1994: 4). Thus, criteria like aesthetic preferences or cost-effectiveness become as important as peer review based on disciplinary considerations. Hence, in Mode 2 the shape of the final solution will normally be beyond that of any single contributing discipline. That is why Gibbons *et al.* believe that it will be transdisciplinary. Transdisciplinary knowledge is to develop its own distinct theoretical structures, research methods, and modes of practice.

Since Mode 2 is marked by the ever closer interaction of knowledge production with a succession of problem contexts, the social organization of this kind of research takes place in more egalitarian frameworks in constellations and teams that operate in more informal social networks (cf. also Ziman, 1996). Contrary to Mode 1, where research results are communicated through institutional channels, in Mode 2 results are communicated to those who have directly participated in producing them. Thus, the distribution of science is accomplished in the process of their production. Furthermore, peer reviewed journals which establish the scientific credentials that allow scientists to gain status and credibility in a certain disciplinary scientific community are virtu-

ally non-existent. Journals are forums where practitioners from different backgrounds can present their ideas and findings.

Unlike the theory of a Mode 2 in knowledge production that claims a new form of science for the future, the work of Gieryn (1995; 1999) is concerned with the creation and maintenance of boundaries between science and non-science, and between disciplines which have different knowledge bases, methods, and practices. It is the negotiation of definitions of the boundaries of science, where people argue over and ultimately decide what is scientific and who is a scientist amidst contests for credibility, prestige, power, and material resources. Gieryn understands boundary-work as those moments when the question of "What is real science?" is explicitly discussed. To this end, boundary-work is understood as a process of defining a social boundary distinguishing science from non-science which is driven by the need to establish the legitimacy and epistemic authority of science, that is, "the legitimate power to define, describe, and explain bounded domains of reality" (Gieryn, 1999: 1).

Gieryn's notion of boundary work will therefore be utilized in my analysis of the development of ecological restoration. In the following I will use this concept to demonstrate that the demarcation between Mode 1 and Mode 2 can be a useful framework that does not appear to be a set of "rules for proper fact-construction, but [...] rhetorical tools deployed in the pursuit or defense of epistemic authority, or in efforts to deny legitimacy to rival claims" (Gieryn, 1999: 362). I will show that all of the above-mentioned features of a Mode 2 in knowledge production have, since the 1970s, *at certain times and places*, held true for the field of ecological restoration, at least as practiced in certain areas of the United States. More specifically, I will highlight some of the historical cornerstones in the development of ecological restoration since World War II and will discuss in more detail the interpretation of this work and its implications for the relationship between humans and the rest of nature as developed since the 1970s, first in the Mid-west of the USA and subsequently in other parts of the world. What I propose is that in the case of ecological restoration, as practiced in many parts of North America, there is a shifting of boundaries between Mode 1 and Mode 2 rather than an irreversible shift from Mode 1 to 2. The thesis for the following pages is that – contrary to the "Gibbonsian" hypothesis – Mode 2 is by no means superior or more timely than Mode 1, but rather that the two Modes belong to one complex and are reciprocally dependent on one another.

Doing it Nature's Way: The Formation of Ecological Restoration

Ecological restoration has only begun to attract the attention of a larger number of people interested in environmental issues since the late 1980s. However, neither the idea nor the practice are entirely new. One could say that humans have practiced ecological restoration ever since farmers discovered shifting cultivation. The first attempts of proto-restoration, however, can be traced to the landscape architects Frederic Law Olmsted and Jens Jensen in the late nineteenth and the early twentieth centuries

(cf. Egan, 1990). The first recorded systematic attempt to restore a piece of land began in 1934 and it is still going on. It is a restored prairie in the Arboretum in Madison, Wisconsin. The main purpose of the Arboretum was to restore examples of the flora and fauna of Wisconsin that would recreate what the state looked like when the first European settlers arrived there in the 1840s. Much of it started with the ideas of Aldo Leopold (1886-1948), a renowned ecologist of the 1930s and 1940s.[3] Although the University of Wisconsin at Madison purchased the piece of land for the establishment of the Arboretum later in the 1930s, it started out as a kind of public project involving local citizens, landscape designers, or interested gardeners who were concerned about the loss of the historic ecosystem, the prairie. In this spirit, Leopold claimed that the science of ecology should be freely accessible to all people in the same way as a sport is open to all. In a far-sighted article "Wilderness as a Land Laboratory," he stated that "the boundary between recreation and science, like the boundaries between park and forest, animal and plant, tame and wild, exists only in the imperfection of the human mind" (Leopold, 1941: 3). To this end, the staff of the Arboretum wanted the town of Madison to learn about Arboretum ideas, so that they could do recreation and restoration on their own land. In focusing on the re-establishment of historic landscapes, particularly those that predated large-scale human settlement, they introduced a whole new concept in ecology: ecological restoration – the process of returning an ecosystem or piece of landscape to a previous, more 'natural,' condition. 'Natural' here explicitly meant including human society.

After the Second World War several changes occurred. The University of Wisconsin discovered the potential for research in the Arboretum. Although citizens were allowed to walk through the area, the idea of a public laboratory waned somewhat. The Arboretum then became part of the Division of Physical Plant and, as such, fell under the administrative supervision of the Vice President of the University, who was in charge of academic affairs (Sachse, 1974: 98). Ecologists like John Curtis did most of the research on the site of the Arboretum in the 1950s and 1960s, but, as Sachse showed, academic research was not everything. It soon became apparent that "what the place really needed now was an organization of protective, educated friends" (Sachse, 1974: 102). Gradually the "Friends of the Arboretum" grew from volunteer and citizen groups; and to this day the members of this non-academic support organization continue to do a good deal of the hands-on work at this site. As this shows, the first 40 years of restoration efforts already suggest a recursively evolving process between concerned practitioners and academic research.

Interestingly enough, it was in the North Branch of the Chicago River area in 1977 that the first amateur-only restoration project started. Stephen Packard, the driving force behind this project of a restoration of a prairie, a savanna, and a woodland recalls that "the group of volunteers in the North Branch Restoration Project did not think that they would start a new discipline called restoration ecology. Our little group was not interested in farming or ecological science, we just thought that nature

needed some help. We experimented and invented and figured out that we were doing something that no one else had done so far" (interview, April 2000). Through the initiative of Packard, many volunteers and citizens interested in hands-on involvement discovered an ecological constellation that had ceased to exist: a pre-settlement oak savanna and a tallgrass prairie. From these few sites along the northern part of the Chicago River, activities have spread all over the United States and recently also to other parts of the world. The North Branch project evolved to a volunteer stewardship network "that by 1993 included more than 5,000 volunteers working on more than 200 Illinois sites covering nearly 30,000 acres, more than half in metropolitan Chicago" (Stevens, 1995: 11).

The important features of ecological restoration as understood here include the belief that their volunteer or citizen science approach is superior to academic research for several reasons. Whereas conservation and preservation generally focus on the threat of species loss, restoration focuses on a long-term re-creation or invention of nature. Practitioners believe that one reason why the citizen science of ecological restoration became so successful was because they saw it as a long term enterprise. In the words of Stephen Packard:

> We also found out a lot of things that other scientists didn't find out, because so much of what we were doing depended on long periods of time. Few academic scientists at that time were doing experiments that lasted more than a few years, at most" (interview, April 2000).[4]

Dave Egan, a restoration practitioner at the Arboretum in Madison for about 20 years, also believes that the citizen scientist approach has advantages over academic ones, because:

> the scientist tries to control the experiment up to the point that they can *do* the experiment. It is pretty much set in a framework that allows them to come up with a conclusion that is fairly short term for various reasons like grants or getting their thesis done. The other thing is that the scientists tend to exclude the human element of any of their experimental work. The amateur experience, so to speak, [...] is more complete (interview, June 2000).

Ecological restoration then can be called a societal long-term-experiment that hence cannot be compared with other traditional sciences. In order to defend ecological restoration against the critique of being a bad science with limited knowledge, Stephen Packard states: "The goal of restorationists is precisely to set in motion processes we neither fully control nor fully understand" (Packard, 1993: 14). The restoration of ecosystems is a field where little theoretical knowledge is available to guide the work of practitioners. Information is acquired primarily through an arduous process of learning by doing. In reflecting on the restoration of the tallgrass savanna, Stephen Packard came to the conclusion that the public experimentation in nature is in fact the most sustainable way to gain knowledge about ecosystems:

> We learned by a trial-and-error process using hundreds of varying uncontrolled restoration experiments. If we had proceeded more systematically, we would by now either have spent a small fortune, or, using those resources available to us, we would only now be getting the results of the first experiments,

> all of which were failures. But using *craft and intuition* we have developed techniques that seem to work (Packard, 1988: 13; emphasis added).

Needless to say, a technique like this was rejected by many traditionally-oriented scientists. Many of the academic ecological scientists did not regard Packard as a reliable source of scientific knowledge. Recalling some of his critics in the early days of ecological restoration in the later 1970s and 1980s, Stephen Packard says: "The idea that someone thought they might be able to learn something new about a revered natural community through lowly restoration experiments seemed especially to offend these critics" (Packard, 1988: 18). In an interview he stated "some scientists sought to slow us down and make the work difficult. They saw us as a threat" (interview, April 2000).

Restoration does not follow a fixed master-plan of action; it is pieced together and built, thought about and tried out, formulated and reformulated, always in negotiation with other people *and* nature. "Only by interacting with nature can we come to appreciate that we humans are part of nature, can we come to understand it, and, we hope, restore it" (Packard, interview April 2000). In other words, a distinctive feature of ecological restoration's performance is that it is experimental and based on 'learning by doing' as a strategy. The strategy is not, however, the outcome of a historical reconstruction, a sign of retrospective failure, but a consciously site-specific approach, one that aims to take full consideration of the nonhuman nature found in these sites. To put it somewhat differently, restoration practice depends, knowingly, on a certain kind of negative knowledge. Knorr Cetina (1999: 63f.) points out that negative knowledge does not mean "non-knowledge, but knowledge of the limits of knowing, of the mistakes we make in trying to know, of the things that interfere with our knowing, of what we are not interested in and do not really want to know." The importance of this approach lies in the fact that the basis for a traditional scientific – that is, foreseeable – decision, cannot be known. In other words, restoration practitioners knowingly admit the limits of knowing (cf. Hoffmann-Riem & Wynne, 2002).

The 'do something' attitude was the driving force in early ecological restoration. Subsequent diffusion of knowledge occurs primarily as the original practitioners move to new problem contexts rather than through reporting results in professional journals or at conferences. Communication links are maintained partly through formal and partly through informal channels. Through this kind of research a good deal of knowledge, though often site-specific, was lost after a few years. The first journal, *Restoration & Management Note*, founded in 1982, was launched with the explicit aim of providing a forum that publishes all kinds of articles related to restoration, including philosophical or aesthetic ones. One of the concerns of founding editor William R. Jordan III was to have a literate journalistic style that is accessible to as many people as possible. So far the state of science has not mattered to the majority of ecological restorationists. But restoration is not only primarily undertaken by non-academics, it is also entirely practice oriented. The practitioners learn as much as they need to restore a system. Bill Jordan points out

the important role a sense of mission and commitment to the landscape plays in this work. Practitioners do know a great deal about the ecology of prairies, but at the same time, "their passion is to get those prairies back. And if they could do that by doing a rain-dance, they would do that" (Jordan interview, June 2000). Jordan's point is that restorationists are motivated by the job to be done, the desire to care for and perhaps participate in the ecosystem, rather than by interests of any particular (academic) discipline. And this, as Jordan's fanciful allusion to a rain-dance suggests, "may even draw the practitioner far beyond ecology and even beyond science itself" (interview, June 2000).

It was in 1987 that the first collection of writing on ecological restoration, entitled *Restoration Ecology*, a term Jordan had coined a few years earlier, was published (Jordan *et al.*, 1987). It contained mainly reflections on the novelty and use of restoration, but also academic and formal science articles, as well as practitioners' and artists' essays. Later in 1987 the *Society for Ecological Restoration* (SER) was established with Bill Jordan as one of the main driving forces behind it. The general aim of SER was to fulfill Aldo Leopold's aspiration for humans to take their place as full members of the land community. Understood in this way, the organization of restoration projects can be called 'egalitarian,' at least when compared to academic research. The practitioner in ecological restoration projects has generally not been the university based researcher. In fact, local knowledge and interest has been one of the primary forces of ecological restoration and by definition it is tried to offer an almost equal role for all participants (cf. McGinnis *et al.*, 1999). Bill Jordan even extends the egalitarian outlook in ecological restoration to the non-human world. "What is involved is as a continual dialogue rather than a program, paralleling in our dealings with the biotic community the dialogue that sustains a democratic society and makes it adaptable to change" (Jordan, 1994: 27).

Today, in a time when academic research is increasingly criticized for being too narrow, method driven, not responsive to real organizational needs, or simply irrelevant to the demands of a knowledge driven approach, ecological restoration appears to be an almost perfect example for the coming age of Mode 2 science and society. At first sight ecological restoration since the 1970s appears to be similar to the new forms of knowledge production: the interests of the neighboring human communities and the general social relevance of designing new natures is understood as the pivotal goal of restoration projects. This supposedly leads to a transdisciplinary context of application, given the fact that transdisciplinarity is understood as having "distinct theoretical structures, research methods and modes of practice […] which may not be locatable in the prevailing disciplinary map" (Gibbons *et al.*, 1994: 168). When the *Society of Ecological Restoration* (SER) was established, there were few in the academic world who seemed to share or even take cognizance of the practitioners' notion of a problem-solving practice. Between 1989 and 1993 several other books on restoration were published (most notably Berger, 1990). The only journal, *Restoration & Management Notes*, continued to publish all kinds of articles and notes from whatever background, as

long as they dealt with subjects that were related to restoration. The annual conferences also included sessions on art and restoration; the last one, however, took place in 1993.

Ecological Restoration as a 'Real' Science: The Academic Reaction

In 1993 things began to change rapidly in the world of ecological restoration. A new journal was founded that explicitly stated in its first editorial that it was to be an academic journal disciplinarily bound to the science of ecology: *Restoration Ecology*. To reach academic standards it also had to be peer reviewed in outlook. The instructions to contributors state that "the primary emphasis of the Journal is on ecological and biological restoration, and it also publishes papers on soils, water, air, and hydrologic functions." Although this did not explicitly exclude pieces on philosophical, aesthetic or social issues, in fact, after two years in print no such articles had appeared, save a few attempts in the very first volumes.[5]

A watershed in 'boundary work' (Gieryn, 1995; 1999) between Mode 1 and Mode 2 as understood here can arguably be discerned in the debate between Eric Higgs (1994) and Anthony Bradshaw (1993; 1994) in the new journal. For proponents of the 'hard science' faction, already in the second issue of this journal, Bradshaw (1993) claimed that restoration has to be a science and a successful restorationist has to be a good scientist (Bradshaw, 1993: 73). A successful scientist, Bradshaw believes, must "establish general principles," has to "carry out proper experiments to test ideas," needs to involve "careful observation," and must have "proper ecological understanding and training" (Bradshaw, 1993: 72). Eric Higgs challenged the attempt and called Bradshaw and others' perspective a naive idea of an "austere and disengaged science" (Higgs, 1994: 138, 145) and "a narrow view of science" that could never work in the practice of restoration ecology. Instead, "restoration ecology ought to be on the forefront of an inclusive, integrated, and holistic ecosystem science". Higgs questioned Bradshaw's idea of "a traditional view of science that makes sharp distinctions between what is and what is not science, and [which] places scientific knowledge above other forms of understanding" (Higgs, 1994: 142). What Higgs further criticized was Bradshaw's failure to include any discussion of the goals of restoration in his essay. "The brilliance of ecological restoration," as Higgs understands it, "thus far has been a fusion of practical and theoretical knowledge and a convivial and unique mingling of amateurs and professionals within the larger environmental movement" (Higgs, 1994: 145). Although Bradshaw (1994) in his reply to Higgs remained remarkably guarded and claims to basically agree with Higgs. His understanding nevertheless differs from Higgs'. Bradshaw pointed out that he simply wanted to clarify that ecology needs to be a understood as science first, but that ecological restoration "has to be taken into the real world where it is much needed, where it will have to work with other disciplines such as economics, politics, sociology, anthropology, and the real matters of people and their hopes and fears" (Bradshaw, 1994: 147f.). Interestingly enough, for seven years after this debate the journal restricted it-

self to articles dealing with basic research and technical problems in ecosystems. Bradshaw's suggestions were supported by articles such as the contributions in Urbanska and Grodzinska (1995) and Urbanska *et al.* (1997) in Europe, which regarded the founding streams of restoration as amateurish attempts, but not as science.[6] The problem was apparently that the trial-and-error attempts of the practitioners did not find their way into peer reviewed journals and did not allow comparative studies that were useful for ecological sites in different places. Thus some of the ideas of the founding members were bracketed out and some practitioners who were also affiliated to academic settings left the non-scientific field. Since the later 1990s certain streams of restoration ecology outside of the North American continent have tried to take either a different direction to that of a traditionally academic field or else it has become a label for a technique for rehabilitating agricultural settings in Third World countries (cf. Gross, 2001). The goal was to build up an academic discipline, and appropriating the catchy title of restoration in order to leave the site-specific approaches of the practitioners. To develop further, restoration needed an academic foundation, whose focus was on basic research.

The annual conventions of SER still had occasional sessions entitled "Community Involvement and Cultural Perspectives in Restoration Projects," "Community Restoration," or "Social Political and Ethical Issues" and similar topics, but these sessions dealt with promotion strategies – how to convince the general public and gain higher rates of acceptance in the wider society for the implementation of academically planned restoration projects. Furthermore, given the enormous number of meetings on purely technical topics in restoration, these sessions appear to be more the observance of proprieties, than serious attempts to formulate a new form of science. Strategies to involve lay people in decisions on the research process *right from start* were not discussed; most likely because that would have undermined the hard science in the eyes of the academic ecologists. Now that the *Society for Ecological Restoration* and several journals have established themselves in many parts of academia around the world, they can finally regard themselves as a 'real' science. They have profited from the work of the early practitioners and have become better defined and refined over the years. Greater authority than that commanded by the original streams of restoration ecology was gained via the claim to be a science by attributing selected characteristics to the institution of science. The old boundary set up by the practitioners, who wished to include aesthetics, community well-being as well as a playful 'trying things out' strategy, was erased by the academics, who regarded basic research in ecology as the only 'real' science. They thus constructed a new boundary.

Put differently, in the 1970s and 1980s ecological restoration started out as a genuinely new form of knowledge production, but soon also became the site of discipline-based knowledge production in the style of Mode 1. The numbers of practitioners grew, but not at nearly so rapid a rate as the mushrooming field of academic restoration. Based on a survey of journals, Young (2000) proves that

Table 1. The Development of Ecological Restoration since the 1970s: An Overview

	Practice Oriented	Academic Oriented
1977	Stephen Packard starts off with the oak openings in Northern Chicago with a handful of volunteers and concerned citizens	
1981	Founding of Practitioner Journal: Restoration & Management Notes (RMM) by William R. Jordan III	
1985	Jordan coins the term Restoration Ecology	
1987	First monograph: Restoration Ecology edited by Jordan et al.; contains both academic/formal science articles as well as practitioners' and artists' essays	
1988	Packard hallmarks restoration as a science of "uncontrolled experiments" and "learning by trial and error" in an oft-quoted RMN essay (Packard 1988)	Academic scientists call Ecological Restoration non-scientific
1987/ 1988		Founding of the *Society for Ecological Restoration* (SER), Jordan is co-founder
1990	Second monograph: *Environmental Restoration* edited by John J. Berger	
Since 1990		Founding of numerous academic programs with restoration as at least one core of the curriculum first in the US, later also elsewhere, especially in Europe and Australia
1993		First Issue of *Restoration Ecology* appears; explicitly academic, disciplinary (the science of ecology) and peer reviewed.
1993-1994	Occasional articles on practice and aesthetic aspects of restoration in *Restoration Ecology*	
1994	Third monograph: *Beyond Preservation* edited by Baldwin et al.; contains mainly philosophical and theoretical essays	
Since 1994		Solely technical articles in *Restoration Ecology*
1997		Urbanska et al. monograph on *Restoration Ecology and Sustainable Development*
1999	*Restoration & Management Notes* renamed to *Ecological Restoration*	
2000		Founding of *Ecological Management and Restoration* (Australia)
2001-2002		First articles since 1994 in *Restoration Ecology* that can be read as "calls for help" from the academic side concerning the cultural and social background of implementation of restoration projects

The monographs listed are general treatises on restoration. By now there are also numerous hand-books for regional and site-specific restoration purposes.

ecological restoration as an academic discipline has undergone growth comparable to that experienced by conservation biology since the mid 1980s. This has to do with the fact that the practitioners' mind-set, which is basically one of long-term recovery of ecosystems, provided useful insights into problems of academic ecology today. A form of new knowledge production that hardly any academic took seriously in the 1970s and 1980s, has partially developed into a traditional Mode 1 form; at any rate, that is, to the extent that it exhibits more features of traditional academically based science than the purportedly transdisciplinary forms of Mode 2. Table 2 below illustrates this development, beginning with the initiatives of Stephen Packard in Chicago.

Ironies in the Recursive Process of Ecological Streams

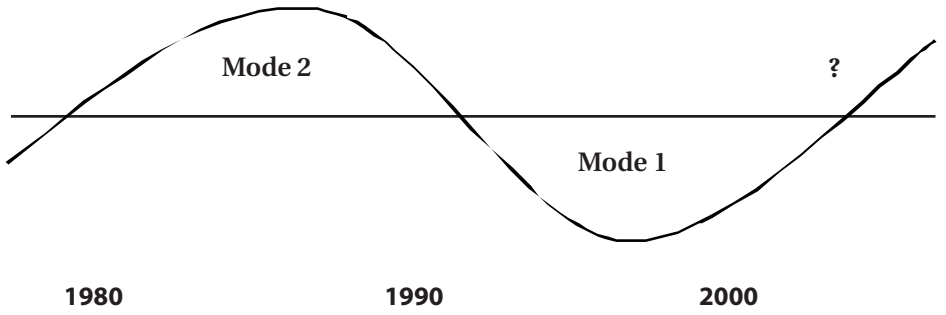
A good deal of modern science has the tendency to implicitly extend research processes beyond the walls of the laboratory into the general public. The traditional model that used to describe the relationship between science and the public was one where the practical use of scientific knowledge was perceived in a linear and deductive fashion: research results are to be used by the public or policy makers in order to make decisions. These basic premises of scientific management have of course been questioned. The technical application of 'value-free,' 'objective,' and 'definite' research results have long since been unmasked as at best an exception, at worst as a social fiction. Scientific research has moved out of the laboratory and can be seen as a process of negotiation between science and the public (cf. Krohn & Weyer, 1994; Gross, 2003). However, although disciplinary research in ecological restoration needs to be implemented in the real world, the development is characterized by some ironies that support the thesis that it is based on a recursive process between academic and 'lay' restoration, with shifting boundaries between what is regarded 'real' and non-science.

Ironically, current debates on the socio-political context of restoration ecology (cf. Pfadenhauer, 2001; Holl & Howarth, 2000; van Diggelen *et al.*, 2001) start off on a level of reflection that apparently falls well behind much of the practitioners' knowledge and expertise of the 1980s. For instance, a number of essays in recent issues of *Restoration Ecology* represent the first since 1994 that – at least partially – deal with the topic of restoration as a problem-solving practice that has to go beyond purely academic aims. Assertions such as the following reveal a complete dearth or only limited knowledge of the pioneers' ideas of ecological restoration: "Many good restoration concepts fail because they were not conceived and developed together with the affected parties" (Pfadenhauer, 2001: 225, 228), as does this plea: "Restoration ecologists must embrace collaboration with the humanities and arts like economics, sociology, and landscape architecture in the form of common research and implementation projects". Academic science here seems to be reinventing the wheel – that very wheel originally invented by non-academics whose work was called non-scientific, an art, or simply flawed by the academic side. Now academic scientists have invented a new wheel, so to speak,

since the sheer size and repercussions of large ecological experiments such those in restoration projects cannot be understood and reliably implemented without the inclusion of so called non-scientific elements like lay knowledge or aesthetic preferences of citizens. Or as Joy Zedler (2000: 402), the first professor of Botany *and* Restoration Ecology (since spring 1998) at the University of Wisconsin, has recognized: "The demand for restoration guidelines has outpaced the science". Together with the statistical analysis done by Young (2000) on the growth of restoration literature in the last 15 years comparable to that experienced by conservation biologyin the 1980s, these remarks support the view that from a grass-roots, bottom-up movement, a disciplinary academic science developed that recently has been seeking to reconnect – at least a little – with its non-disciplinary origins. It appears that the 'non-scientific' can be allowed to move back in after all.

More ironically, if we understand Mode 2 as a moral program for a new science – and not an analysis of actual changes – there is one point where the advocates of a new knowledge production could prove to be right: In the long run academic and disciplinary research cannot make progress without including the boundary negotiations with wider society and this means that the decision on the 'right' science is conditioned by the context of application and evolves with it. In ecological restoration the implementation of new natural areas to be designated will be beyond that of any single contributing discipline or interest group, but will be based instead on a re-

Table 2. The Shifting of Boundaries between Mode 1 and Mode 2



The Ascendancies of Mode 2 and Mode 1 in Ecological Restoration since the late 1970s. A dominance of practitioners (Mode 2) since the later 1970s until the early 1990s and a relative decline of Mode 2 with the formation of a new academic discipline. Recent trends suggest a greater importance of practitioners' science for the future.

cursive loop between old science and new practice.

In terms of this irony, a further interesting observation can be added: After more than twenty years of universities turning their backs on citizen involvement and programs supporting community-based restoration, very recently new programs have begun to be developed to provide college-level training for leaders of community-oriented conservation efforts, that is, institutionalizing a Mode 2 approach in academic research and teaching and thus shifting the boundary of "real" science back once again. University programs like the *New Academy for Nature and Culture* in Chicago (which is connected with two major Universities), which was started by Bill Jordan in early 2001, has now found several collaborators who are currently developing similar centers with universities in Texas, Florida, Arizona, and California; ventures that would have been impossible only five years earlier.[7]

Conclusions

For the first twenty-five years of the field of environmental restoration – if we want to leave out the first 40 years here – the thesis made prominent by Gibbons *et al.* (1994) that in the 21st century the whole world of science is moving ineluctably towards a new kind of science and knowledge production characterized by the dissolution of disciplinary boundaries has proven premature. Rather, one is tempted to speculate, that ecological restoration can *firstly* be understood as a process of recursive learning where Mode 1 and Mode 2 are reciprocally dependent on one another. *Secondly*, at the same time it needs to be understood as a process of shifting boundaries for the demarcation between an understanding of a Mode 1-like and a Mode 2-like science. Claims for scientific authority, however, are made from both sides, that is, the academically oriented as well as the practice oriented. Generally put, the development of restoration can be understood as on-going boundary work between two Modes of knowledge production, and not a general displacement of Mode 1. As these boundaries are flexible, their constructions serve as a legitimating ideology in the struggle for scientific authority. As soon as this authority has clearly been ceded to one side, the other side is allowed to move in as an addition. To this end, boundary work is both strategic and reactive (Weingart, 2001: 242). Academically-based restoration is strategic towards its goal of being a 'real' science and reactive towards its social embeddedness, that is, the potential and knowledge of practitioners.

Put another way, ecological restoration appeared on the agenda as a Mode 2 form of science in the later 1970s. Subsequently, from these accomplishments, an official form of scientific knowledge production (Mode 1) was gradually established, before it began to be partially superseded by another phase of ascending Mode 2 knowledge production. Thus it can be concluded that in the case of ecological restoration, there is an interdependence between Mode 1 and Mode 2 production of knowledge. The demarcation of forms of knowledge production, does not split them off from one another, but rather – to paraphrase a quote from Martin Heidegger's (1977: 171) "Science and Reflection" – it "yields a border traffic between them by means of which boundary areas are marked out.

These areas are the source of a special impetus that produces new formulations of questions that are often decisive" This, however, does not mean, as Huff (2000: 293) with reference to business schools has argued, that the Mode 1 production of knowledge "can be expected to decline", since a Mode 1.5 would be a desirable solution "above" the other two modes in order to redress the limitations of both modes. Quite the contrary, based on our history of ecological restoration, one can conclude that both Modes are (1) meaningful analytical tools and (2) that their analytic indications also belong to the tool-kits of practitioners' and academic researchers' to defend their respective form of knowledge production. Nevertheless, the Modes are to be understood as recursively dependant on one another and not as a current path on the way to an irreversible shift from one form to the other.

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Notes

1 This definition was developed by the SER Policy Working Group in 1996. It can be found online at http://www.ser.org/definitions.html. However, many other definitions and understandings of restoration exist.

2 The literature is extensive. To name but a few authors from both camps: Godin (1998), Hofmänner (2000), Huff (2000), Pestre (2000), Shinn (1999), and Weingart (1997).

3 Some of the historical information on the Arboretum and the early days of ecological restoration is based on interviews with Bill Jordan (Madison/Chicago) and David Egan (Madison) conducted in May and June 2000.

4 For this study key informants and activists in the field, that is, practitioners, lay-participants, and academic ecologists, have been interviewed in spring and summer 2000. They were asked to respond to a series of questions on the past, present, and future potentialities of ecological restoration. The survey data used are from Young (2000).

5 The information on the meetings and conferences on restoration stem from conversations and in house publications of practitioners I interviewed. The catalogues and conference materials partially can also be obtained on the net, most easily on the SER website at www.ser.org. Due to this, the empirical findings in this paper are to be understood as exploratory in outlook.

6 Most of the time they were simply ignored, for instance in Europe (cf. Urbanska & Grodzinska, 1995) or Australia (see the new journal *Ecological Management and Restoration*).

7 Similar developments can be observed in Australia. See for instance the special issue of the journal *Ecological Management & Restoration*, founded in 2000, e.g., the editor's viewpoint (McDonald, 2002) as well as recent articles on the importance of public evaluation of ecosystems in ecological restoration by Brunckhorst (2002) or Morrison (2002).

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