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Postprint / Postprint
Zeitschriftenartikel / journal article

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Empfohlene Zitierung / Suggested Citation:
Gross, M., & Hoffmann-Riem, H. (2005). Ecological restoration as a real-world experiment: designing robust implementation strategies in an urban environment. *Public Understanding of Science*, *14*(3), 269-284. https://doi.org/10.1177/0963662505050791

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Public Understand. Sci. **14** (2005) 269–284

Ecological restoration as a real-world experiment: designing robust implementation strategies in an urban environment

Matthias Gross and Holger Hoffmann-Riem

The concept of real-world experiments is a framework to understand environmental design projects under real world conditions. Contrary to laboratory experiments that are generally thought to exclude the public, real-world experiments involve combinations of social and natural factors. In this paper the theory of real-world experiments is applied to the fieldwork of ecological restoration. The case discussed here is an ecological design process at Montrose Point, a peninsula built on landfill in Lake Michigan on the North Side of Chicago. It illustrates how, in the practice of ecological restoration, the idea of experiment can be understood as being built on processes of recursive learning that include different parts of the wider society and nature. The paper outlines a concept of robust implementation strategies in which public involvement is a pivotal part of a more encompassing activity of ecological practice. This is undertaken to aim at a better understanding of learning processes taking place in natural and social systems.

1. Introduction

In the social sciences, early ideas about real-world experimentation were developed following the Chernobyl nuclear disaster in 1986 (e.g., Krohn and Weingart, 1986, 1987). Chernobyl was understood as an experiment in retrospect. Subsequently, and on a more general basis, the need to develop an understanding of experiments beyond the laboratory was spurred by the observation that modern research in general was likely to be further extended outside of the laboratory to test institutional practices and thus safety assumptions. In this sense, society is the laboratory (Krohn and Weyer, 1994). Here the borders between technology development and detached scientific knowledge production on the one side and the application of knowledge and technologies in the wider society on the other side tend to become blurred. Today failures in scientific practice often appear as the driving force for developing theoretical models, and the experimenters outside the laboratory face many new challenges. The scientist's participation occurs within a complex network of actors whose activities cannot be controlled with traditional scientific methods. Thus, negotiations in ecological real-world experiments call for a redistribution of scientific responsibility.

© SAGE Publications ISSN 0963-6625 DOI: 10.1177/0963662505050791

Introducing the methods of science into society means moving research into society, which in turn calls for a new understanding of science on the part of the public.

In the following we want to further develop this stream of thought, seeking to extend the original contributions of Krohn and others. We will argue that the concept of real-world experiments, as outlined here, not only delivers a more complete understanding of ecological fieldwork and large scale implementations, but—compared to traditional understandings of the relationship between science, nature and society—is more precisely aimed at integrating wider social contexts into scientific practice. We will illustrate this with an example from an ecological restoration project at Montrose Point, a peninsula built on landfill in Lake Michigan on the North Side of Chicago. In a first step we introduce and discuss the background of the idea of real-world experiments. Subsequently we discuss the recursive field practice of ecological restoration as exemplified at Montrose Point.

2. Experiments beyond the laboratory: from Chernobyl to ecological restoration

The early essays on experiments outside the scientific laboratory by Wolfgang Krohn and his co-authors understood scientific research in late modernity as increasingly erasing the boundaries between the laboratory and society. To describe this trend, the terms real-world experiments (German: *Realexperimente*)[1] as well as "implicit experimentation" (Krohn and Weingart, 1986) were introduced. These studies built on the observation that an increasing number of scientific processes have been released into society at large; some intentionally, as in the case of gene technology, others unintentionally, as in the case of the explosion of the Chernobyl nuclear power plant. Experiments in this sense are therefore experiments out of control. They are not designed in the tradition where an experimenter has complete control and can "schedule treatments and measurements for optimal statistical efficiency, with complexity emerging only from that goal of efficiency" (Campbell and Stanley, 1963: 1). The point made by Krohn and his colleagues since the 1980s was that the experimental method in the laboratory is extended to the public, that means, the public is subjected to the risks of these experiments. Because of the growth in complexity it is characteristic of high technologies that in many respects one can learn *from* them only by implementing them. They are too complex for exact scientific prognosis.[2] Thus, the problem posed by ecological risks cannot be solved with certainty on the basis of traditional experimental (field) methods. Human–nature interactions in the real world can cause highly unstable reactions, aptly captured by Charles Perrow's catch phrase, "normal accidents" (cf. Perrow, 1984). Experimentation outside the laboratory, as Krohn and others argue, can be associated with recursive learning processes that sometimes "accidentally" result in a more successful implementation. The context of discovery (the production of knowledge) and the context of justification (the application of knowledge) coincide so that new knowledge enters into practical implementation immediately (cf. Krohn, 1997, 2003; Constant, 2000).[3]

Many other past results of scientific activities can be regarded as experiments in retrospect, including the use of DDT and dioxin. In some cases an accident is necessary to uncover an "experiment on society." The general assumption behind this perspective is that in so-called modern societies the risks of scientific research are being "unloaded" on to society, so that society has to bear the burden of deciding about the scientific risks of novel technologies. Studies in this line of thought ranged from the development of waste management technologies (Herbold, 1995; Krohn, 1997), the introduction of genetically modified plants in agriculture (Krohn and van den Daele, 1998), innovation networks and technology development in industrial engineering (Asdonk et al., 1991; Kowol, 1998), strategies of modern warfare (Weyer, 1994), to the above mentioned reflections on the meltdown of the Chernobyl power plant in 1986, which retrospectively shows elements of experimental research. More recent studies focus on ecological restoration practice in North America (Gross, 2002, 2003a) and the rehabilitation of Lake Sempach in Switzerland (Gross et al., 2003; Hoffmann-Riem, 2003).[4] In general, real-world experiments aim to deliver a theoretical and process-oriented understanding of different experiments extended to the “real world,” including many different human and non-human actors.

In this paper, however, we want to outline how the ideas of real-world experiments, which so far have been mainly understood as a burden for society, can be constructively used for designing socially robust ecological implementations that include the wider public. In the next section we discuss the experimental practice of ecological restoration. Subsequently we illustrate the restoration of Montrose Point with a model of recursive learning that includes heterogeneous groups as part of an experimental implementation into the natural world.

3. Ecological restoration in a real world context

Ecological restoration in the United States had its origins in the 1930s as midwestern ecologists realized that almost all of the tall grass prairies in Wisconsin, Illinois, Iowa and neighboring states had been turned into agricultural land or urban space. To reverse this trend, advocates of ecological restoration consequently tried to think beyond the concept of preserving and protecting ecosystems. Instead they attempted to make humans an integral part of the process. However, ecological restoration has only captured wide interest since the late 1980s (cf. Jordan et al., 1987). Today some leaders in this new field see restoration as a way of compensating for unavoidable usage of the natural world and also as a basis for a positive relationship between society and nature. This idea of the restoration of ecosystems is normally understood as a step beyond one-sided conservationist strategies of traditional environmentalists and conventional attempts at protecting nature. It is regarded as a development away from the ideal type of a hands-off strategy to an active attempt to re-create, invent, design, or restore ecosystems. Consequently, restorationists are excavating buried marshes or importing new animals, cutting down unwanted woods and breaching dams, as well as restoring prairies and creating whole landscapes. The official definition of ecological restoration endorsed by the Society for Ecological Restoration (SER), states that “ecological restoration is an intentional activity that initiates or accelerates the recovery of an ecosystem with respect to its health, integrity and sustainability” (Science & Policy Working Group, 2002). Although many other definitions and analyses exist (see e.g., Baldwin et al., 1994; Friederici, 2003; Gobster and Hull, 2000; Higgs, 2003; Jordan, 2003; Moore, 2004), the practice of ecological restoration is similar to the concept of real-world experiments in that the focus aims at the experimental and public character of restoring natural ecosystems. This also includes the acceptance and inclusion of unintended occurrences as part of restoration work including variations in public perceptions and desires towards the natural environment as well as changing ecological patterns. The latter is to be seen as a potentially welcome “reaction” in a successful performance and execution of a restoration project and a basis for learning from the field. The knowledge resulting from these unexpected “reactions” is being fed into the next step of the project. In some streams of ecological restoration the planning and practice involves lay people, volunteers and academic ecologists alike, and thus brings in elements hitherto regarded as “un-scientific.”

However, here neither is it the traditional idea of nature turned into a laboratory for natural scientists, nor is it—as Krohn and others have suggested—society that has become the laboratory for scientists. Rather restoring nature has become a "public experiment"[5] where the gaining of new insights and the application of new knowledge can go hand in hand (cf. Gross, 2003a). We follow Cook and Campbell on holding that "experiments involve at least a treatment, an outcome measure, units of assignments, and some comparison from which change can be inferred and hopefully attributed to the treatment" (1979: 5). This also means that experiments in this sense do not include random assignments. They are nevertheless a deliberate intrusion in order to describe and understand causal effects.[6] In that sense ecological restoration implies an experimental approach to research extending along a continuum of systems of different orders of complexity, carried out in the field with and without controlled conditions. This continuum also indicates a close relationship between restoration ecology, agricultural research, and other forms of ecological implementations (Jordan et al., 1987: 18–21).

The aim of this paper is to further develop a framework that prominently includes the idea of the participation of non-academic researchers and volunteers in order to involve the conflicting environmental goals of competing social groups, e.g., volleyball players versus historical restorationists. Real-world experiments taking place in wider society thus need to take into account that natural areas can have multiple functions for humans ranging from recreation, relaxation, and sport activities to restoration, scientific investigations, and implementations. Variability and unexpected occurrences, which do not have a place in laboratory experiments or technological interventions, are to be perceived as a pivotal point in the understanding of ecological restoration as a real-world experiment. Public participation in community conservation projects is frequently seen as a way to improve the quality of implementation. Some academic analyses have stressed that participation should follow an appropriately "democratic" process in terms of participants and agenda. Many different models of public participation exist and have also been criticized (e.g., Agrawal and Gibson, 2001; Campbell and Vainio-Mattila, 2003; Huntington, 2000; Park, 1992; Rowe and Frewer, 2004; Sharp, 2002). Our goal in this paper is not to produce yet another normative statement of how public participation can be improved. Rather, we aim to open the door to a new way of understanding ecological design *and* participation as part of one "experimental cycle."

Real-world experiments are to be understood as taking place *in* and *with* human–nature systems, since the subject of experimentation has been extended so as to make it either a societal self-experiment, or as Krohn and Weingart pointed out with reference to technical inventions, it becomes a double blind test, "an experiment with the experimenters" (1987: 53). There comes a point in the course of an ecological restoration project where the practitioner steps back and realizes that he/she has been participating in his/her own ecosystem and is intimately part of natural processes.

With the example of Montrose Point in Chicago we now want to discuss such an understanding of experiments applied to a real world case. This should sharpen our understanding of ecological field practice so as to include the public. We have chosen the restoration of Montrose Point, since it adds an important case to the public involvement of restoration projects, particularly given the artificial nature of Montrose Point's creation and evolution. The latter point seems to be crucial since, as observers such as Bruno Latour (2004) have argued, in late modernity the social and the natural have become inseparable from one another and thus should be viewed together, that is, in the form of emerging collectives. The design of Montrose Point, we contend, seems to be such a case where the differentiation between the social and natural has become difficult to maintain.

4. Nature on a dumpster: Montrose Point, Chicago

Montrose Point is a peninsula on the North Side of Chicago that did not exist before the 1910s. The whole area of about 5 acres was gradually built on a dump. The waste of the human community and the construction waste, which had been removed for subway development, was thrown into the water and over the years developed into a peninsula reaching into Lake Michigan (cf. Furnweger, 1997; Gobster, 2002; Gobster and Barro, 2000; Larson, 1998). Today the point is surrounded by Lake Michigan on three sides. It is open to the north and east and serves as a harbor on the south side (see Figure 1).

Although a plan for turning the landfill into a park was already established in 1938 by noted landscape architect Alfred Caldwell, with the beginning of World War II the US Army took over the peninsula for use as a radar station. In the 1950s it was used as a missile base as part of the Cold War strategy to protect Chicago. Finally, in the 1970s, the area was reclaimed as a park space. By then the landscape consisted mainly of scattered trees and honeysuckle hedgerow. The historical reference point to "restore" Montrose Point in the literal sense of the word would be to turn it back into part of Lake Michigan. Instead, ecological restorationists involved in today's project attempt to design a landscape *as it might have* looked before European settlement *if* the land that is now Montrose Point had actually existed and the savannas of Illinois *had* reached into Lake Michigan. As in the case

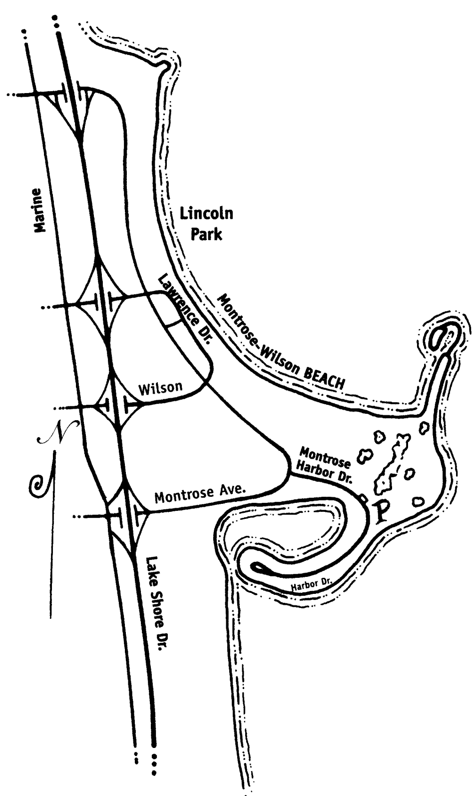

Figure 1. Map of Montrose Point peninsula with the "Magic Hedge" at its center. From: *Chicago Wilderness Magazine*, copyright © 1998 Lynda Wallis; reprinted with permission.

of numerous current practices, a historical or another reference point is chosen by people living in a specific area together with restoration ecologists (cf. Egan and Howell, 2001). An important point in the case discussed here is that in the spring of 1996, in a preceding restoration project in the metropolitan Chicago forest preserves, a fierce controversy erupted over the ecological restoration of prairies and oak savannas (cf. Gobster, 1997; Helford, 2000; Ross, 1997; Shore, 1997; Siewers, 1998). The local and even national news took great interest in the controversy. The opposing groups were successful in interrupting most of the restoration activity in the Chicago area for about a year. This controversy was used as a touchstone to examine questions about people's values regarding nature. One of the results was that, as Paul Gobster of the United States Department of Agriculture (USDA) Forest Service in Evanston points out, most people did not object to the idea of restoration per se, but expressed concern with how and where specific practices, e.g., killing deer or removing trees, were carried out. The wider public wanted to have a say and to be directly involved in the process. The USDA and the City of Chicago learned from this experience that involving the public can be crucial to successful implementation strategies. Hence, from early on in the development of Montrose Point, a bottom-up approach was seen to be the most successful.[7] Montrose Point would be a piece of land designed by the people and for the users of the place. "The negotiations," as Gobster further clarifies in an interview, "need to be open, as inclusive as possible, they need to include the possibility to be iterative, and must be based on adaptive design and management." Gobster and Barro (2000: 187) called the approach used in the design of Montrose Point "participation with a view," referring to the landscape architect Randolf Hester (1996). In this sense in the next section we will introduce a model (Figure 2) that visualizes a cycle of recursive or "iterative" ecological design.

5. Recursive design: a real-world experiment perspective

In order to analyze an ecological restoration project like the design of Montrose Point on the basis of "an experiment with the experimenters," we introduce a model (Figure 2) that visualizes a cycle of recursive ecological design. This cycle is based on the empirical analysis of transcripts, minutes, and published material, which were codified with a program for qualitative text analysis. We identified a set of recurring themes, which were compared and discussed until an overall coding scheme was agreed upon.[8] This cycle can be understood as a variation and refinement of the classical view of social experimentation set forth by Riecken et al. (1974: 13–14). Riecken et al. defined social experimentation most generally "as a cycle that begins with problem analysis, proceeds through the planning of an intervention, its development, experimental trial, and evaluation; and ends in either program implementation or in replanning the intervention." However, unlike in their and other ideas of an "experimenting society" (cf. Campbell, 1988: 290–314; Cook and Shadish, 1994) here we want to outline an approach where the public can also be seen as initiating the experiment and not merely as reacting or adapting to it.

Today community involvement is regarded as the key to a long-term survival of Chicago's nature preserves [3,4] (the numbers in square brackets refer to the numbers in Figure 2). As one of the Lincoln Park Advisory Council project managers stated, the situation has become very different since 1996, with managers having learned from previous failures:

> Whoever wants to be involved in the process can be. . . . The results will then be given to the landscape architect we hire to inform the design process. And the plan that person

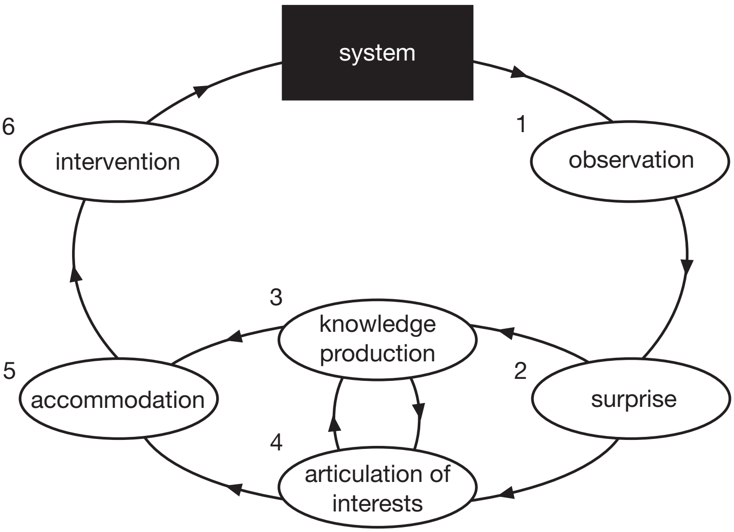

Figure 2. Working model of the recursive design cycle. The numbers in this figure refer to the numbers in brackets in the text.

> comes up with will be subject to a lot of review by the planning committee, which will also have community people involved. (as quoted in Furnweger, 1997: 3)

This means that in our cycle (Figure 2) the observation by experts [1] can go hand in hand with the problems perceived by people not previously involved and not perceived as "experts." Experts here can as well mean "lay" experts, stakeholder groups, or academic ecologists.[9] It was the lay participants of the surrounding human communities whose ideas on nature were first heard [4], and the academic ecologists were invited later to assess (together with the stakeholders involved) solutions that would be ecologically feasible and desirable [3]. The groups involved included birders, restorationists, historic preservationists, recreationists, anglers, and representatives of disabled and local neighborhood communities. The core interest here is that scientific experts—in a broad sense of expertise—and the broader public met to evaluate options, negotiate strategies and adjust knowledge before an intervention [2;3;4;5].

At the beginning of the cycle we are dealing with a system that includes both social and natural elements. The dynamics of the system are being observed [1] by natural scientists, organized interest groups, or sometimes simply by hikers happening to pass by. An observation is regarded as "normal" as long as the system changes according to the expectations of the observing actors involved. However, in complex systems, especially when little fully developed knowledge is available, things often fail to follow the expected path. We call the reaction to such an event a surprise [2]. Our notion of surprise is informed by the work of Georg Simmel as well as C.S. Holling. In Holling's (1986: 294) perspective a

> surprise concerns both the natural system and the people who seek to understand causes, to expect behaviors, and to achieve some defined purpose by action. Surprises occur when causes turn out to be sharply different than was conceived, when behaviors are profoundly unexpected, and when action produces a result opposite to that intended.

In Simmel's understanding, a surprise can be everything that departs from human planning and expectation since

> as soon as the human-made work is completed, it not only has an objective being and a life of its own independent of humans, but it also holds in its being . . . strengths and weaknesses, components and significances, that we are completely innocent of and which often take us by surprise. (Simmel, 1998: 213)[10]

In both cases, if a surprise is taken seriously, it forces the actors to question their previous knowledge of the human–nature system and to adjust their theories and their future actions accordingly [3].[11] Especially in Simmel's understanding, surprises are not necessarily perceived as a *negative* deviation from rational planning or goal attainment, but quite often as the driving force of social and natural processes (Gross, 2001). Following this stream, we will illustrate how "surprises" can be incorporated into a recursive model of social experimentation, which includes the expectation or even an aspiration for surprises. If a surprise leads to the appearance of unintended side effects or even a complete failure of previous arrangements, then a process of negotiation [3 to 4] may result in the questioning of existing theories and assumptions about strategies and plans of action which can lead to an "accommodation" [5] of the original strategies. The term "accommodation" here is used in the sense developed by Park and Burgess (1972: 663–6). In their understanding the social world does not—as for instance in a social-Darwinist perspective—passively *adapt* to the environment, nor is it perceived as a successful and all-encompassing resistance against the coercion of the outside world. Rather it is seen as a hybrid between the two perspectives, which points to human will and potential for invention, but at the same time points to the limits of the natural and the social environment. This understanding of accommodation thus serves as a dialectic between human invention and adaptation to natural occurrences.[12] Between the accommodation of strategies [5] and knowledge production [4], a tight interaction needs to be noted: on the one hand, theoretical developments make it possible to stimulate a chosen strategy, and on the other hand, the revision of an old strategy can make it necessary to develop new knowledge. To be sure, the revision of goals and theories can alter the whole restoration process.

Theoretical developments can also be initiated via scientific research in settings outside the ecosystem as well as knowledge stemming from external sources [4]. Furthermore, the entire scientific project (including goals, funding etc.) is embedded in wider social relations, such as national political debates or legal regulations. In Figure 2 this is summarized as "articulation of interests" [4]. Scientific strategies, therefore, need to be developed in negotiation with different social actors. These networks of multifaceted actors can consist of policymakers, stakeholders, environmental or other interest groups, as well as academic scientists or outside experts. This requires a research strategy that is open for changes in attitudes and open in outlook towards cooperation and negotiation (e.g., mediation). In cooperation with stakeholders, for instance, academic ecologists often have to accommodate certain strategies [5]. Here it can also happen that the goals of the stakeholders are incompatible with the goals—both scientific as well as political—of restoration scientists and engineers. Hence, scientific options [4] and the decision about strategies [5] are closely linked to one another. Whatever the details might be in different real-world experiments, the last step is an intervention [6] into the system, which can once again expose its own "natural" dynamics. In this view, an experiment can be considered a real-world experiment if (i) the cycle in Figure 2 is closed, so that recursive learning processes become possible and if (ii) it is purposefully embedded in its social context. Only with the implementation finished, can a new observation [1] in a loop of recursive learning begin. A recursive learning process can be regarded as complete when a reciprocal interaction between observation and intervention leads to a closure of the circle and, on the one side, new knowledge enters into new arrangements and, on the other, new arrangements feed back to produce new knowledge.

In the next section we want to illustrate some of the recursive or iterative learning processes at Montrose Point based on our analysis of transcripts from focus group meetings and of published sources. We subsequently focus on two examples of a recursive closure between natural changes and the human reaction to these changes: the development of the so-called "Magic Hedge" and the growth of dunes near the volleyball beach on the north side of the point.

6. Ecological restoration in an urban context

The most general goal of all groups involved in the restoration of Montrose Point was to enhance the peninsula as a user-friendly and special place in Chicago. Residents wanted their nearby park areas to be more "natural." The Lincoln Park Framework Plan, which set out to develop Montrose Point as a wildlife habitat area, had already been published in 1994. This plan was the work of the Chicago Park District and the Lincoln Park Steering Committee. The latter was a group consisting of members of the Lincoln Park Advisory Council (LPAC), an advisory council for Lincoln Park, as well as representatives of the park users from nearby communities. Even before the Chicago controversy of 1996, in 1995 an educational program for Chicago schoolchildren under the theme "Nature along the Lake" was initiated in order to involve the wider public. The actual planning and design process began with a series of focus groups in early 1997. Representatives of anglers, walkers, picnickers and other recreational users were recruited on site at random by inviting them to participate in these meetings. Participants for the other groups, especially the historic preservationists, bird watchers, the volleyballers and the yacht club, were invited via the official organizations (cf. Gobster and Barro, 2000; Gobster, 2001). Gobster (2001) was able to categorize four visions of nature expressed by Montrose Point stakeholders in analyzing focus group interviews from the years 1997 to 1999. Most of the ideas of the numerous participants came more or less close to what can be called a savanna, as they existed before European settlement. The complex social and ecological history of Montrose Point, however, limited the degree to which tools used to achieve these goals—via ecological restoration—could be applied successfully. This appeared to be especially crucial since, as the studies of Montrose Point by Paul Gobster (2001, 2002) have shown, despite the area's relative isolation, many competing and often changing recreation interests among the interest groups existed and still exist.

The process of accommodating [5] to knowledge gained by negotiation with actors [4] regarding intervention [6] was based on meetings with community members and experts in order to balance habitat and design restoration, as well as to complement adjacent recreational uses. The actual implementation work was then done via Chicago Park District's (CPD) funding, together with different volunteer groups, field trips by school classes, as well as paid (academic) experts. Restoration workdays were advertised and announced in local newspapers, flyers in the mail, and other media. They were held throughout the year and included activities such as seed collection and planting, brush clearing, and invasive species removal.

However, surprises do not only arise from competing human ideas on nature, but also from the natural system itself. For example, in the early 1990s an observation was made that led to a surprise [2]; apparently the dynamics of the natural system over the years led to the development of something that would later change the course of Montrose Point as park space. Because much of the area was neglected during the 1970s, honeysuckle hedgerow, a European plant introduced accidentally, unexpectedly became a magnet for rare birds. Visitors quite fittingly called the hedge the "Magic Hedge," since it took root there without human planning and attracted birds to use these hedges as a resting area.[13] The 1997 plan was to restore the center of the point to resemble an early nineteenth century savanna. This would have meant tearing out the honeysuckle hedgerow. However, the European hedge fostered rare native birds. At a focus group meeting, one participant aptly remarked that "one thing to remember at Montrose is that we have a lot of weird weather patterns and stuff. And we can do the monitoring but birds, I don't know, if you read the paper you'll see there's no real rhyme or reason sometimes about why they use what they use." Native birds on a European hedgerow indicated a surprising turn, since that contradicted the original goal to "restore" the point to a savanna with mainly native plants and animals. Nature thus contributed to a surprise that did not belong to the original human plan. Many of the stakeholders also made use of knowledge provided by outside experts about plants and the behavior of birds [3;4]. Today more than 200 different species can be counted at Magic Hedge during spring and fall migration (Gobster, 2001: 37). The Magic Hedge has a national and international reputation as a habitat for rare native birds and other species.

The observation of these birds changed the plan for designing the point considerably. New ecological knowledge [3] about migration habits of rare birds, some of them even thought to be extinct in this part of the United States, in negotiation with different interest groups [4] led to a strategic accommodation [5] which now protects the Magic Hedge. The human actors involved thus accommodated to the new situation by revising their goals, theories and approaches according to the natural possibilities and the cultural ideas of nature.

Another surprising observation [1;2] was made in the fall of 1999. A volunteer noticed some striking green stems emerging from the sand near the shoreline on the north side of the point. In the following May the plant was identified as lakeshore rush (*Juncus balticus*), a plant that had not been found on Chicago's lakefront since 1946 (cf. *Chicago Wilderness Magazine*, Fall 2000). The lakeshore rush, however, grew on a dune formation, which had only begun to develop a few years earlier. Together with other plants, the rushes were helping to bind sand, which would lead to further dune development. Again, this surprise did not lead to a complete dismissal or change of the plan, although the volleyball interest group at Montrose Beach initially feared that one day the naturally growing dunes would "roll over" their volleyball area [5]. First the volleyball group objected to the growth of the dunes and pleaded for an intervention that would have stopped the growth. However, they also soon found that dunes with bushes nearby meant protection from the stares of passers-by. It also meant a welcome area to be used as a natural "comfort station." However, if the dunes continue to grow further, the current volleyball field may have to be moved up north a bit [5;6]. The natural development of the dunes is being integrated into the revised plan. Overall the volleyball players found restoration activities acceptable as long as the portion of the beach they used for court space was not jeopardized. Within this natural context, most of the groups thus wanted to see Montrose Point designed and managed so that their uses could be accommodated and other uses would not conflict with their own interests (Gobster and Barro, 2000: 193).

After almost ten years of restoring Montrose Point with organized interest groups it has turned out to be practical to carve out the different visions of nature of all the stakeholders involved [3], who in cooperation with natural scientists and landscape architects [4] try to design the area. It is interesting to note here that via the work at the point both the natural scientists as well as citizens and volunteers involved developed some new knowledge that is important for their respective areas of interest and expertise [3;4].[14] Paul Gobster and Susan Barro know from the experience of designing Montrose Point that "many stakeholder groups hold higher levels of knowledge about particular restoration issues than do planners or designers leading the process, and outside experts can often provide fresh perspectives from other places and experiences" (Gobster and Barro, 2000: 187). Owing to the dynamic nature of Montrose Point, a constant negotiation between the responsible actors involved and reactions to developments of the ecosystem itself, are both part of a successful ecological design project. For these negotiations numerous interviews and focus groups with diverse interest groups were repeatedly conducted in order to help inform the design and management of each part of the site [4]. While the various groups involved had their particular interests and emphases for each site, most individuals agreed on the uniqueness of the places and the complementary values that could be achieved through management. The dialogue has helped to construct robust ecological designs suited to each area and based on negotiated considerations about desired naturalness, degree of human access, and the amount of public participation in planning and management. The project at Montrose Point continues to evolve as it moves out of one phase of the cycle in response to changes in actors, policies, and natural factors (observation, surprise, knowledge production, articulation of interests, potential accommodation) into an implementation (cf. Gobster, 2002). The overall integrity of the restoration process at Montrose Point could be upheld, since its recursive design was able to accommodate revisions and modifications to issues that changed, although they were previously agreed upon. New knowledge could be fed into the system to expose it to further observation.

7. Outlook: robust restoration strategies through recursive learning

The case of Montrose Point shows that the expectation of "surprises as chance" renders obsolete the idea of a detached and austere science, since surprises can be perceived by different actors, which can initiate new processes of recursive learning. This calls for a science that is robust enough via recursive learning processes to "listen" to both different interest constellations *and* unexpected natural changes. Even more so, knowledge production in the real world beyond the laboratory must be able to embed the learning process in such a way that new surprises can be absorbed with fewer problems than in traditional management strategies of scientific implementation. Surprises should rather be understood as opportunities.

Since experiments taking place in the real world often become part of the public's everyday life, negotiation of the design among the heterogeneous actors can be accomplished by turning concerned citizens into hands-on practitioners to handle surprises and to successfully renegotiate the design. The restoration project at Montrose Point has shown that time-consuming and laborious hearings, and the involvement of volunteer group organizations and stakeholders via focus groups have been successful in the long run. The original project design at Montrose has been recursively refined and specified in taking into account the frequently changing ecological *and* social realities.

The restoration of Montrose Point is a form of research that tries not to juxtapose the scientific importance and ecological science with the irrational and culturally tainted ideas of the public. Consequently, for Reid Helford the practice of ecological restoration represents a new understanding of science, where the traditional boundary "is no longer the boundary between science and non-science, but that between a sensitive, 'natural' science and a removed, 'unnatural' science" (Helford, 1999: 68). This observation fits nicely with our understanding of real-world experiments, where the wider public simply becomes a part of scientific work, rather than undermining the power of science, as was the case in the traditional presentation of the conflict between “ignorant” lay people and rational or objective natural scientists/experts. People here are not passive subjects but active agents in the scientific process. In ecological field practice, contestation of restoration knowledge via the involvement of the human community has produced a transformed and enlarged definition of “scientific research” and has fostered public involvement in science. Learning here thus can be understood as an ongoing and perhaps never ending process, performed as a real-world experiment based on recursive loops. In real-world experiments the relative lack of control over boundary conditions is absorbed and compensated by the recursive design of the research process and the institutional steps in the design cycle, here for instance: frequent public participation or the openness to surprises by the actors involved. The recursive process of learning allows both positive as well as negative experiences to be fed back into the next cycle of the design process.

Acknowledgements

This paper is part of an interdisciplinary research project funded by the Volkswagen Foundation. The authors would like to thank their advisor Wolfgang Krohn without whom the project would not have been possible. We are also grateful to Paul Gobster for making the minutes from meetings and workshops of the Montrose case available to us. Further thanks to Dominic Robinson and Natalie Gulsrud for helpful comments on earlier versions of the article. Thanks also to the support of the Department of Sociology at Loyola University Chicago, where Matthias Gross spent a semester to conduct research on the restoration of Montrose Point. Earlier versions of the paper were presented at a conference on *New Directions in Interdisciplinary Research* at Penn State University in October 2003, the *Community and Ecology* conference of the International Sociological Association (ISA) in San Francisco in August 2004, as well as various seminar settings at Bielefeld University and Loyola University Chicago.

Notes

1 The first translation of the German term *Realexperimente* into English was “real-life experiments” (cf. Krohn and Weyer, 1994; Weingart, 1991). However, we feel that we are dealing with experiments in the real world, potentially including the lives of many actors and individuals, plants and animals as well as landscapes and whole ecosystems; thus real-world experiments.

2 Complexity here is meant in the general sense of a more intricate combination of parts compared with earlier phases in a development process. For an overview on the heterogeneity of the notion of complexity and related concepts, see Law and Mol (2002).

3 The difference between “the context of discovery” and “the context of justification” was pivotally explained by Hans Reichenbach (1938: chap. 1). In his understanding it is the difference between what a researcher actually does in the laboratory and the way in which the results are written up for publication or are presented to the public. As far back as 1935 Ludwik Fleck doubted that this was a useful distinction and discussed the social conditionality of any kind of knowledge (especially Fleck, 1979: 46–51). Thomas Kuhn (1970) later prominently took up the topic. On the relationship between research and publication in science from a sociological perspective and departing from this line of thought, cf. Knorr Cetina (1981). Related, but more useful distinctions can be found in Sheila Jasanoff’s (1990) notion of research vs regulatory science as well as Liora Salter’s (1988) research vs mandated science.

4 A further source of inspiration for the current thought on real-world experiments can be found in what is generally labeled “adaptive management” (e.g., Holling, 1986; Walters, 1986). However, the framework of real-world experiments does not mainly address natural resource management issues, but as much cultural and social issues involved in all forms of science in its natural *and* societal contexts.

5 This understanding of public experiments differs from that of Collins (1988), who discusses public experiments

as scientific tests conducted in public to resolve issues such as doubts about the safety of technological innovations. The view here comes closer to what Robertson and Hull (2003) have called a "public ecology" or what Nassauer (1997) referred to when she talks about "cultural sustainability," that is, the evocation of a sustained attention of people to align public interest and ecology.

6 We are grateful to Thomas D. Cook for discussing these issues with us (cf. Cook, 2004).

7 These approaches are well known in planning and community design, but practiced in only some areas of ecological restoration (see Gross, 2003a; Jordan, 2003; Moore, 2004; Robertson and Hull, 2003; Ryan, 2000). For an example of designing urban waste lands in the German capital of Berlin, see Lachmund (2004).

8 The material was codified with the qualitative text analysis program MaxQDA. This work was done with the help of our student assistants Natalie Gulsrud, Thomas Leineweber and Melanie Lüttig. Some of the information on the Montrose case is also based on interviews and conversations with Paul H. Gobster of the USDA Forest Service and a co-leader of North Central's Research Program. Gobster was in charge of many of the analysis and focus groups conducted in the Montrose project. Other information for writing this paper stems from visits and field trips to the site in April 2000, February 2001, and several visits in the fall of 2003.

9 Instead of believing that there is "scientific" knowledge in all groups of society, we prefer the differentiation between certified and uncertified experts proposed by Collins and Evans (2002). For another case discussing the importance of different kinds of "expertise" see Gross et al. (2003).

10 Our translation from the German.

11 Our notion of surprise can also be connected to Robert Merton's usage of the term "serendipity" (Merton, 1968: 157), which he introduced to describe accidental discoveries in science that lead to new theories (cf. Gross, 2003b).

12 For a more in-depth discussion of this classical sociological usage of accommodation, see Teherani-Krönner (1992: 76–100) and Gross (2003a: 107–10).

13 When and by whom the site was named "Magic Hedge" cannot be said with certainty. According to Larson (1998) a small area of shrubs and trees apparently was already called Magic Hedge in the 1970s.

14 It is beyond the scope of this paper to discuss the natural scientific impulses this "public experiment" has initiated. However, Douglas Stotz, an ornithologist at the University of Chicago, has begun to study the migration patterns of birds at Montrose Point spurred by the observations of "lay" birders. So far it is too early for results and official publications (personal communication with P. Gobster).

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