Ecological restoration

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Ecological Restoration: State of the Art or State of the Science?

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Introduction

This special issue contains 13 papers presented at the Groningen Conference on Restoration Ecology, held from 25–30 August 1998 in the Netherlands. This conference was organized under the auspices of the Society for Ecological Restoration (SER), the European Ecological Federation (EEF), the Dutch–Flemish Ecological Society (NECOV) and the International Ecological Engineering Society (IEES). This was the second International Conference on Restoration Ecology with over 200 participants from 22 countries; the first conference was held in Zurich, Switzerland (Urbanska et al. 1997). The second conference resulted in a total of 29 papers, published in the journals *Restoration Ecology* (13 papers), *Applied Vegetation Science* (2000 Vol. 3:1; 8 papers) and *Ecological Engineering* (8 papers).

The objective of the conference was to investigate the state-of-the-art scientific knowledge of restoration. Due to its geographic position in Europe, the conference was clearly biased toward cultural and semi-natural ecosystems. Other consequences of its location in a densely populated area were an emphasis on the societal involvement in proposed restoration efforts and the desire to combine multiple functions in restoration projects.

Ecological Restoration – The Present State

According to SER, *ecological restoration is 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* (http://www.ser.org/definitions.html). This broad definition includes many elements but does not address *how* to restore a spoiled site or fragmented landscape. Most people, therefore, would agree that in practical cases one should collect as much knowledge and public support as possible. In reality, however, such an approach appears to be more an exception than the rule. The necessity to oppose unwanted developments is often felt to be so urgent that there is no time to address the problem in a proper scientific way and then use this knowledge to formulate restoration strategies. Instead, the feeling is often that the situation is so critical that one should act immediately and try to salvage all that can be.

Under such conditions, restoration is clearly more art than science. The quality of the work relies heavily on the skills of the practitioners involved. Past successes are generally considered templates for later work, similar to medical practitioners building up their knowledge from a series of case histories, rather than by fundamental investigation of underlying principles and mechanisms. We acknowledge the large value experience plays in restoration work and are not promoting the idea that restoration projects cannot start before scientists have finished thoroughly studying a site. We realize that in many cases restoration can be quite successful without detailed knowledge of the functioning of target ecosystems. However, we also recognize inherent weaknesses in this approach. Except for very similar cases, templates often have limited value and good practitioners are scarce.

In this paper we advocate a more formal way and will present some elements of a scientific framework for restoration ecology. We believe that such a formal approach not only improves restoration success but also enables a better understanding of knowledge gaps.

Restoration Goals

Restoration scientists usually stress the necessity to define and agree upon common targets in restoration projects (Hobbs & Norton 1996; Pfadenhauer & Grootjans 1999; Bakker et al. 2000). They advocate the use of clearly defined target communities and/or target species to measure success. A definition of targets, however, depends to a large degree on the level of ambition of a particular reconstruction project. We suggest there are three levels:

The first level is sometimes called *reclamation* and consists of attempts to increase biodiversity per se, often in highly disturbed sites (Fattorini 2001; Patzelt et al. 2001). The landscape as a whole would benefit from implementing such measures but reclamation does not necessarily contribute to the protection of red list species.

The second goal is often called *rehabilitation* and consists of the reintroduction of certain ecosystem func-

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tions (Mitsch & Jørgenson 1989; Wali 1992), such as reducing flood risks by creating water retention systems or restarting peat growth to fix CO_2 in peat layers. Rehabilitation would make the landscape as a whole more "natural," but it would not necessarily result in a significant increase in biodiversity.

The third and most ambitious level can be called "true" *restoration* and consists of a reconstruction of a prior ecosystem. This includes not only the reestablishment of former functions but also of the characteristic species, communities and structure (Pfadenhauer 2001; Grootjans et al. 2001).

The above-mentioned goals are generally associated with different scales, especially in densely populated areas where most restoration activities take place. Although it is technically possible to "recreate" some former communities on a local scale and at high costs, true restoration is generally impossible at the landscape scale because of land use conflicts, long distance effects of other activities and other reasons. Reclamation is often the only realistic option at this scale. Rehabilitation seems to be practical at an intermediate scale, often as a network within a certain landscape, e.g., riparian restoration (Kentula 1997).

Technical Implementation of Restoration Programs

It is our opinion that in order to maximize the success of restoration projects, several key elements should be considered first.

Once the restoration goal has been agreed upon, the next logical step to follow would be an *analysis* of the actual, non-optimal situation in relation to the desired state. This should not only consist of a comparison with reference areas to estimate the degree of degradation (Brinson & Rheinhardt 1996) but also include an identification of the processes, which have led to degradation (Hobbs & Norton 1996). This may not always be obvious. System features should also be taken into consideration (Hobbs & Harris 2001). The effects of fragmentation (Opdam et al. 1993) or long-distance hydrological interference (Grootjans & van Diggelen 1995) are not always clearly visible and can have an impact that becomes evident only after several decades.

The next step should logically consist of an evaluation of *possible restoration strategies*. Ideally, this should lead to a complete removal of the causes for degradation, but in practice, this is often not possible, especially in the case of large-scale landscape interference with many interacting forms of land use. In the latter case mitigation may be the only possible solution (van Diggelen 1998). In such a situation, substantial efforts may be required to reach the target (Brouwer & Roelofs 2001; Tallowin & Smith 2001; Willems 2001).

Sustainability should be a very important criterion when deciding between alternative strategies. Especially in severely impacted western countries, there is a tendency to set targets very high. Given sufficient funding, these targets may indeed be attainable but will often require a continuously high input of human support (WallisDeVries & Raemakers 2001). The alternative of choosing less ambitious targets, when less money is available or when continuous management cannot be secured, may result in less gain of rare species and communities but may be wiser in the long run (Ehrenfeld 2000; Prach et al. in press).

While deciding on targets and choosing between alternative restoration strategies, one should not overestimate the *predictability* of developments. It is becoming increasingly clear that the conditions at any particular site are the result of a historically unique combination of processes for that location (Parker & Pickett 1997). Communities and landscapes have evolved over centuries and the template of underlying processes has changed considerably during their development. Historical and spatial references, therefore, may be of limited value. In most landscapes, a complete return to a former situation is very unlikely (Hobbs & Norton 1996). Predictability may be limited further by year-to-year variations or catastrophic events (Klötzli & Grootjans 2001).

Estimates of *time scales* involved in restoration programs are often far too optimistic. It is increasingly clear that process rates of both abiotic transformations and species turnover are often low and should be expressed in decades rather than in years. A practical consequence of this observation is that it seems less relevant to define ultimate goals. It could be more sensible to agree upon rather modest intermediate goals and reverse the decline of degrading sites (Hobbs & Norton 1996; Janiesch et al 1998; Stanturf et al. 2001).

In densely populated areas, *multi-purpose restoration* is often more attractive than a "strict" restoration program, devised entirely on behalf of ecological targets. When, for example, ecological recovery is combined with objectives such as wastewater purification (Comín et al. 2001) and recreation, the public support will be much greater. In addition, without public support there will be no ecological restoration in densely populated areas.

Societal Implementation

Until now, most restoration practitioners and ecologists tended to see their jobs as strictly technical. In reality, however, restoration is as much a cultural activity as any other human endeavor. As Higgs (1997) has compellingly argued, good restoration requires a view expanded beyond the technical to include historical, social, cultural, political, aesthetic and moral aspects. Support from other groups in society is therefore essential for the success of any restoration project, as not only "experts" have information useful to reaching a restoration goal (Webber 1992). In addition, conflicts may arise when restoration programs impact heavily on local populations (Light & Higgs 1996; Swart et al. 2001). Swart et al. (2001) provide a model of how some of these disparate considerations may be combined to form an integrated "valuation" of ecosystems and their restoration.

We must not, however, lay ourselves open to the charge that ecological restoration is not much different from gardening, as Aronson et al. (2000) warn us. Restoration projects, therefore, should be communicated to all the people involved, especially members of the local community (Pfadenhauer 2001; Swart et al. 2001; Hobbs & Harris 2001). Pfadenhauer (2001) indicates how, using two case histories, restoration may be implemented when integrated into the social and technical mechanisms of land use decision making.

How then to rise to this complex challenge? Hobbs and Harris (2001) set out an agenda for setting goals, measuring status and progress and putting into practice deliverable restoration programs.

Epilogue

This issue of *Restoration Ecology* presents several approaches and techniques of restoration projects, in which scientists were actively involved. They have tried to further develop a firm scientific framework for restoration ecology and hope they have presented building blocks for an international audience.

We believe that ecological restoration will be most successful when it is based on available scientific knowledge. We also believe that good communication and inclusion of all interested groups is of similar importance for sustainable results. Both with the organization of the congress and the publication of its results, we hope to have contributed to the communication of state-of-the-art scientific knowledge on restoration ecology.

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