

# The role of spontaneous vegetation succession in ecosystem restoration: A perspective

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**Abstract.** The paper summarizes ideas which were discussed during the 'Spontaneous Succession in Ecosystem Restoration' conference and elaborated through further discussion among the authors. It seeks to promote the integration of scientific knowledge on spontaneous vegetation succession into restoration programs. A scheme illustrating how knowledge of spontaneous succession may be applied to restoration is presented, and perspectives and possible future research on using spontaneous vegetation succession in ecosystem restoration are proposed. It is concluded that when implementing spontaneous succession for ecological restoration the following points must be considered: setting clear aims; evaluation of environmental site conditions; deciding whether spontaneous succession is an appropriate way to achieve the aims; prediction of successional development; monitoring of the results. The need for interdisciplinary approaches and communication between scientists, engineers and decision-makers is emphasized.

**Keywords:** Directed succession; Monitoring; Prediction.

## Introduction

Restoration ecology is a young discipline, still developing its own conceptual framework, theories and methodology (Bradshaw 1993; Hobbs & Norton 1996). Restoration is playing an increasingly important role in conservation biology, and this is likely to continue as natural and semi-natural habitats become more scarce and opportunities to restore ecosystems damaged by human activities become more common. Despite some discussion on the role of science and scientists in restoration ecology it is evident that a scientific base, including knowledge of ecological processes and functioning,

is necessary for successful restoration (Bradshaw 1993; Edwards et al. 1997; Palmer et al. 1997; Young 2000). In particular, it is crucial to incorporate the principles of vegetation succession into the discipline, especially as relatively stable seral stages are generally the desired goal of restoration (Parker 1997; Harker et al. 1999). The challenge for ecologists is to enhance the integration of scientific knowledge of spontaneous vegetation succession into restoration programs and to ensure effective implementation of theoretical and practical information. This paper summarizes the key issues relating to this challenge and proposes a scheme to encourage integration of spontaneous vegetation succession into restoration ecology. Terrestrial and semi-terrestrial ecosystems are considered here as restoration of aquatic habitats requires a different methodology and conceptual (hydrobiological) framework. Severely disturbed sites where succession starts on bare ground, and sites with established vegetation cover which can be improved by spontaneous or directed succession, are both included. The paper summarizes the ideas which were discussed during the conference on 'Spontaneous Succession in Ecosystem Restoration' held on September 5-9, 1999 in České Budějovice, Czech Republic, and were developed with further debate among the authors.

## Setting targets and obtaining information

Use of spontaneous vegetation succession in an ecosystem restoration program requires an existing knowledge base and application to specific aims. A target ecosystem should be set, including its expected structure and functions, in order to set clear aims for the

particular restoration effort. The scientific debate over setting restoration goals has tended to polarize. On one hand, a frequent aim is to return degraded biological communities to their original state and to re-establish self-regulatory natural processes. On the other hand, attempts to return damaged ecosystems to some kind of productive use or socially acceptable condition may be more realistic, a process that has been referred to as reclamation rather than restoration (Jordan et al. 1988). The distinction between the two goals may be blurred, however, and has led to considerable discussion over the ecological, cultural and socio-economic values of naturalness (Hobbs & Norton 1996; Blumrich et al. 1998). Nevertheless, spontaneous succession can be considered to help achieve either goal.

Once a target for restoration has been established, knowledge of the possible course of spontaneous vegetation succession in a given site can be summarized. For this, information of site environmental conditions is critical, including knowledge of the ecological functioning and processes operating, such as hydrological dynamics, nutrient cycling and plant dispersal and competition (Edwards et al. 1997; van Diggelen 1998). Moreover, restoration of site environmental conditions may have to precede spontaneous succession (Pfadenhauer & Klötzli 1996; Large 2001) especially if conditions were profoundly altered and are adverse for vegetation.

The optimum situation exists if results of an exact case study conducted on the site or comparable sites nearby are available, or if there is time to schedule and conduct such a study. However, this is usually not the case. Generally, results of other studies should be used with care for predicting successional changes in a given site – even if studies have been performed in a similar habitat elsewhere – as the course of succession is influenced by numerous factors (Pickett et al. 1987; Walker & Chapin 1987; Glenn-Lewin et al. 1992).

A crucial point, therefore, is the prediction of spontaneous successional changes. To achieve this, information from three sources can be used: (1) detailed case studies, (2) field experience and (3) comparative studies. Results of many case studies have been published (see journals dealing with vegetation ecology; Burrows 1990; Glenn-Lewin et al. 1992, etc.). Although these are not usually from sites highly relevant to the specific restoration program, they may still provide important information. Practical field experience can also be exploited in restoration. There are many local experts, usually good botanists with ecological knowledge, who are familiar with their locality and can help in suggesting and developing restoration programs. Comparative studies, in which successional seres are quantitatively compared over a larger area, are still rare (Prach et al. 2001) but we consider this approach to be promising for future restoration activities.

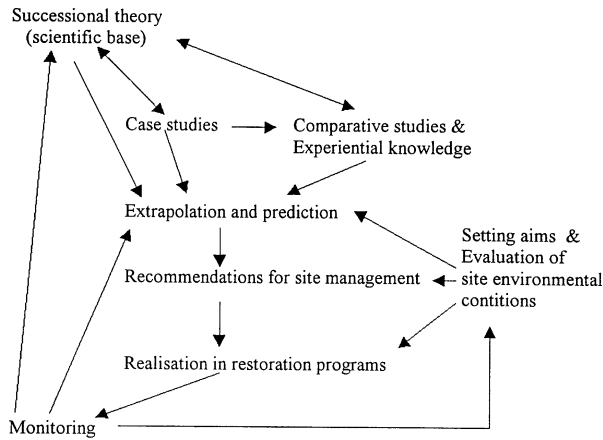
## **Implementing spontaneous succession in restoration programs**

Assuming that some knowledge on spontaneous succession in a given site, and information on site environmental conditions, are available will allow decisions to be made regarding which measures can be adopted i.e. technical, directed vegetation succession or reliance on spontaneous succession (Kirmer & Mahn 2001). The final option is always cheaper and often leads to ‘better’ results than engineered restoration. Unfortunately, we are not aware of any specific study where restoration by means of spontaneous succession is quantitatively compared with engineered restoration. Knowledge of spontaneous succession can determine the outcome of restoration measures and the likely time frame, as it can often be readily directed (Luken 1990) to achieve the desired vegetation cover. To direct succession successfully it is necessary to know, for example, at what stage it is best to introduce desirable species so that their mortality due to competition with spontaneously established species or adverse abiotic factors is minimized. Furthermore, it is possible to determine optimal timing for eradication or control of undesirable spontaneously established species, such as invasive aliens. Carefully designed changes in site management (e.g. vegetation cutting, grazing or turf removal) may help to achieve these goals (Krahulec et al. 2001). Hence, knowledge of spontaneous succession obtained from the three sources described in the previous paragraph can be successfully applied in order to direct succession.

When a restoration program is implemented monitoring should begin. Results of monitoring provide a feedback for predictions and facilitate adaptations to the restoration program if required. Monitoring can also serve as a convenient base for other scientific research, including testing ideas previously suggested. Occasionally, results of monitoring can improve the theoretical base (e.g. succession theory). The scheme in Fig. 1 summarizes how knowledge of spontaneous succession can be integrated into restoration ecology and illustrates relationships between key elements of the process.

## **Perspectives and possible future research**

Ecological approaches to restoration, including those which rely upon spontaneous processes, are receiving increasing attention compared to the technical measures that previously prevailed, when a site was usually prepared for artificial afforestation or agricultural use. This is especially evident in highly developed western European countries rather than countries such as the Czech Republic, Hungary or Poland. In the latter countries, the



**Fig. 1.** General scheme showing how knowledge of spontaneous succession can be integrated into restoration ecology.

former communist economy left many derelict sites that are now either left without any intervention (providing suitable subjects for studying succession) or reclaimed using technical means. There are even peculiar situations such as observed in one particular abandoned sand quarry where a close, spontaneous cover of pine trees was removed and pines were artificially planted again. To avoid such situations, and to educate and raise awareness of the issues, close communication between researchers, restoration practitioners and local authorities is necessary, in all countries. We emphasize the need for integration between and within disciplines, including scientists, engineers and decision-makers, as the successful realization of restoration programs requires multidisciplinary co-operation. The increasing involvement of scientists in restoration programs is evident (Luken 1990; Bakker et al. 1998) and was reflected by the launch of the journal *Restoration Ecology* in 1993. However, we consider that the present level of this involvement and the current scale of interdisciplinary communication is still insufficient.

We believe that future research involving spontaneous succession in ecosystem restoration should concentrate on the following activities.

1. Case studies of long-term research in permanent plots including studying mechanisms of succession, interactions of vegetation pattern with environmental site conditions (e.g. soil characteristics, hydrology, and biotic interactions), directing succession and consequently timing and designing appropriate site management.

2. Studies of ecosystem functioning and their key ecological processes (e.g. nutrient dynamics, plant establishment and competition).

3. Extrapolation of data from particular case studies into a landscape framework.

4. Increased analysis of the landscape framework, including the history of landscape alteration, especially linking regional, local and community species pools and site conditions (Zobel et al. 1998).

5. Studies on seed ecology, i.e. sources and transport of diaspores in fragmented landscape and viability of seeds in the seed bank. These can be very helpful in predicting spontaneous vegetation processes (Poschlod et al. 1996; Strykstra et al. 1998).

6. Integration of the previous five activities in comparative studies on succession at larger geographical scales and under a wider range of environmental conditions.

7. Incorporation of the knowledge obtained from case studies, comparative studies, and from field experience into expert systems and Geographic Information Systems that can help predict and monitor succession in restoration programs (Prach et al. 1999).

The focus of this paper (and volume) is vegetation succession, but other ecosystem components must also be considered in future research: soil, hydrological regime, other biota, human intervention and economical, social and political aspects of ecosystem restoration (Pickett & Parker 1994; Edwards et al. 1997). We expect that using spontaneous succession will increasingly become an integral part of ecological restoration programs.

## Conclusions

We believe that an awareness of the role and efficiency of spontaneous vegetation succession for ecosystem restoration should be encouraged. We suggest that when implementing spontaneous succession in ecological restoration the following points should be addressed.

- Aims of restoration, including (1) target ecosystem, (2) functioning of restored ecosystem, (3) processes leading to restoration and (4) time frame in which the aims should be achieved.
- Environmental site characteristics and how these may or may not influence succession.
- Communication between researchers, restoration practitioners and authorities, including education and public awareness and integration between and within disciplines.
- The extent of possible generalization between sites and regions and the level of predictability of successional patterns and processes.
- Monitoring and post-project evaluation, both in terms of feeding back to the same project and for the application of experience to other projects.

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