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Salt-marsh restoration: evaluating the success of de-embankments in north-west Europe

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Abstract

De-embankment of historically reclaimed salt marshes has become a widespread option for re-creating salt marshes, but to date little information exists on the success of de-embankments. One reason is the absence of pre-defined targets, impeding the measurement of success. In this review, success has been measured as a saturation index, where the presence of target plant species in a restoration site is expressed as a percentage of a regional target species pool. This review is intended to evaluate and compare success of many different sites on an idealistic concept where all regional target species have the potential to establish in a site, but may not actually do so because the site is unsuitable or inaccessible. Factors affecting suitability and accessibility and management options to increase regional species diversity are discussed. The results show that many sites contain less than 50% of the regional target species, especially when sites are smaller than 30 ha. Higher species diversity is observed for sites exceeding 100 ha and for sites with the largest elevational range within mean high water neap to mean high water spring tide. Most sites younger than 20 years contain more target species than older sites. For future de-embankments it is recommended that clear targets are set from the start. This brings along the need for monitoring. Only 37 out of 70 sites with de-embankment were monitored for plant species assemblages. Setting targets will also allow adaptive management of the site. Management options that are likely to result in higher species diversity are the construction and maintenance of drainage structures and the implementation of a grazing or mowing regime.

Keywords: Managed realignment; Regional species pool; Restoration success; Saturation index; Summerpolder; Target species

1. Introduction

Over the past centuries, large areas of salt marsh have been reclaimed from the sea by the construction of embankments (Dijkema, 1987; Pethick, 2002). These embankments would either function as the main sea defence, protecting the hinterland from all tidal flooding, or as low summerdikes in front of an existing seawall, protecting the reclaimed land (polder) from normal tidal inundations, but not during winter storms (Bakker et al., 2002). The polder was usually used for intensive agricultural exploitation, which often involved the construction and/or maintenance of drainage structures and the application of fertiliser. As a result, the characteristic halophytic communities have largely disappeared. Continuing sediment accumulation in front of the embankments resulted in the development of new salt marshes and, after sufficient vertical accretion, these could in turn be reclaimed.

This process of successive reclamations has now become less acceptable for various reasons. First, the need for extension of agricultural areas has diminished

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(Bakker et al., 1997). At the same time, it has been realised that salt-marsh communities are important habitats that need to be preserved. Apart from their nature conservation interest, salt marshes are important for coastal defence, as they act as a natural buffer for dissipating wave energy (Möller et al., 1996). Moreover, regular tidal inundation on salt marshes ensures the input of fresh sediment, the rate of which may be high enough to compensate for current and future sea level rise. In contrast, most embanked polders are characterised by a sediment deficit and may subside to below mean sea level. The presence of a salt marsh in front of a seawall will thus improve safety of the hinterland and reduce the cost involved in seawall maintenance (King and Lester, 1995). Especially in the United Kingdom, where a combination of the sinking of the land and rising sea level has caused extensive erosion of salt marshes (Cooper et al., 2001), coastal defence is the main incentive for de-embankment (Pethick, 2002).

The idea for using de-embankment to re-create salt marshes is developed from evidence of spontaneous salt-marsh formation after accidental breaching of seawalls due to storm tides (French, 1999). However, not all natural breaches have resulted in successful salt-marsh development, hence it will be important to evaluate the success of different sites in order to provide insight into possible outcomes for deliberate de-embankments. In this paper the results of several natural and deliberate de-embankment cases will be discussed. Under deliberate de-embankment we include complete or partial removal of a seawall or summerdike as well as regulated tidal exchange where sluices or one-way valves have been inserted in the embankment to allow specified tidal amplitude (Lamberth and Haycock, 2001). The aims of the paper are: (1) to present an overview of sites subjected to natural or deliberate breaching of seawalls or summerdikes or regulated tidal exchange, (2) to introduce a method for evaluating restoration success, (3) to compare restoration success of different sites, (4) to determine which factors are likely to affect restoration success, and (5) to provide recommendations for future restoration schemes.

2. Selection and general description of study sites

A literature survey was conducted to identify restoration sites across north-west Europe. This resulted in a total of 89 sites (Appendix A). Sites that had no information on location, type of scheme, size or year of restoration, or sites for which the scheduled restoration had not been implemented, were not included in the analysis. This reduced their number to 70. The majority of the restoration sites (48) is located in the United Kingdom, in particular on the south-east coast (Fig. 1). However, they rarely exceed 100 ha in size and the total restoration area of these 48 sites (2007 ha) is lower than that of the ten German sites (2590 ha) (Fig. 2). For fifty percent of the sites, embankments were accidentally breached during storm surges, in particular in 1897 and 1953. The oldest accidentally breached embankment reported in the literature dates back to 1802. The first deliberate de-embankment was executed in 1991 (Northey Island, site Nr. 30b), after which between one and seven new de-embankments were initiated in north-west Europe each year (Fig. 3). Habitat creation/restoration is the most common reason for de-embankment, especially in the Netherlands, Belgium and Germany (Fig. 3). In many cases this habitat creation is driven by European legislation e.g., the Habitats Directive, which requires member states to designate special areas of conservation (Pethick, 2002). Flood defence is another major reason for de-embankment, as the re-creation of a saltmarsh in front of a sea defence is considered a cost-effective way of improving safety to the hinterland.

3. How to evaluate success?

3.1. Definition of success

There is much recent debate on the question of how to define restoration success. One approach is to determine whether or not the terms set in an agreement, contract or permit have been met (Kentula, 2000). Use of compliance success is appropriate whenever restoration targets are set beforehand. However, in many cases there are no clearly specified targets. In the present overview, for example, many sites had no clear pre-defined targets. Other possibilities for assessing success are to compare the ecological structure or functioning of a restored site with one or more reference sites (Thom et al., 2002; Edwards and Proffitt, 2003). However, the choice of the reference sites strongly affects the outcome of such a comparison (Kentula, 2000; Morgan and Short, 2002). Besides, comparing conditions with a natural reference system may not be realistic or appropriate because restoration may start on different substrate or different elevation (Thom, 2000), or because the reference site itself may be degraded. Historical reference has also been used for assessing success, in which case success criteria have often been based on the situation before the industrial revolution and before the application of artificial fertiliser (De Jonge and De Jong, 2002). However, when taking into account the increased human population with the accompanying levels of pollution, landscape fragmentation and species extinctions, a return to pre-industrial revolution ecosystems is hardly achievable.