



## Restoration of coastal ecosystems – an introduction

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During recent decades, coastal ecosystems have been increasingly affected by large-scale land-use change and by sea level rise due to global warming (Doody 2001, 2004). Both salt marshes and dunes have an important function in protecting coastal regions from flooding and erosion and provide habitats for plant and animal species with special adaptations for survival under harsh environmental conditions. For successful restoration, the dispersal of target species is less limiting in coastal ecosystems than in most inland ecosystems (e.g. Wolters et al. 2005a, Gallego Fernandez & García Novo 2007). However, restoration can be constrained by difficulties in restoring the natural dynamics of flooding, sedimentation, sand accumulation and erosion processes, and therefore the appropriate environmental conditions on which target species depend (Bakker et al. 2002, Grootjans et al. 2002, Wolters et al. 2005b).

Different processes threaten drift-lines, beach and dune ecosystems, for example the removal of seagrass and seaweed, recreation activities, coastal protection measures, sea level rise, construction activities and pollution (Doody 2001). During the 20<sup>th</sup> century, land use changed and both shrub and woodlands, for example with *Hippophaë rhamnoides* and *Rosa rugosa*, spread rapidly and dominate at present large dune areas, forming dense, impenetrable thickets. Therefore, species richness and biodiversity, especially of open dune grasslands, declined (Isermann 2007, Isermann et al. 2007). Restoration efforts lead from dense shrubland to open species-rich dune grasslands (Provoost et al. 2004, Leten et al. 2005). Moreover, grazing (over- and undergrazing) of grey and brown dunes e.g. by cattle and rabbits, has still important effects on species composition as well as on habitat heterogeneity (Doody 2001). During the last decades, grasses such as *Carex arenaria*, *Deschampsia flexuosa* and *Ammophila arenaria* as well as mosses like the neophyte *Campylopus introflexus* encroached in grey and brown dunes mainly due to nutrient enrichment (e.g. Kooijman et al. 1998).

Natural processes and species richness of dune slacks were mainly affected by lowering of the water table due to drinking water production. Restoration measures, already established since the middle of the 20<sup>th</sup> century, included for example the re-introduction of traditional management techniques in dune slacks, such as mowing, grazing and sod removal, or construction of artificial dune slacks to compensate for biodiversity loss elsewhere (Grootjans et al. 2002).

Salt marshes and brackish coastal communities in Europe have been endangered due to large-scale embankments and intensive agricultural land use in the past (Dijkema et al. 1984, Stock et al. 1997, Bakker et al. 2002, Bakker & Piersma 2006). During the last decades, however, several projects on the restoration of coastal marshes by de-embankment and dike-breaching have been started at the North Sea (Crooks et al. 2002, Wolters et al. 2005b) and the Baltic Sea (Bernhardt & Koch 2003, Seiberling 2003) as well as in Southern Europe (e.g. Gallego Fernandez & Garcia Novo 2002 & 2007). Furthermore, European salt marshes were affected by land use changes during the last decades. At the Baltic Sea and in brackish marshes of the Wadden Sea area, the abandonment of traditional land use by mowing or grazing favours the spreading of *Phragmites australis* and other tall species, which can have a negative effect on low-growing halophyte species (Dijkema 1990, Jutila 2001, Esselink et al. 2002). Here, restoration efforts have to focus on land-use optimisation in relation to local environmental conditions.

In the Wadden Sea salt marshes, restoration targets have differed between countries over recent decades. In the Netherlands, nature conservation and restoration focussed on the maintenance and re-establishment of high plant species density (e.g. Bakker 1989, Bakker et al. 1997), whereas in the German National Parks the main target was to enhance natural dynamics both concerning abiotic processes as well as species interactions (Stock 1997, Stock et al. 1997, Bakker et al. 2005). In the Netherlands, re-introduction of cattle grazing in species-poor abandoned high salt marshes dominated by *Elymus athericus* led to an increase in plant species density but in the low marsh grazing and trampling had a negative effect on species density (Bakker 1989, Bakker & Piersma 2006). In the German Wadden Sea area, large-scale grazing reduction and abandonment was necessary to allow the spreading of typical salt marsh species, which had become rare after decades of very intensive grazing (Kiehl et al. 1996, Stock et al. 1997). Up to now, salt marsh restoration by grazing cessation and reduction in combination with neglecting the artificial drainage systems, showed mainly positive effects on species density and establishment of target species (Schröder et al. 2002, Kiehl et al. 2007).

In summary, these examples show that ecological restoration of beaches, dunes and salt marshes includes the maintenance and improvement of natural environmental dynamics and the restoration of biodiversity through the promotion of habitat-specific target species and by favouring environmental heterogeneity and landscape diversity. In practice, ecological restoration of coastal ecosystems has to comprise coastal conservation policies, technical aspects of restoration activities and habitat management as well as scientific research on the effectiveness of restoration and conservation measures (e.g. Bauer et al. 2004, Wolters et al. 2005, Zedler 2005).

The Fifth European Conference on Ecological Restoration of the Society for Ecological Restoration (SER) focused on “Land use changes in Europe as a challenge for restoration: ecological, economical and ethical dimensions” and was held from 21 to 25 August 2006 in Greifswald, Germany. During this conference, a special symposium on the restoration of coastal ecosystems was organised with sessions on saltmarshes and dunes. Six contributions from this symposium are published in this volume. They cover a broad field from restoration recommendations for mangroves in relation to their historic distribution (Kholeif 2007); vegetation studies on permanent plots for the evaluation of large-scale land-use changes in Wadden-Sea saltmarshes (Kiehl et al. 2007); the significance of ground beetles and spiders as indicators for the evaluation of salt-marsh and dune restoration (Desender et al. 2007, Maelfait et al. 2007); to studies on restoration of dune ecosystems for the promotion of target species (van Til & Kooijman 2007) and landscape perception (García-Novo et al. 2007).

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