



Beach and Dune Restoration

KARL F. NORDSTROM

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BEACH AND DUNE RESTORATION

This book analyzes the tradeoffs involved in restoring beaches and dunes on intensively developed coasts, the most effective approaches to use, and the ways to educate and involve stakeholders. It identifies restoration strategies that can be employed to enhance natural processes and make coastal landforms more dynamic while maintaining their value for shore protection. In addition to ecological values, the concept of restoration is expanded to include physical, economic, social and ethical principles, and ideals. Compromise management solutions are suggested to accommodate the needs of many different user groups, including municipal managers and individual property owners, whose role has remained unassessed by existing publications on the same issue. The means of overcoming inertia or antagonism to environmentally friendly actions are also discussed. The book is written for coastal scientists, engineers, planners and managers, and also serves as a useful supplementary reference text for courses dealing with issues in coastal management, ecology and environmental ethics.

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Preface

This book is about restoring landforms and enhancing their functions and services on intensively developed coasts. It is a follow-up to my book *Beaches and Dunes of Developed Coasts*, which identified the many ways beaches and dunes are transformed by human actions and the differences between natural landforms and the human artifacts that replace them. In writing that book, it became obvious that many transformations of the coastal landscape, even those involving construction of new landforms, were being done with little thought given both to the accompanying environmental losses and the potential opportunities for achieving new environmental gains. Traditional beach and dune building practices emphasize the use of landforms for protection and recreation, but that does not preclude adding new natural resource values compatible with those uses. In many cases, the modification of traditional shore protection projects to achieve nature goals can be accomplished with little change in design or cost. I acknowledge that human-use functions will be the driving forces for managing beaches in developed areas, so a return to a condition of pristine nature is not an option. Restored landforms and habitats will be subject to direct human use or indirect effects resulting from land uses in adjacent areas, and these landforms may require periodic human adjustments to survive. The impossibility of returning to pristine nature should not deter efforts to regain elements of the natural environment and reverse the trend toward environmental loss.

The great competition for space near the land–ocean interface and the increasing demands of different interest groups on the new resources made available by constructing beaches and dunes require evaluation of the new environments in a framework that considers physical, biological, and social goals and objectives, and the tradeoffs and compromises involved. This focus on compromise and the need to accommodate different user groups, including shorefront residents and tourists, is another distinguishing characteristic of this book. My working assumption is that some nature is better than none, even if it is imperfect, providing that no better

option is available given the economic or political climate at the time. I consider this assumption valid if the restored environments are considered interim states that will be improved as natural features become more acceptable to stakeholders and greater resources are devoted to improving them.

This book is not a manual of procedures for building beaches and dunes. Numerous books and technical reports provide practical guidelines for emplacing sediment, installing sand-trapping fences, and planting dunes (e.g. CERC 1984; Ranwell and Boar 1986; Technische Adviescommissie voor de Waterkeringen 1995; Dean 2002; US Army Corps of Engineers 2002), and there are many information sheets produced by government departments and environmental commissions, such as the outstanding series of leaflets produced by the Beach Protection Authority of Queensland. Most guidelines, and the studies on which they are based, focus on how to build landforms and habitats rather than how they can or should evolve as natural systems after they are constructed. The principal difference between this book and previous books on beach and dune management is the emphasis on trying to find ways to modify existing practices to enhance natural processes and make landforms more dynamic while maintaining their function as shore protection structures and managing them as natural features after construction. It is intended to be a companion volume to design manuals rather than a substitute for them.

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1

The need for restoration

The problem

The shorelines of the world are being converted to artifacts through damaging actions such as eliminating dunes to facilitate construction of buildings and support infrastructure, grading beaches and dunes flat to facilitate access and create space for recreation, and mechanically cleaning beaches to make them more attractive. Progressive beach erosion, combined with human attempts to retain shorefront buildings and infrastructure in fixed positions, can result in truncation or complete loss of beach, dune, and active bluff environments. The lost sediment may be replaced in artificial beach nourishment operations, but nourishment is usually conducted to protect shorefront buildings and provide a recreational platform rather than to restore natural values (Figure 1.1). Sometimes nourished beaches are capped by a linear dune designed to function as a dike against wave attack and flooding. Many of these dune dikes are built by earth-moving machinery rather than by aeolian processes (Figure 1.2), resulting in both an outward form and internal structure that differ from natural landforms. Dunes on private properties landward of public beaches are often graded and kept free of vegetation or graded and re-vegetated, but this vegetation cover may bear little similarity to a natural cover (Nordstrom 2003). Transformation of landscapes to tourist economies can convert distinct landscapes in different parts of the world into a single landscape of tourism, that simulates components of landscapes perceived to be effective in attracting tourists, thus dissolving geographic particularity and landscape identity (Turkenli 2005).

Pressure on coastal environments is intensified by the human tendency to move close to the coast, either for tourism or to avoid conflicts or population pressures inland (Roberts and Hawkins 1999; Brown and McLachlan 2002). By 2020 over 60% of the population may reside within 60 km of the coast (UNCED 1992). Many remote locations that were spared development in the past are undergoing development pressure (Smith 1992; Wong 1993; Lubke *et al.* 1995; Brown *et al.* 2008).



Figure 1.1. La Victoria Beach in Cádiz, Spain, showing lack of topography and vegetation on a nourished beach maintained and cleaned for recreation.



Figure 1.2. Protective dune near Koserow, Mecklenburg-Vorpommern, Germany, showing the linear nature of the dune and its abrupt contact with the planted protective forest landward.

The effects of global warming and sea level rise are added to human pressures. The most significant threat to coastal species is loss of habitat, especially if sea level rise is accompanied by increased storminess (Brown *et al.* 2008).

Retreat from the coast would resolve problems of erosion and provide space for new landforms and biota to become re-established, but retreat appears unlikely except on sparsely developed shores (Kriesel *et al.* 2004). Most local governments and property owners would probably advocate management options that approach the status quo (Leafe *et al.* 1998), even under accelerated sea level rise (Titus 1990). The great value of land and real estate is the driving force, and too much may be invested on developed shores to consider anything short of holding the line (Nordstrom and Mauriello 2001).

Problems associated with the conversion of coastal landscapes to accommodate human uses include loss of topographical variability (Nordstrom 2000), loss of natural habitat and biological diversity (Beatley 1991), fragmentation of landscapes (Berlanga-Robles and Ruiz-Luna 2002), threats to endangered species (Melvin *et al.* 1991), reduction in seed sources and decreased resilience of plant communities in adjacent undeveloped areas following loss by storms (Cunniff 1985), loss of intrinsic value (Nordstrom 1990), loss of original aesthetic and recreational values (Cruz 1996; Demirayak and Ulas 1996), and loss of the natural heritage or image of the coast that affects the ability of stakeholders to make informed decisions on environmental issues (Télez-Duarte 1993; Golfi 1996; Nordstrom *et al.* 2000).

Natural processes cannot be relied on to re-establish natural characteristics in developed areas. Buildings and support infrastructure destroyed by long-term erosion or major storms are quickly rebuilt in reconstruction efforts, and post-storm landscapes often bear a greater human imprint than pre-storm landscapes (Fischer 1989; Meyer-Arendt 1990; FitzGerald *et al.* 1994; Nordstrom and Jackson 1995). Establishment of coastal reserves, such as state/provincial or national parks, help maintain environmental inventories, but inaccessibility to these locations or restrictions on intensity of use do not provide the opportunity for many tourists to experience nature within them (Nordstrom 2003). Natural enclaves near regions that are developed and protected by structures are subject to sediment starvation and accelerated erosion that alter the character and function of habitat from the natural conditions that formerly existed there (Roman and Nordstrom 1988). Natural processes may be constrained even within areas managed for nature protection because of the need to modify those environments to provide predictable levels of flood protection for adjacent developed areas (Nordstrom *et al.* 2007c). Designating protected areas to preserve endangered species may have limited effect in re-establishing natural coastal environments unless entire habitats or landscapes are included in preservation efforts (Waks 1996; Watson *et al.* 1997). Establishment of coastal preserves may also have the negative effect of providing an excuse for

ignoring the need for nature protection or enhancement in human-occupied areas (Nordstrom 2003).

Alternatives that enhance the resilience of coastal systems or their capacity to respond to perturbations by maintaining biodiversity should supplement alternatives that resist the effects of erosion and flooding associated with climate change (Nicholls and Hoozemans 1996; Klein *et al.* 1998; Nicholls and Branson 1998). Studies have called attention to the potential for restoring lost beach and dune habitat to compensate for environmental losses elsewhere, protect endangered species, retain seed sources, strengthen the drawing power of the shore for tourism, and re-establish an appreciation for naturally functioning landscape components (Breton and Esteban 1995; Breton *et al.* 1996, 2000; Nordstrom *et al.* 2000). Ecologists, geomorphologists, and environmental philosophers point to the need to help safeguard nature on developed coasts by promoting a new nature that has an optimal diversity of landforms, species, and ecosystems that remain as dynamic and natural as possible in appearance and function while being compatible with human values (van der Maarel 1979; Doody 1989; Westhoff 1985, 1989; Roberts 1989; Light and Higgs 1996; Pethick 1996; Nordstrom *et al.* 2000). There is also a growing interest in trying to develop a new symbiotic, sustainable relationship between human society and nature (with its diversity and dynamism) and value the non-human world for the sake of relations between humans and nature in addition to intrinsic and utility value (Jackson *et al.* 1995; Cox 1997; Naveh 1998; Higgs 2003).

Human modifications

The increasing pace of human alteration of the landscape and the increasing potential for people to reconstruct nature to provide many services and functions require re-examination of human activities in terms of the many ways they can be made more compatible with nature. Human actions can eliminate beaches and dunes to construct human facilities, alter these landforms through consumptive uses, reshape or rebuild them, change their mobility by altering surface cover or employing stabilizing devices, alter sediment budgets, or alter growth conditions through changes in pollutant levels or changes in water budgets (Table 1.1). Some environmental losses are associated with every modification, even the most benign ones, but the losses may be small and temporary. Human-modified landforms are often smaller than their natural equivalents, with fewer distinctive sub-environments, a lower degree of connectivity between sub-environments, and often a progressive restriction in the resilience of the coast to future environmental losses (Pethick 2001). The challenge is to enhance the natural value of these landforms through creative human actions.

Table 1.1. *Ways that landforms and habitat are altered by human actions (from Ranwell and Boar 1986; Nordstrom 2000; Doody 2001; Brown and McLachlan 2002; Brown et al. 2008)*

Eliminating for alternative uses

Constructing buildings, transportation routes, promenades

Constructing alternative surfaces

Mining

Altering through use

Trampling

Off road vehicle use

Fishing and harvesting

Grazing

Extracting oil, gas, water

Laying pipelines

Extracting and recharging water

Military activities

Reshaping (grading)

Piling up sand to increase flood protection levels

Removing sand that inundates facilities

Breaching barriers to control flooding

Dredging channels to create or maintain inlets

Widening beaches to accommodate visitors

Eliminating topographic obstacles to facilitate access or construction

Removing dunes to provide views of the sea

Building more naturalistic landscapes

Altering landform mobility

Constructing shore protection and navigation structures

Constructing marinas and harbors

Placing structures between sediment sources and sinks

Introducing more or less resistant sediments into beach or dune

Clearing the beach of litter

Stabilizing landforms using sand fences, vegetation plantings, or resistant materials

Remobilizing landforms by burning or removing vegetation

Altering external conditions

Damming or mining streams

Diverting or channelizing runoff

Introducing pollutants

Salt water intrusion

Creating or changing habitat

Nourishing beaches and dunes

Restoring sediment budgets (bypass, backpass)

Burying unwanted or unused structures

Creating environments to attract wildlife

Controlling vegetation by mowing, grazing, fires

Removing or cleaning polluted substrate

Adding species to increase diversity

Introducing or removing exotic vegetation

Introducing pets or feral animals

Human actions are not always negative, especially if applied in moderation and with an awareness of environmental impacts. The effects of agriculture can vary from “disastrous” to real added ecological values (Heslenfeld *et al.* 2004). Intensive grazing can destroy vegetation cover and mobilize entire dune fields, but controlled grazing can restore or maintain species diversity (Grootjans *et al.* 2004; Kooijman 2004). Many sequences of vegetation succession, now assumed to be natural, appear to have been initiated by human activity when examined more closely (Jackson *et al.* 1995; Doody 2001). Many changes, such as conversion of the Dutch dunes to recharge areas for drinking water, introduced a new kind of nature, with different species utilization and different uses for nature appreciation (Baeyens and Martínez 2004). The protection provided by beaches and dunes altered by humans to provide flood protection has allowed more stable natural environments to form that have developed their own nature conservation interest and may even be protected by environmental regulations (Orford and Jennings 1998; Doody 1995). The messages are clear: humans are responsible for nature; and human actions can be made more compatible with nature by modifying practices to retain as many natural functions and values as possible in modifying landscapes for human use. These two messages are increasingly applicable in natural areas used as parks as well as developed areas.

Values, goods, and services of beaches and dunes

Beaches and dunes have their own intrinsic value, but they also provide many goods and services of direct and indirect benefit to humans (Table 1.2). Not all goods and services can be provided within a given shoreline segment, even in natural systems, but most may be available regionally given sufficient space and variety in exposure to coastal processes and sediment types. It may not be possible to take advantage of all of the goods and services, even where the potential exists. Mining and several forms of active recreation may be incompatible with use of beaches for nesting. Alternatively, beaches and dunes can have multiple uses, such as protecting property from coastal hazards and provide nesting sites, habitable substrate, and refuge areas for wildlife, providing human uses are controlled using compatible regulations.

Not all uses that take advantage of the goods and services provided by beaches and dunes should be targets of practical restoration efforts. It makes little sense to restore minerals in a landform only to re-mine them. Provision of new sources of fuel to a subsistence economy may be accommodated in more efficient ways than attempting to favor driftwood accumulation on a restored beach or planting trees on a dune. In these cases, restoration efforts may not be required to sustain a human use, but they may be required to reinstate microhabitats lost through previous exploitation. Components of ecosystems should not be seen as exchangeable goals

Table 1.2. *Values, goods and services provided by coastal landforms, habitats or species (modified from Lubke and Avis 1998; Arens et al. 2001; Peterson and Lipcius 2003)*

Protecting human structures (providing sediment, physical barrier or resistant vegetation)
Providing subsistence for local human populations (food, fuel, medicinal material)
Market value for traditional and industrial economies (residences, resorts, mines)
Providing sites for active recreation
Aesthetic, psychological, therapeutic opportunities
Filtering pollutants
Source of groundwater (in dunes)
Denitrification
Ecological niche for plants adapted to extreme conditions
Habitable substrate for invertebrates
Refuge areas (e.g. invertebrates in wrack; rabbits in dunes)
Nest or incubation sites (e.g. turtles, horseshoe crabs, grunion, surf smelt in beaches)
Food for primary consumers (e.g. invertebrates in wrack)
Food for higher trophic levels (scavengers and predators)
Sequestering carbon
Reducing concentrations of greenhouse gasses
Providing synergistic benefits of multiple habitat types (e.g. corridors)
Intrinsic value

that can be used and created again to suit human needs (Higgs 2003; Throop and Purdom 2006).

The need for restoring beaches and dunes

Coastal evolution may take different routes. The development process need not proceed unidirectionally toward reshaping of beaches into flat, featureless recreation platforms (Figure 1.1) or total elimination of dune environments in favor of structures. The trend toward becoming a cultural artifact can be reversed, even on intensively developed shores, if management actions are taken to restore naturally functioning beaches and dunes and rediscover the coastal-environmental heritage (Nordstrom and Mauriello 2001). Creating and maintaining natural environments in developed areas (Figure 1.3) can help familiarize people with nature, instill the importance of restoring or preserving it, enhance the image of a developed coast, influence landscaping actions taken by neighbors, and enhance the likelihood that natural features will be a positive factor in the resale of coastal property (Norton 2000; Savard *et al.* 2000; Conway and Nordstrom 2003). Tourism that is based on environmental values can add new cycles of seasonality on the landscape (Turkenli 2005) and extend the duration of the tourist season. Restoration of natural habitats thus has great human-use value in addition to natural value.