1
The Need for Restoration

1.1 The Problem

The shorelines of the world continue to be converted to artifacts through human 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 to beach users. 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 beach nourishment operations, but nourishment is usually conducted to protect shorefront buildings or provide a recreational platform rather than to restore natural values (Figure 1.1). Sometimes nourished beaches are capped by a linear dune of uniform height alongshore 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, resulting in an outward form and an 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 vegetated with a cover that may bear little similarity to a natural cover.

Transformation of coastal environments is intensified by the human tendency to move close to the coast (Smith 1992; Wong 1993; Lubke et al. 1995; Roberts and Hawkins 1999; Brown and McLachlan 2002; Brown et al. 2008; Romano and Zullo 2014). The effects of global warming and sea level rise and increased impact of coastal storms are added to human pressures (FitzGerald et al. 2008; Boon 2012; Cazenave and Le Cozannet 2013; Miller et al. 2013; Stocker et al. 2013; Vousdoukas et al. 2018; Barnard et al. 2019; Fang et al. 2020; Mathew et al. 2020), further amplifying the transformation. 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). Coastal development has already eliminated much natural beach and dune habitat worldwide (Defeo et al. 2009).

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

Sandy beach ecosystems could adapt to storms and sea level rise by retreating landward and maintaining structure and function over various spatial and temporal scales (Orford and Pethick 2006; Cooper and McKenna 2008; Berry et al. 2013). Retreat from the coast (managed realignment) would resolve problems of erosion and provide space for new landforms and biota to become reestablished. The advantages of adapting by retreat are acknowledged, but actual responses by removing human structures from developed ocean coasts are limited and often resisted by the public (Ledoux et al. 2005; Abel et al. 2011; Luisetti et al. 2011; Morris 2012; Niven and Bardsley 2013; Cooper and Pile 2014; National Research Council 2014; Costas et al. 2015; Harman et al. 2015). 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 on coastlines and the level of investment on developed shores are too great to consider anything short of holding the line (Nordstrom and Mauriello 2001; Niven and Bardsley 2013).

Post-storm evaluations reveal ample evidence of the vulnerability of shorefront houses and infrastructure to storm damage (Saffir 1991; Sparks 1991; Platt et al. 2002; Kennedy et al. 2011; Hatzikyriakou et al. 2016; Hu et al. 2016; O'Neil and Van Abs 2016). Despite this destruction, strategies for reducing the number of people and buildings at risk and redistributing the risks, benefits, and costs among stakeholders are rarely implemented (Abel et al. 2011; Rabenold 2013; National Research Council 2014). More often, buildings and support infrastructure destroyed by long-term erosion or major storms are quickly rebuilt in reconstruction efforts, and landscapes after the storm often bear a greater human imprint than landscapes before the storm (Fischer 1989; Meyer-Arendt 1990; FitzGerald et al. 1994; Nordstrom and Jackson 1995; Platt et al. 2002). Market and policy incentives for development and redevelopment in coastal communities can overwhelm attempts of planners to discourage development (Andrews 2016; Holcomb 2016).

Problems associated with conversion of coasts to accommodate human uses include loss of topographical variability (Nordstrom 2000); loss of natural landforms and their habitats (Beatley 1991; Garcia-Lozano et al. 2018; Pérez-Hernández et al. 2020); reduction in space for remaining habitat (Dugan et al. 2008) or elimination of biota from those surfaces (Kelly 2014); fragmentation of landscapes (Berlanga-Robles and Ruiz-Luna 2002; Masucci and Reimer 2019); threats to endangered species (Melvin et al. 1991; Maslo et al. 2019); reduction in seed sources and decreased resilience of plant communities following loss by storms (Cunniff 1985; Gallego-Fernández et al. 2020); 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, which affects appreciation of environmental benefits or ability of stakeholders to make informed decisions on environmental issues (Télez-Duarte 1993; Golfi 1996; Nordstrom et al. 2000; Gesing 2019; Lapointe et al. 2020). Natural physical and ecological processes cannot be relied on to reestablish natural characteristics in developed areas without people allowing these processes to occur. Establishment of coastal preserves, such as state/provincial or national parks, helps maintain environmental inventories, but inaccessibility to these locations or restrictions on intensity of use do not provide the opportunity for many visitors to experience nature within them (Nordstrom 2003). Natural enclaves near regions that are intensively developed may be too small to evolve naturally (De Ruyck et al. 2001). Natural enclaves near regions with shore protection structures are subject to sediment starvation and accelerated erosion that alter the character and function of habitat from former conditions (Roman and Nordstrom 1988). Natural processes may be constrained 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 a limited effect in reestablishing 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 areas occupied by humans (Nordstrom 2003).

Alternatives that enhance the capacity of coastal systems to respond to perturbations by maintaining diverse landforms and habitats should supplement or replace 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; Orford and Pethick 2006; Cooper and McKenna 2008). Restoring lost beach and dune habitat can compensate for environmental losses elsewhere, protect endangered species, retain seed sources, strengthen the drawing power of the shore for tourism, and reestablish 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 uses (van der Maarel 1979; Westhoff 1985, 1989; Doody 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 to value the natural world for the sake of relations between humans and nature (Jackson et al. 1995; Cox 1997; Naveh 1998; Higgs 2003; Gesing 2019).

1.2 Human Modifications

Coastal changes and economically driven human actions are now recognized as mutually linked, often in iterative cycles, such as erosion and mitigation (Lazarus et al. 2011, 2016; Murray et al. 2013; Gopalakrishnan et al. 2016). The increasing pace of human alterations and the increasing potential for people to reconstruct nature for human use require reexamination of human activities (Table 1.1) in terms of the many ways they can be made more compatible with nature. 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

Table 1.1. *Ways that landforms and habitat are altered by human actions*

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
Saltwater 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

Table 1.1. (*cont.*)

Removing or cleaning polluted substrate
Adding species to increase diversity
Introducing or removing exotic vegetation
Introducing pets or feral animals

(*Sources*: Ranwell and Boar 1986; Nordstrom 2000; Doody 2001; Brown and McLachlan 2002; Brown et al. 2008).

often a progressive restriction in the ability of the coast to adjust to future environmental losses (Pethick 2001). The challenge for restoration initiatives is to enhance the natural value of these landforms and increase their resilience through human actions.

Human actions are not always negative, especially if applied in moderation and with an awareness of environmental impacts. The effects of agriculture can range from "disastrous" to adding real 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 landscape, 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 (Doody 1995; Orford and Jennings 1998). 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 as possible in modifying landscapes for human use. These two messages are increasingly applicable in natural coastal areas used as parks as well as developed areas.

1.3 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). In coastal environments, a good can range from nesting and incubation sites for commercial marine species to potable water supplied by dune fields. Services can include filtering of pollutants or natural beach accretion that provides recreational

Table 1.2. *Values, goods, and services provided by coastal landforms, habitats, or species*

Protection for human structures (providing sediment, physical barrier, or resistant vegetation)
Subsistence for local human populations (food, fuel, medicinal material)
Market for real estate and resort economies
Raw materials for construction and industrial use
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 gases
Providing synergistic benefits of multiple habitat types (e.g., corridors)
Education and research
Intrinsic value

(*Sources*: Lubke and Avis 1998; Arens et al. 2001; Peterson and Lipcius 2003; Everard et al. 2010; Barbier et al. 2011).

opportunities. The term "value" used in this book indicates human value (that assigned to the beach/dune system as a result of the goods and services produced) and the natural value inherent to the beach/dune system independent of human assignation (intrinsic value). The term "natural capital" is often applied as an alternative term for goods and services. Debates over the natural capital concept may occur because it appears to reduce nature to its monetary exchange or instrumental value and cannot be justified in arguments about preservation or intrinsic value (Daly 2020; Des Roches 2020). For example, a wide beach and dune that provide storm protection to oceanfront property and recreation for tourists can be placed in economic terms (Lazarus et al. 2011; Taylor et al. 2015), whereas the significance for a noncommercial species or the therapeutic use of a landscape is more challenging. Optimum designs for beaches and dunes that enhance these alternative uses can be quite different, as will be seen in subsequent chapters. The natural capital concept has many applications useful to economic or social arguments and philosophical debate but appears less convincing as a rationale for managing natural resources than the terms "values," "goods," or "services" without disciplinary contexts and subtexts. Accordingly, we use these terms, favoring the word "value" for general application.

Ecosystem services often exhibit spatial and temporal variation within a given landscape, and they can have weak association with other services (Biel et al. 2017). Not all goods and services can be provided within a given shoreline segment, even in natural systems, but many may be available regionally, given sufficient space and alongshore variation in exposure to coastal processes and sediment types. It may not be possible to take advantage of some of the goods and services, even where the potential exists. One or a few goods and services can be overexploited, resulting in the loss of others (Pérez-Maqueo et al. 2014). 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 while providing nesting sites, habitable substrate, and refuge areas for wildlife, if human uses are controlled using compatible regulations (Nordstrom et al. 2011).

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 mine them later. 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 the microhabitats and associated processes that were lost through previous exploitation. Components of ecosystems should not be seen as exchangeable goals that can be used and created again to suit human needs (Higgs 2003; Throop and Purdom 2006).

1.4 Approaches for Restoring and Maintaining Natural Landforms and Habitats

Coastal evolution may take different routes. The development process need not result in reshaping of beaches into flat, featureless recreation platforms (Figure 1.1) or totally eliminating dune environments in favor of structures. The trend toward becoming a cultural artifact can be reversed, even on intensively developed coasts, if management actions are taken to restore natural features (Nordstrom et al. 2011). Creating and maintaining natural assemblages of landforms and biota in developed areas (Figure 1.2) 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

Figure 1.2 Two views of Folly Beach, South Carolina, USA, showing the effect of beach nourishment in reestablishing dunes.

environmental values can extend the duration of the tourist season beyond summer (Turkenli 2005). Restoration of natural habitats thus has great human-use value in addition to natural value.

The reasons for restoration may be classified in different ways (Hobbs and Norton 1996; Peterson and Lipcius 2003) such as (1) improving habitat degraded by pollutants, physical disturbance, or exotic species; (2) replenishing resources depleted by overuse; (3) replacing landforms and habitats lost through erosion; (4) allowing human-altered land (e.g., farms) to revert to nature; (5) compensating for loss of natural areas resulting from construction of new human facilities; and (6) establishing a new landscape image or recapturing lost environmental heritage. Restoration can be conducted at virtually any scale and used in a variety of ways.

The terms conservation and restoration have been distinct as policy directives, but programs for either will have elements of the other within them. Maintenance of the abundance and diversity of natural landforms and habitats depends on the adoption of several actions including (1) identifying remaining natural and semi-natural habitat; (2) establishing new nature reserves; (3) protecting existing reserves from peripheral damage; (4) making human uses in other areas compatible with the need for sustainability; and (5) rehabilitating degraded areas, including reinstating natural dynamic processes (Doody 1995). The first four actions may be defined as conservation, whereas the last action may be defined as restoration. This book addresses this last need in its many forms and scales, with special emphasis on regional and local actions. The goals for conservation and restoration become complementary in a changing world in which species are shifting distributions, communities are disassembling and reassembling in new configurations, extreme events are pushing systems beyond past thresholds, and outcomes of human actions are increasingly uncertain (Wiens and Hobbs 2015). Restoration of a lost habitat makes that habitat a target of future conservation; maintenance of habitat in a conservation area subject to degradation by human activities may require periodic restoration efforts; and successful evolution of a restored area may depend on the proximity of seed banks in a nearby conservation area. Many of the management principles appropriate to conservation or restoration will apply to the other and can be tailored to the specific context. Restoration goals can be compatible with conservation goals in improving degraded habitat. Alternatively, restoration goals can counteract conservation goals; for example, using restoration as compensation or mitigation for development of natural areas – a practice severely criticized because of the difficulty of replicating lost environments (Zedler 1991).

Many coastal environments are protected by international, national, and regional policies governing use of natural resources and establishment of nature reserves by governmental and nongovernmental organizations (Doody 2001; Rhind and Jones 2009). The EU Habitats Directive and its designation of the Natura 2000 network of protected areas covering Europe's most valuable and threatened species and habitats is key to conservation and restoration in much of Europe. Natural habitat types and animal and plant species whose conservation requires the designation of special areas of conservation are identified as are criteria for selecting eligible sites for inclusion. Natura 2000 sites are protected through a series of policy instruments put in place by the directives and subsequently translated into legislation by EU countries. For example, Article 6 of the Habitats Directive requires member states to take measures within Natura 2000 to maintain and restore the habitats and species in a favorable conservation status and avoid activities that could significantly disturb these species or result in damage or deterioration of their habitats or habitat types. Other EU initiatives provide impetus, rationale, and suggestions for maintaining and enhancing key environmental resources. The EUrosion study (European Commission 2004) promotes the need to work with natural processes; for coasts, this means working with the sediments and processes as the foundation for the habitats and the species they support (Rees et al. 2015). Every country has numerous policies and regulations affecting management of coastal resources (e.g., the Wildlife and Countryside Act, the Convention on Biological Diversity, and Biodiversity Action Plan in the United Kingdom). About 83 percent of the dune area in the United Kingdom has been protected under legislation because of biological interest (Williams and Davies 2001). The number of national regulations can be large. Ariza (2011) lists twenty-nine legal texts for beach management in Spain alone. The number of regulations is not necessarily the answer to nature protection in some locations. Local actions can disregard the principles and guidelines developed at higher levels of government (Cristiano et al. 2018; Jayappa and Deepika 2018).

Evaluation of the significance of local legal provisions is beyond the scope of this book, but examples of international policy guidelines for conservation and