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The developed coastal landscape: temporal and spatial characteristics

Introduction

Human-altered coasts vary greatly in appearance, from landscapes where human impact is significant but barely perceptible (Figure 1.1) to landscapes where cultural features visually dominate the landscape (Figure 1.2). No one would deny the prominent role that humans play in altering the coastal landscape (Walker 1984). The more difficult tasks involve identifying: (1) how human-altered landforms may be defined; (2) whether humans are or should be the dominant agent in landscape evolution; and (3) whether human needs or actions should determine the characteristics and values of the resulting landforms. These broad issues can be separated into several areas of investigation (Table 1.1) that are examined in detail. It is assumed here that the landforms of interest (beaches and dunes) and the habitats within them are desirable for both their natural and human values, and that it is better to have these landforms than not to have them. Human actions are then evaluated in terms of loss, gain or conversion of these landforms.

This chapter addresses the first two areas of investigation identified in Table 1.1 by providing a historical perspective on the human forces that drive coastal development and the processes and stages of alteration from natural shorelines to artifacts in attempts to maximize human values. The focus is on long-term and large-scale transformations of landscapes within which individual landforms are altered. The most obtrusive human modifications are highlighted, along with some of the economic and social reasons for the conversion. Evolution at the scale of individual landforms and at shorter temporal scales are evaluated in greater detail in subsequent chapters.

The historical perspective is based largely on activities in western Europe and the USA, because of the availability of information for those locations. Recent economic and social forces are evaluated to show how improvements in communication and transportation, increases in expendable income and

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Figure 1.1 Manzanita Oregon, USA. The natural-appearing dune in the foreground has been transformed from its natural appearance as a result of the introduction of European beach grass (*Ammophila arenaria*). This vegetation was first planted in the nineteenth century. It spread rapidly along the Pacific coast and provided a more complete trap to blown sand than the native vegetation and created a higher, more linear, and better vegetated foredune than existed previously.



Figure 1.2 Arma di Taggia, Italy, showing onshore and offshore structures and beach grading operations that have changed the appearance and function of the coast by altering the energy of the waves, the topography of the beach and the natural vegetation and habitat.

Table 1.1 *Major areas of investigation addressed in this book*

How do developed coasts evolve?
How do landforms and landscapes change due to changes in social and economic processes?
How are landforms altered to achieve specific human needs?
How are landforms enhanced to retain their utility?
What are the physical characteristics of the resulting landforms?
What are the temporal scales of evolution of coastal landforms?
Under what conditions are humans intrinsic or extrinsic agents of landscape evolution?
How effective are regulations affecting landforms?
What are the viable alternative approaches to restoring landforms?
How can human alterations be made compatible with natural processes?
What are the ways that natural values can be maintained while accommodating human use?
What is the significance of using static or dynamic approaches to management?
What are the research requirements for beaches and dunes on developed coasts?

creation of global economies have made human alterations an international phenomenon, contributing to an exponential increase in the pace and scale of development. Much emphasis is placed on the evolution of tourism, because it has been a driving force in altering beaches and dunes, and on the implementation of shore protection projects that have extended the impact of humans beyond the initial modifications to the landscape that were designed to accommodate tourism activities.

Perspective on some of these trends is provided in an assessment of a case study of the shoreline of New Jersey, USA, a location that is examined in some detail throughout the rest of the book. The New Jersey coast has the longest history of stabilized barrier island shoreline in North America; it has the most developed coastal barriers and the highest degree of stabilization in the USA; and it has been identified as a template by which developing barriers can be evaluated to show the incompatibility of shorefront development (Pilkey 1981; Nordstrom 1987a; Mitchell 1987; Pilkey and Wright 1988; Hall and Pilkey 1991).

The impact of humans through time

Finding detailed information on the impacts of humans on beaches and dunes through time is a difficult task. There is less information on these landforms than on many other aspects of the environment because these features were of little value in traditional economies. There is little doubt that some human impact on coasts dates back tens of thousands or even hundreds of thousands of years in some areas. Human presence along the coast of Italy, for example, is described as occasional, beginning about 300 000 years BP, and the first settlement is documented about 40 000 years BP (Torresani 1989).

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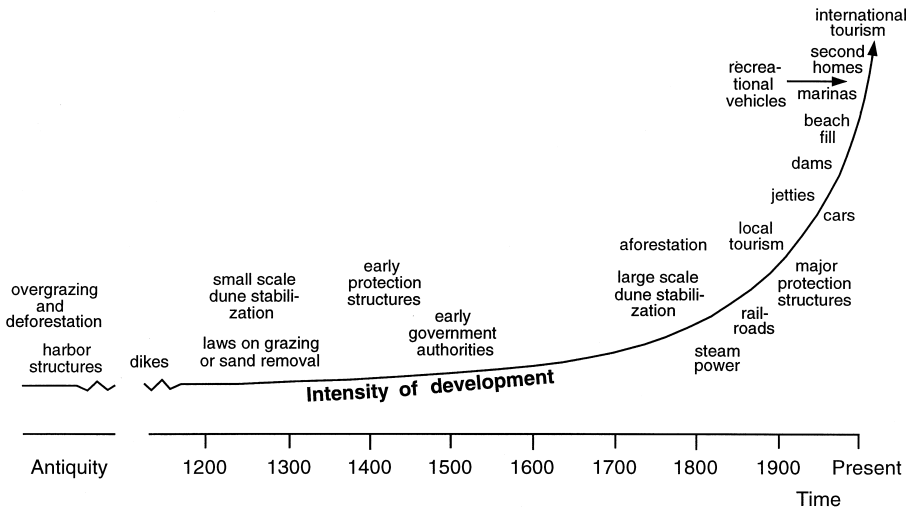


Figure 1.3 Idealized representation of the intensity of human development through time with contributing human actions or features.

Evidence of human influence in the past is obscured due to sea level rise. Most coastal and nearshore archaeological sites are less than 6000 years old because of the rapid rise in sea level prior to that time (Walker 1981a; Bird and Fabbri 1987). Real influence on the coastal landscape in Italy apparently started with the Etruscians from the ninth century BC (Torresani 1989), and there is a rich assemblage of archaeological and geomorphological evidence in Italy and other parts of the Mediterranean in the past 2000 years (Bird and Fabbri 1987).

Figure 1.3 presents an idealized representation of the intensity of development in historical times (revealed in the trend line) along with the principal human actions or features for which there is adequate documentation. The figure is based largely on reports of activities in western Europe and North America. The time of initiation of human activities is generalized because data prior to about 1800 are spotty and site-specific, but the figure does reveal the general change from incidental or accidental actions to direct modification in response to changes in population pressures, perception of resources, income, leisure time and technological advances. Other locations may have gone through similar phases of landscape conversion, but the phases may have been at different dates or have had different durations.

The trend line in Figure 1.3 is portrayed as smooth because it represents a global curve. A site-specific curve would show considerable short-term fluctuations. The impacts of humans on the coast have always undergone periods of greater and lesser impact. In the distant past, periods of declining human use

have been related to piracy, war and disease (Torresani 1989). Pronounced cycles of shoreline advance and retreat are associated with changes in social and demographic characteristics on the Mediterranean coast (Innocente and Pranzini 1993), and at least one and perhaps several phases of active deposition of sediment and advance of the shoreline occurred on the Mediterranean coast in classical antiquity as a result of human activity (Paskoff 1987).

There is a pronounced change in the slope of the curve beginning about two centuries ago corresponding to the availability of steam power that enabled large modifications to the landscape (Marsh 1885; De Moor and Bloome 1988; Terwindt *et al.* 1988; Meyer-Arendt 1992). The slope of the curve has increased with increases in the size and availability of machinery, with development of the internal combustion engine, and with the growth of tourism as a major industry.

Overgrazing and deforestation

Overgrazing and deforestation of drainage basins leads to increased quantities of sediment delivered to the coast. These human actions were likely the earliest causes of major changes to coasts (Walker 1985), and they have undoubtedly had great impact in the Mediterranean, where there has been a long history of human settlement. Deforestation in Italy occurred at a modest scale during the Roman period (Fabbri 1985a; Postma 1989). Deforestation there accelerated in the Middle Ages when people migrated from the coast to higher and drier regions and needed new land for agriculture and settlement; and large areas were deforested by the middle of the nineteenth century when farming reached its maximum extent (Postma 1989). Deforestation associated with settlement in the USA led to delivery of considerable volumes of sediment in the nineteenth and twentieth centuries, leading to locally high rates of accretion on the Pacific coast where rivers flowed directly to the ocean.

Overgrazing and deforestation had a more direct effect on coastal landforms when these activities were practiced in the dunes themselves. Historical perspective on problems of dune destabilization are presented in Sherman and Nordstrom (1994). Human activity in dune fields in Cornwall, England exists from the Neolithic that occurred from about 6500 to 4500 BP (Lewis 1992). There is evidence of Bronze Age occupation of dune fields in Europe (Higgins 1933). Actual reports of wind blown sand and sand drift date back to the tenth century in continental Europe (Klijn 1990) and prior to 1066 in Wales (Higgins 1933). Dune mobility has been increased by human activities associated with grazing, such as burning plant species to produce more desirable vegetation cover and cutting wood in trees to supply shelter or fuel for shepherds (Corona *et al.* 1988). Problems of dune destabilization appeared to

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reach their greatest extent in Europe in the eighteenth and nineteenth centuries, when actions at the national scale were taken to stabilize the dunes.

Dune stabilization

Stabilization of drift sands with vegetation plantings was practiced in Great Britain after the stormy periods of the fourteenth and fifteenth centuries (Ranwell 1972). Aforestation occurred as early as the early part of the sixteenth century in Japan (Hotta *et al.* 1991). Aforestation took place in the Doñana Dunes in Spain in 1737 using *Pinus pinea*, but, since then, many other species were used all over the Mediterranean and Portugal using mainly non-indigenous species (van der Meulen and Salman 1996). Aforestation led to commercial activities to make use of the new resources, including lumbering and charcoal-making (Corona *et al.* 1988). The relative success of dune aforestations led to the belief that dunes had to be stabilized with trees whether they were mobile or not (van der Meulen and Salman 1996). Large-scale measures were taken to stabilize drift sand in the eighteenth century in Prussia, Denmark and France (Marsh 1885) and in the nineteenth century in Poland (Piotrowska 1989) and The Netherlands (Klijn 1990). Foredues for controlling wind blown sand were widely built in European countries in the eighteenth and nineteenth centuries in Europe and in the 1920s in Japan (Hotta *et al.* 1991). Active measures to stabilize drift sand in the USA occurred at Cape Cod, USA before 1775 (Marsh 1885). Stabilization of present-day Golden Gate Park in San Francisco began in 1869 Lamb (1898). Large-scale stabilization projects began on the Oregon coast of the USA in the early twentieth century.

Water regulation activities

Water regulation activities affect coastal sediment budgets, leading to erosion and accretion at the shoreline. These activities may include reclamation, stream channel diversion and stream damming. It is likely that attempts to reclaim land and control flooding have occurred for millennia in population centers near ports. Fabbri (1985a) notes that patterns of canals of Roman Age (2200 to 2000 BP) still exist on the landscape in the plain of the Po River, and he speculates that artificial levees built by the Romans along channels of the Po River affected sedimentation rates on adjacent beaches. A dramatic increase in human influence on European coasts occurred on the Dutch coast between 1100 and 1300 (Berendsen and Zagwijn 1984). This is about the time when dikes are identified on maps in France (Lahousse *et al.* 1993) and when dikes became common in Britain and Germany (Doody 1996; Garniel and Mierwald 1996).

Large-scale stream diversion occurred near the end of the sixteenth century

in northeastern Italy when the Venetians diverted several rivers near their city, including the Po and the Piave (Zunica 1990; Bondesan *et al.* 1995). Diversion of the Po was extensive, involving relocation of a portion of the channel more than 5 km long (Bondesan *et al.* 1995).

Dramatic change in coastal sediment budgets occurred in the twentieth century owing to reduction in river sediment supply because of upstream dams and mining of sediment from river beds (Ferrante *et al.* 1992; Marabani and Veggiani 1993). Major periods of dam building affecting coastal sediment budgets occurred prior to World War II in many industrial countries and after World War II in many others (Paskoff 1992). The recent increases in sedimentation rates at dams have reduced the amount of sediment delivered to the coast and reversed the accretional trends that formerly occurred in many areas due to overgrazing and deforestation.

Navigation improvements

Navigation improvement structures are among the earliest human features used to directly control coastal processes, and they are among the earliest structures identified in inventories of human alterations (Leidersdorf *et al.* 1994). Harbor works that are still functioning may be traced back to antiquity (Inman 1974). These structures have great longevity because of their scale (that results in a high degree of survivability) or because of their importance (that justifies rebuilding if they are damaged).

The most profound changes to coasts due to navigation improvements have occurred since the mid nineteenth century, when advances in power machinery facilitated opening and closing of inlets and enabled construction of massive jetties and channel dredging projects to stabilize them. Many jetties were constructed at inlets on the coast of the USA from the late nineteenth century to present. Nearly every harbor in southern California is artificial, being either dredged in low sandy areas, followed by jetty construction, or created by building breakwaters in the nearshore (Wiegel 1994). The coast of New South Wales has over 30 jettied river entrances (Druery and Nielsen 1980). The effects of these human actions extend far beyond the limits of the navigation channels themselves because the alterations affect the sediment exchanges and shoreline fluctuations at a larger spatial scale than the site of the navigation improvement.

Early regulations

Early laws to preserve littoral defences by prohibiting cattle on dikes or removing sand and vegetation date from the thirteenth century in Italy (Franco and Tomasicchio 1992). Laws to control migrating sand date from the

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thirteenth century in The Netherlands (van der Meulen and van der Maarel 1989) and the sixteenth century in Denmark and Great Britain (Marsh 1885; Gray 1909; Ranwell 1959; Jensen 1994). Government authorities designed to deal with coastal hazards and erosion problems date back to the fifteenth century with formation of the Dutch water boards and the Venetian Water Committee (Franco and Tomasicchio 1992). Laws regulating activities on dikes and in dunes appear to have been the principal actions taken to control activities in coastal landforms prior to the twentieth century and were driven by the need to control specific types of coastal hazard, rather than to protect natural components from irreversible losses. The late twentieth century saw passage of many laws that attempt to reduce losses from coastal hazards and protect the natural environment in the face of dramatic increases in the pace of coastal development.

The growth of tourism

There was little or no interest in direct use of the exposed part of the coastal zone in many countries up to the mid nineteenth century due to the difficulty of traversing lagoons and marshes and the occurrence of malaria (Cencini and Varani 1989). The second half of the nineteenth century saw the beginning of relatively large-scale coastal tourism and development of seaside resorts in many locations (Meyer-Arendt 1990; Ehlers and Kunz 1993; Grechishev *et al.* 1993; Kelletat 1993; Nordstrom 1994a; Fabbri 1996). Contributors to increased use of the coast and change in the character of resorts during that time period were expansion of steamship service and railroad systems, changes in the organization of time between working and non-working hours, reduction in the number of hours in the work week, reduction of time devoted to religious practices on Sundays, and formation of an urban middle class with money and mobility (Fabbri 1990).

Mass tourism occurred after World War II, due to a general increase in national incomes and its distribution to different social levels, combined with increased free time (Cencini and Varani 1989; Ridolfi 1989). The diffusion of tourism has turned many ports and fishing villages into resorts (Fabbri 1989; Meyer-Arendt 1991; Anthony 1997). Automobile access has been the primary stimulus for development in many areas, extending the zone of development beyond centers of mass transit. For example, construction of the Trans-peninsular Highway in Baja California, Mexico in 1973 increased tourist arrivals 500 percent (Fermán-Almada *et al.* 1993).

Second homes have become more popular in recent decades, resulting in a greater amount of environmental degradation and exposure to coastal hazards than occurred in formerly clustered hotel-dependent activities

(Ridolfi 1989; Good 1994). Spaniards vacationing in Cantabria, for example, prefer to buy or rent flats in new high-rise hotels rather than stay in hotels or camping areas, contributing to the extension of urbanization into areas formerly occupied by farms (Fischer *et al.* 1995). Many new homes are detached single-family or duplex structures that use considerably greater space than condominiums. Many homes often are used only for a few weeks a year, raising questions as to whether their cost is worth their use (Fabbri 1989). In other cases, older weekend cottages are torn down and replaced by larger homes (Griggs *et al.* 1991b).

A large number of marinas have been built in recent years, particularly on the Atlantic coast of France and in the Mediterranean, where they are considered a means of drawing income to a municipality and contributing to its prestige (Miossec 1988; McDowell *et al.* 1993; Anthony 1994, 1997). Pleasure boating in Italy was limited and elitist up to the end of the 1960s but has expanded greatly since then as a result of increased leisure time, leveling of standards of living, widespread increase in income and perception of yachting as a less exclusive pastime (Rizzo 1989). The average distance between harbors on the northern Adriatic coast is now 6 to 7 km (Rizzo 1989), yet demand often exceeds mooring capacity (Ridolfi 1989). There are up to 50 marinas on the French coast, where they are considered a threat to the natural environment (Miossec 1993). There are over 4000 harbors in Japan, or about one for every 8 km of shoreline; many of them are built out from shore into the open sea (Walker 1985).

Mobile homes (or caravans) have increased in numbers over the past several decades. These units may be static and rented on site, towed or self-propelled. The direct impact of vehicles varies according to whether they are confined to regulated camping sites or allowed to drive to undeveloped sites where their subsequent use is uncontrolled. Their indirect impact is related to: (1) the increased access of a larger number of beach and dune users to relatively undeveloped areas; (2) increases in the number of pedestrian trips across dunes as users make return trips to their caravans; and (3) damage to surface cover and substrate as users create burial pits for disposal of refuse (Mather and Ritchie 1977).

Off-road vehicle use has increased as well. Small off-road vehicles, “dune buggies,” were a novelty at Sand Lake, Oregon, USA until the 1960s, but they numbered in the thousands on weekends in 1979 (Wiedemann 1990). Off-road vehicle registrations at Cape Cod National Seashore USA grew from 966 in 1964 to 5843 in 1978, and 33 378 vehicle passes were made through access points in this seashore between June and September 1976 (Godfrey and Godfrey 1981). The Aberffraw sand dune system in Anglesey, Wales had 3.2

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km of vehicle tracks and 2.2 km of footpaths in 1960 and 11.7 km of vehicle tracks and 16.5 km of footpaths in 1970 (Liddle and Grieg-Smith 1975a).

Stages of landscape conversion through tourism

The relationship between natural coasts and human-modified coasts may be presented in terms of generic scenarios, representing the results of applying different human values and levels of investment. Most coastal communities undergo incremental development that progresses through stages. The stages in many resorts in Thailand, for example, include: (1) construction of simple low-budget visitor dwellings; (2) upgrading of these structures as visitor numbers increase; (3) selling of land to developers; (4) construction of hotels to meet increasing demand; and (5) expanding buildings and infrastructure while ignoring legislation on zoning and land use (Chou and Sudara 1991). Models for growth of European and North American resorts present growth in terms of: (1) an exploration stage; (2) a period of commercial involvement and infrastructure development; (3) a settlement-expansion stage; and (4) an increase in intensification of sites already developed (Butler 1980; Meyer-Arendt 1990, 1993a). The end of the settlement stages is a maturation stage when all potentially developable land has been developed as either low or high density, and levels of tourist visits have stabilized (Meyer-Arendt 1993a). By this stage, human-induced environmental degradation is often recognized and translated into government controls (Meyer-Arendt 1993a). Levels of maturation vary from site to site, reflecting a combination of physical and cultural attributes, land use regulations and market demands; locations that developed prior to restrictive legislation can mature within the stage of land use intensification, whereas locations that developed more slowly may have been halted in earlier stages (Meyer-Arendt 1993a).

Meyer-Arendt (1985, 1990, 1991, 1992, 1993a) reviews the characteristics of seaside resorts and how their form has changed since the nineteenth century. Resorts in the nineteenth century reflected an urban spatial structure attributed largely to the mode of access (steamship or railroad), resulting in a concentration of tourists at nodes. Concentric zones of human activity and infrastructure emanated from locations where transportation routes ended, either near the shorefront or at docks or railroad stations somewhat inland from the beach. These zones (Figure 1.4) have been subject to redefinition through time, but they include: (1) the core central business district (CBD), often of compact shape; (2) the recreational business district (RBD), usually of linear shape, corresponding to the orientation of the beach and swash/surf zone that is the principal attraction of coastal resorts; (3) an accommodation