The Coasts and Their Costs

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Chapter 18
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18.1 Introduction

Coastal dunes are unique ecosystems with considerable ecological, social, and economic relevance (Martínez et al. 2004a, b). Ecologically, they are unique because they include species with specific tolerance to burial by sand and salinity (Maun 2009; Gallego-Fernández and Martínez 2011). These species share their functional responses to the peculiar environment of the coastal dunes and yet their phylogeny is very diverse, providing a clear example of evolutionary convergence in both plants and animals. They are also the preferred site to test the theory of successional dynamics (Martínez et al. 2001; Feagin et al. 2005; Isermann 2011).

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In fact, ecological theory on plant succession was first described in coastal dunes a century ago (Cowles 1899), and there is still ongoing research on how community dynamics works in these ecosystems.

Socially, a large fraction of the global human population lives at or near the coast (Martínez et al. 2007); many cities are also located here, and have developed on top of dunes. Twenty-one of the 33 megacities (>10 million inhabitants) of the world are located at the coast and population growth trends indicate that here, human population will continue increasing at a faster rate than inland (Martínez et al. 2007). This human preference results in urban development and the construction of infrastructure, which transforms and even destroys coastal dunes.

Economically, tourism, one of the largest industries in the world, takes place predominantly at the coast, especially on sandy coasts, yielding millions of dollars in revenue. Besides these direct economic benefits, coastal dunes are also highly relevant to humans, since they offer many ecosystem services to society, such as the protection of human structures from erosion as well as the impact of hurricanes and storms by providing sediments, a physical barrier, or resistant vegetation (Nordstrom and Jackson, Chap. 2, this volume). Protection, in particular, will become increasingly relevant because of the encroaching human population at the coast, and also because of the risks associated with global climate change such as an increasing sea level and storminess (Webster et al. 2005).

Other additional ecosystem services provided by sandy coasts and coastal dunes include: sand and minerals for extraction, retention and purification of ground water, raw materials, plants with pharmaceutical use, food for primary and higher trophic level consumers, habitats and refuge for plants and animals, recreation, education, scientific research, cultural and environmental heritage (Bell and Leeworthy 1990; King 1995; Lubke and Avis 1998; Arens et al. 2001; Peterson and Lipcius 2003; Everard et al. 2010; Nordstrom and Jackson, Chap. 2, this volume).

In spite of the evident relevance of coastal dunes, they are threatened by human encroachment throughout the world. As they are lost, the ecosystem services provided by them will be lost too. Because the economic value of the ecosystem services has seldom been assessed, the ecological and socio-economic consequences of their destruction remain largely unknown. Large amounts of money have already been invested in coastal dune restoration and, since destruction continues, restoration needs (and their costs) will also increase. Given this scenario, it is relevant to analyze what would be the best option for our beaches and coastal dunes: to restore? To conserve these ecosystems and manage their ecosystem services? Should we sustain the status quo because of immediate revenues? An important question to answer is: what are the costs of our coasts? What are the costs of restoring beaches and coastal dunes, and what are the economic benefits derived from ecosystem services provided by them?

In this chapter we aim to achieve three goals: first, we performed a literature search to assess a proxy estimate of the economic value of the beach and coastal dunes in terms of their ecosystem services. Second, we used the information that was available on the costs of restoration projects described in this book, which have been performed on beaches and coastal dunes in different countries: New

Zealand (Hesp and Hilton, Chap. 5, this volume); Italy (Acosta et al., Chap. 12, this volume); USA (Pickart, Chap. 10, this volume; Feagin, Chap. 6, this volume); Netherlands (Arens et al., Chap. 7, this volume; Grootjans et al., Chap. 15, this volume); Denmark (Vestergaard, Chap. 4, this volume), and Spain (Muñoz-Reinoso et al., Chap. 9, this volume). We also gathered additional information in order to have a larger set of data with which we could analyze the costs of coastal dune restoration. Finally, we carried out an analysis of the conservation benefits in terms of ecosystem services, versus the costs of restoring beaches and coastal dunes, to determine the best management option for our sandy coasts.

18.2 Ecosystem Services

Natural ecosystems provide a variety of direct and indirect services and intangible benefits to humans and other living organisms (Costanza et al. 1997), and because of their relevance to society, these ecosystem services, goods and their economic value have become a focus of interest for scientists, policy makers, and stakeholders over the last decade (Troy and Wilson 2006). The provision of ecosystem services is directly related to the functionality of natural ecosystems upon which ecological processes and ecosystem structures depend (de Groot et al. 2002). Thus, the better preserved natural ecosystems are, the more ecosystem services they can provide to society (Balvanera et al. 2001).

To gather information on the ecosystem services provided by the beach and coastal dunes, we performed a literature search including the databases environmental valuation reference inventory (EVRI), Envalue, and ecosystem services database (ESD) (McComb et al. 2006) and applicable gray literature (government statistics and graduate theses) (Shuang 2007; Mendoza-González 2009; Lithgow-Serrano 2007). Based on these databases and the published literature we determined specific ecosystem services from the beach and coastal dunes. Using the Millennium Ecosystem Assessment ecosystem services classification (supporting, provisioning, regulatory, and cultural) the ecosystem services provided by the beach and coastal dunes can be grouped as shown in Table 18.1.

Table 18.1 Summary of ecosystem services provided by coastal dunes to society (modified from Everard et al. 2010)

Supporting	Provisioning	Regulatory	Cultural/aesthetic
Soil formation	Drinking water	Storm/flood/erosion protection	Recreation/tourism
Primary production	Food	Climate regulation	Aesthetic value
Nutrient cycling	Fiber and fuels	Water storage	Cultural heritage
Water cycling	Genetic resources	Pest/disease regulation	Spiritual
Photosynthesis	Medicine	Pest control	Art
Carbon storage	Ornamental	Water purification	Social relations
Habitat/diversity	Mineral extraction	Pollination	Education/science

The above-mentioned ecosystem services have not been studied in as much detail as is needed. For instance, the literature on ecosystem services (ISI Web of Science January 2012) displayed 3,070 publications that mention ecosystem services in the title, abstract, or key words. Of these, 271 focus on the coast, and this includes the beach, coastal dunes, and any other coastal ecosystem such as wetlands, marshes and mangrove forests. Less than 30 studies referred to ecosystem services of coastal dunes and the beach.

We located a total of only 18 studies where ecosystem services from the beach and coastal dunes have been analyzed and their economic value has been calculated (Table 18.2). Most of them (11; 55 %) focus on the beach; 6 (30 %) deal exclusively with coastal dunes and only 2 (10 %) with the beach and coastal dunes as an integrated system. We found only one study (5 %) that took place in wet slacks. In this set of studies, the ecosystem services that have been studied on the beach and coastal dunes are: aesthetic/recreational/cultural (cultural); disturbance/prevention/protection (regulatory), and carbon sequestration (supporting; Table 18.2). To our knowledge, no ecosystem services that deal with provisioning have been studied, so far, for the beach and coastal dunes, probably because here, some ecosystem services (aesthetic, protection) are more heavily exploited (and apparently considered more relevant) than others (pollination, water cycle, nutrient cycle, and others mentioned in Table 18.1). However, the above does not mean that these are the only ecosystem services of coastal ecosystems, but that a handful of them are of greater interest to humans than the others. In addition, it is interesting to note that it is necessary to consider if losing these ecosystem services after land use change (urbanization, for example, instead of tourism) is compensated for by the value gain. Such a valuation is currently being performed.

The economic values of ecosystem services that we found in the literature were estimated in different years, in different countries, and with a variety of methodologies. This heterogeneity in how economic values were assessed made it necessary to standardize them in order to be able to compare studies. Thus, the economic values estimated for ecosystem services from different ecosystems were adjusted to US$ currency using the consumer price index (CPI) and the purchasing power parity (PPP) for 2010, obtained from US government statistics (US Department of Labor). We thus adjusted the original values estimated in the 18 studies we used (Table 18.2), to US dollars (2010), using the following formula (Envalue 2007):

$$\text{ESV} = \frac{(\text{Value}/\text{CPI}) \text{ x } 100}{\text{PPP}} \text{ x USA PPP}$$

where:

Value is the value in the original year in the original currency
CPI is an index of inflation of the source data, with a base year in 2010
PPP is the PPP between the original currency and US$ in 2010

Table 18.2 Ecosystem services and their calculated economic value estimated in different countries. Valuation methods are: WTP= willingness to pay; HP = hedonic pricing; CV =contingent valuation; TC = travel cost. All estimated costs are standardized to USD per ha per year in 2010

Ecosystem	Ecosystem service	Reference	Country	GDP Per capita /year 2010	GINI Index/ year	Method	Year of study	CPI	PPP country studied 2010	US(2010) /ha/year
Beach	Aesthetic and Recreational	Edwards and Gable 1991	USA	47,198.50	45(2007)	HP	2004	96.72	1	$55
Beach	Aesthetic and Recreational	Kline and Swallow 1998	USA	47,198.50	45(2007)	TC	2004	96.72	1	$15,838
Beach	Aesthetic and Recreational	Silberman et al. 1992	USA	47,198.50	45(2007)	CV	2004	96.72	1	$8,653
Beach	Aesthetic and Recreational	Taylor and Smith 2000	USA	47,198.50	45(2007)	HP	2004	96.72	1	$303
Average										**$6,212**
Beach	Recreation	Lindsay et al. 1992.	USA	47,198.50	45(2007)	WTP	1992	71.85	1	$43
Average										**$43**
Dunes	Recreation	Mendoza-González et al. 2012	MEXICO	9,123.41	46.05 (2004)	WTP	2011	103.2	7.951476	$12,192
Dunes	Recreation	Mendoza-González et al. 2012	CHILE	12,431.03	54.92 (2003)	WTP	2011	103.2	403.1928	$8,388
Average										**$10,290**
Beach	Cultural and Spiritual	Taylor and Smith 2000	USA	47,198.50	45(2007)	HP	2004	96.72	1	$10
Average										**$10**
Wetslack	Carbon sequestration	Jones et al. 2010	UK	36,143.94	34(2005)		2010	114.5	0.65151	$4
Average										**$4**
Drydune	Carbon sequestration	Jones et al. 2010	UK	36,143.94	34(2005)		2010	114.5	0.65151	$3

(continued)

Table 18.2 (continued)

Ecosystem	Ecosystem service	Reference	Country	GDP Per capita /year 2010	GINI Index/ year	Method	Year of study	CPI	PPP country studied 2010	US(2010) /ha/year
Average										**$3**
Beach	Disturbance prevention	Pearsons and Powell 2001	USA	47,198.50	45(2007)	HP	2004	96.72	1	$8,709
Beach	Disturbance prevention	Pompe and Rinehart 1995	USA	47,198.50	45(2007)	HP	2004	96.72	1	$14,117
Average										**$11,413**
Dunes & Shingles	protection	Jones et al. 2010	UK	36,143.94	34(2005)	Avoided costs	2010	114.5	0.65151	5272
Beach and Dunes	Protection/ Erosion	Scottish Natural Heritage 2000	UK	36,143.94	34(2005)	Replacement cost	2000	93.06	0.65151	19424
Average										**$12,348**
Dunes	Protection	Mendoza-González et al. 2012	MEXICO	9,123.41	46.05 (2004)	Replacement cost	2011	103.2	7.951476	65743
Dunes	protection	Pye et al. 2007	UK	36,143.94	34(2005)		2007	104.7	0.65151	6661
Average										**$36,202**
Beach, Dune & Sand plains	All	Alves et al. 2009	Portugal	21,504.81	38.5(2007)	Tranfer value	2000	85.55	0.633975	$27,812
Average										**$27,812**
Beach	All		USA	47,198.50	45(2007)	WTP	2004	96.72	1	$17,642
Average										**$17,642**

There are limited data available that estimate the economic values of ecosystem services from the beach and coastal dunes, and those data do not cover many of the possible ecosystem services in detail. We only found economic values for beach and dune ecosystem services from Chile, Mexico, Portugal, the UK, and the USA, although most of the data acquired came from the UK and the USA. When we compare the list of ecosystem services that are recognized as being supplied by the beach and coastal dunes (Table 18.1) with the list of ecosystem services that have been studied in more detail and their economic values calculated, it becomes evident that supporting ecosystem services are generally overlooked in the literature, and other provisioning and regulatory ecosystem services are also ignored.

The estimated economic values of ecosystem services such as recreational, cultural, and aesthetic have been studied most, with a total of 8. In this case, most of them have focused on the beach and only 2 were performed on coastal dunes. It is interesting to note that the economic value of the ecosystem service of protection against storms, hurricanes, and floods had a relatively low number of estimates (a total of 6), even though it seems likely that it would be a very important ecosystem service. Most of these studies have focused on coastal dunes (4) and 2 on the beach. Finally, carbon sequestration is an ecosystem service that has been studied occasionally in coastal dunes and slacks (Table 18.2).

In the economic estimates that we gathered, it is obvious that the economic values of the costs of protection were high both for the beach and the coastal dunes, although those for the dunes were higher. Slowly but surely, stakeholders and the government are becoming more aware of the relevance of coastal protection and are willing to invest more in coastal dune restoration in order to gain protection against natural hazards (storm, storm surges, flooding, erosion). Aesthetic and recreational ecosystem services are also considered to be very valuable to the beach (aesthetic and recreational) and the dunes (recreational). In fact, Mendoza-González (2009) found that tourists were willing to pay for higher hotel prices as long as they were closer to the beach (recreational) and had access to the scenic beauty of the coast (hotel rooms looking at the ocean versus not looking at the ocean; aesthetic value). Of course, further studies are necessary to obtain a better understanding of the economic benefits that society receives from the ecosystem services provided by the beach and coastal dunes.

18.3 The Costs of Restoration Efforts

Although the set of examples on restoration efforts presented in this book were performed in several countries, the economic costs of such actions were not always readily available. Usually, scientists are asked to monitor the effectiveness of restoration actions and do not deal with the socioeconomic part of restoration. In our case, we were only able to gather information from European countries and for the USA. This is probably because the information from the funding agencies (local and federal governments) is not always available to the public.

The activities involved in coastal dune restoration include a wide array of actions, such as use of machinery, planting, fencing, elimination of exotics, remobilization of stabilized dunes, geotubes, sod cutting, and even tree felling (Table 18.3). The goals of these activities are not as diverse, and mostly include protection of endangered or native species; restoring mobility and native flora; recreation, protection, and aesthetic. Indeed, the costs involved in these actions are equally variable. In the data we gathered, we noticed that removal of unwanted vegetation by means of sod cutting, tree felling, and elimination of exotics was, no doubt, amongst the most expensive coastal dune restoration actions. Likewise, creating an artificial dune and planting it with native vegetation was a very expensive activity in Denmark (US$77,393/ha), but it seems to have been successful (Table 18.3) (Vestergaard, Chap. 4, this volume), with high annual maintenance costs (US$2,229/ha; Table 18.3). Coastal dune re-mobilization is also a difficult and expensive task and needs to be repeated every few years (Arens et al., Chap. 7, this volume).

Although the information is still not readily available, and restoration actions are scattered in different countries and take place with different intensities, millions of dollars are already being spent on this activity. For instance, in The Netherlands, there have been more than 100 restoration projects over the last 20 years that, overall, have cost from 10 to 20 million Euros (Grootjans, personal communication). In Spain, more than one million Euros were spent on recovering the native maritime juniper woodlands in Andalusia in a project that lasted 5 years (Muñoz-Reinoso et al., Chap. 9, this volume).

It is also interesting to notice that funding for restoration actions almost always comes from local and federal governments, and usually restoration is performed in national parks, nature reserves, and on public beaches (Table 18.3). An exception to this were the activities that were carried out in Galveston, Texas (USA), where private owners and stakeholders paid for beach and coastal dune restoration as an investment in the protection of their properties against the recurring impacts of hurricanes. In this case, the owners felt that the original dune and swale structure had protected their homes from incurring much greater expense during Hurricane Ike. Moreover, residents said that the reconstructed dunes also enhanced the aesthetic value of their property and buffered them from public intrusion onto their property (Feagin, Chap. 6, this volume; Table 18.3).

Besides the government and stakeholders being interested in paying for coastal dune restoration programs, the public, in general, seems to be gradually becoming more and more interested in these actions (Table 18.3). For instance, volunteer work for either planting dune vegetation (Grootjans et al., Chap. 15, this volume) or removing invasive species (Pickart, Chap. 10, this volume) has played a key role in achieving the goals of restoration in the Netherlands and the USA respectively. Additionally, in Israel, Lehrer et al. (Chap. 17, this volume) found that the public was willing to pay US$10.06 (38 NIS) a year for the containment efforts of invasive species and US$10.63 (40.12 NIS) for its elimination from a national park. Certainly, as the society becomes more involved in the conservation or restoration of natural ecosystems in general (not only the beach and coastal

Table 3 Example of the costs of restoration projects performed in different countries

Action/ mechanism	Goals of restoration actions	Country	Area/ volume restored	Year	Reference	Funding Agency	CPI	PPP country studied 2010	$US(2010)	Units
Removing pine trees	Protect native Maritime Juniper Woodlands in Andalusia	Spain	50 ha	2002-2006	Muñoz-Reinoso et al.	Government	103.517792	0.719016464	1,545,628	USD/ha
Creating artificial dune; planting native vegetation	Recreation and protection	Denmark	500 ha	1978	Vestergaard	Government	33.5947391	7.959994283	77,393	USD/ha
Elimination of exotics	Restore mobility and diversity of native flora	USA	327 ha	1998	Pickart	Government/ volunteers	83.46917	1	65,293	USD/ha
Sod cutting	Restore mobility and diversity of native flora	Netherlands	6 ha	last 20 years	Grootjans et al.	Government	107.939317	0.838259729	29,414	USD/ha
Restoration (grazing, sod cutting, rewetting, re-mobilization)	Restore mobility and diversity of native flora	Netherlands	100 ha	1993	Grootjans et al.	Government	75.9065759	0.838259729	12,053	USD/ha
Yearly maintenance costs of created dune	Recreation and protection	Denmark	500 ha	1986	Vestergaard	Government	62.7957965	7.959994283	2,229	USD/ha
Re-mobilization/, monitoring	Restore mobility and diversity of native flora	New Zealand	150m shoreline	2011	Hesp and Hilton	Government	115.252411	1	1,123	USD/m

(continued)

Table 3 (continued)

Action/ mechanism	**Goals of restoration actions**	**Country**	**Area/ volume restored**	**Year**	**Reference**	**Funding Agency**	**CPI**	**PPP country studied 2010**	**$US(2010)**	**Units**
Fencing	Plant diversity	Italy	7,000 m2	2007	Acosta et al.	Government	103.928931	0.811506578	962	USD/ ha
Vegetation	Aesthetic	USA	2,373 m	2007	Feagin	Stakeholders/ Government	106.170642	1	275	USD/ m
Geotubes	Storm protection	USA	2,373 m	1999	Feagin	Stakeholders/ Government	85.2954982	1	247	USD/ m
Sand movement/ vegetation	Storm protection	USA	2,373 m shoreline	2009	Feagin	Stakeholders/ Government	109.854662	1	99	USD/ m
Consultant fee, heavy machinery, planting, fencing,	Restore mobility and diversity of native flora	New Zealand	150m shoreline	2000	Hesp and Hilton	Government	88.4352555	1	58	USD/ m
Re-mobilization	Restore mobility and diversity of native flora	Netherlands	3,000 m3	2010	Arens et al.	Government	107.939317	0.838259729	9	USD/ m3
Planting	Aesthetic	USA	17,830 m3	1999	Feagin	Stakeholders/ Government	85.2954982	1	2	USD/ m3

dunes) these activities will become more effective. To achieve this, environmental education becomes a keystone.

18.4 Future Perspectives

The beach and coastal dunes provide society with a wide array of ecosystem services, including supporting, provisioning, regulatory and cultural/aesthetic (Table 18.1). Protection, recreation, and aesthetic are the ones most frequently studied and their economic values have been calculated, while many other ecosystem services remain largely overlooked (Tables 18.1, 18.2) (Everard et al. 2010). Needless to say, it is obvious that many of the goals of restoration actions are also aimed at recovering ecosystem services such as storm protection, recreation, and aesthetic (Table 18.3). An additional goal of restoration that is not directly related to publically recognized ecosystem services is recovering the natural dynamics of the beach and coastal dunes. That is, many restoration projects developed on coastal dunes have been aimed at restoring the mobility and diversity of native flora. Vegetation removal may seem counter-intuitive to what is expected by restoration, but, in the case of coastal dunes and beaches, recovering their natural dynamics is a very important goal (Martínez et al., Chap. 20, this volume). Upon recovering the natural functionality of these ecosystems, it will be possible to recover ecosystem services.

Our findings show that the economic value of ecosystem services provided by coastal dunes is quite high. That is, the economic benefits that society receives because of the natural functioning of the beach and coastal dunes are very high, especially protection, recreation, and aesthetic. The porous structure and substrate mobility of coastal dunes and beaches absorbs and dissipates wave energy, which helps to protect the coasts and inland infrastructure with minimal human intervention necessary (as long as natural dynamics are allowed to operate) (Everard et al. 2010). Through this capacity of absorbing and dissipating wave energy, the costs of hard engineering solutions are reduced. In addition to the above, a dynamic beach and coastal dune stores sand and provides new sediments that re-enter the marine sediment transport system, which can later nourish beaches after erosion events. Finally, as the natural dynamics of coastal dunes is maintained, native species will be able to survive and grow, and the scenic beauty of the beach/dune system is maintained. In brief, in well-preserved coastal dunes and beaches, the potential benefits to society are maximized, since ecosystem services are maintained under optimal conditions.

The paradox is that, because of the strong interest in these ecosystems, coasts are often over-exploited in order to obtain short-term benefits from recreation and their natural beauty. But, as we exploit these ecosystem services, we degrade them: the landscape is not as beautiful; beaches are flat and deserted; a coast with urban infrastructure is not capable of offering protection. That is, our short-term actions and interests negatively affect the ecosystem services that we value the most.

A logical consequence is that the funds required for restoration actions are large, and will probably increase as the human impact on the coasts increases.

Why are we moving toward this dead-end situation? Two explanations can be set out to interpret this difficult situation and suggest possible ways out: ecosystem services are not considered in decision-making processes, and some ecosystem services are over-exploited, resulting in their loss or degradation together with other ecosystem services that are also very relevant to society, although they may not be directly appreciated.

18.4.1 Ecosystem Services are not Considered in the Decision-Making Processes

Most of the ecosystem services provided by the beach and coastal dunes are not considered in the decision-making process. The result of this incomplete assessment of the use of natural resources is that coastal ecosystems are being fragmented and degraded, on the basis of short-term financial gain rather than their long-term value to society (de Groot 2006). A consequence of this myopic vision is that ecosystem services (even those considered most valuable) are spoiled and even lost. This problem is derived from the fact that ecosystem services are assigned little or no value in the cost–benefit analysis of development projects, because of the absence of market mechanisms. That is, many ecosystem services that the beach and coastal dunes provide to society are usually overlooked, even though the importance of these systems is increasingly being acknowledged. Nevertheless, the societal value of natural ecosystems (specifically the beach and coastal dunes) is often underappreciated (Everard et al. 2010).

One potential solution to the currently inadequate decision-making process is to recognize the societal value of the beach and coastal dunes, including the full range of benefits that they confer to society besides recreational, aesthetic, and protective (see Table 18.1). The estimates of the economic value of these ecosystem services constitute a useful tool that can help with a better-informed process, because marginal costs can also be considered. For instance, before making the decision to destroy coastal dunes and build an urban infrastructure on top of them (houses, hotels, roads), it would be useful to consider the ecological, social, and economic costs of losing the protection from a dynamic beach and its mobile dunes. In this case we would use the ecosystem service value calculated for coastal protection and incorporate it in the cost–benefit analyses of development projects. Here, it is worth highlighting that calculating the economic costs of ecosystem services does not mean that nature and its dynamics are for sale. These calculations are only intended to be used as a tool to aid the decision-making processes.

18.4.2 Over-Exploitation of a Few Ecosystem Services at the Expense of Others

Often, one or a few ecosystem services provided by natural ecosystems are over-exploited and then the provision of other ecosystem services is reduced. This is known as a trade-off across ecosystem services (Rodríguez et al. 2006). These trade-offs can arise as a result of explicit management choices, but can also occur without any awareness that a trade-off is taking place. Trade-offs between ecosystem services can occur both across space (when one ecosystem service is used in one location, another is depleted somewhere else) (Pérez-Maqueo et al., submitted for publication) and over time (when the exploitation of one ecosystem service negatively affects another ecosystem service in the future) (Mendoza-González et al. 2012). Finally, some groups of ecosystem services are more frequently chosen over others. For instance, Rodriguez et al. (2006) found that provisioning and regulating services are frequently preferred over supporting and cultural services.

In the case of the beach and coastal dunes, direct explicit choices are made in which the recreational, aesthetic, and protective functions are generally exploited, at the expense of many other ecosystem services. That is, regulatory (storm protection) and cultural (recreational, aesthetic) services are the most frequently used ecosystem services in the beach and coastal dunes. These trade-offs occur in space and time. Spatially, when for instance the scenic beauty of the coast is chosen, then urban infrastructure is developed and the potential for protection is lost along with all the ecosystem services listed in Table 18.1. Urbanized coasts can become "deserts" with no natural plants or animals, and with a flat topography; these systems are non-functional and offer zero ecosystem services, except for aesthetics and recreation, although in a degraded system, even these are diminished. When the beach and coastal dunes are damaged or lost, ecosystem services for the future are also lost. Obviously, this is not the best possible scenario for the future. Ideally, biodiversity and dynamism should be preserved, which in turn would help maintain ecosystem services (Balvanera et al. 2001). Successful management policies need to consider ecosystem service trade-offs on different spatial and temporal scales (Rodríguez et al. 2006) and should aim to minimize the effects of trade-offs.

18.5 Conclusions

Beaches and coastal dunes provide many ecosystem services to society of which a few are excessively over-exploited. Such over-exploitation results in a degraded and even lost natural ecosystem and, consequently, valuable ecosystem services are also lost as well. In consequence, restoration efforts are becoming increasingly necessary at increasingly high costs.

A better alternative is to preserve these (and any other) natural ecosystems and use the many ecosystem services in a more rational manner, instead of over-exploiting a few of them. By preserving natural ecosystems, they remain dynamic and functional, and ecosystem services are preserved too (Balvanera et al. 2001). This would be a win–win situation yielding important economic benefits, improved human well-being, and better-preserved natural ecosystems. Because of the crucial role that sandy beaches and coastal dunes play in human society (recreational, aesthetic and protective) plus the multiple beneficial services that they provide to society and, on top of the inherent reasons for protection, our focus on these ecosystem services need to be prioritized and far more recognized than at present if we want to continue to receive the benefits from them. In brief, before investing in restoration (which is not always 100 % successful, but is usually very expensive) natural ecosystems should be preserved in their own integrity, and also because of the many benefits to our society.

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