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Evolution of Ecosystem Services in a Mediterranean Cultural Landscape: Doñana Case Study, Spain (1956-2006)

Erik Gómez-Baggethun^{1,2}, Berta Martín-López², Pedro L. Lomas²,
Pedro Zorrilla² and Carlos Montes²

¹*Institute of Environmental Science and Technology,
Universitat Autònoma de Barcelona*

²*Social-Ecological Systems Laboratory, Department of Ecology,
Universidad Autónoma de Madrid
Spain*

1. Introduction

The conceptualization of ecosystems as natural capital that provides services to society, to some extent emerges as a strategic or pragmatic attempt to put in value the role that nature plays in human well-being. Several classifications of the benefits that society receives from ecosystems have been developed in the scientific literature, both in terms of services and in terms of functions or using both concepts with different connotations (King, 1966; Daily, 1997; Costanza et al., 1997; De Groot et al., 2002; Douguet & O'Connor, 2003; Naveh, 2004). These classifications have also been used at international projects such as the CRITINC project (Van der Perk & De Groot, 2000), the Millennium Ecosystem Assessment (MA, 2003), and the initiative The Economics of Ecosystems and Biodiversity (Kumar (ed.), 2010).

Assessing ecosystem services involves, for analytical purposes, the translation of complex and interlinked ecological structures and processes into a limited number of ecosystem functions that in turn provide diverse services for humans at different scales (De Groot, 1992, 2006; De Groot et al., 2002). The main difference between ecosystem functions and ecosystem services is related to the direct enjoyment, consumption or use by humans. Sometimes ecosystems generate ecosystem functions that are neither demanded nor valued by humans (e.g. remote inhabited and unexploited ecosystems) and thus do not strictly involve the supply of ecosystem services except a few global scale services such as carbon sequestration or biodiversity conservation. In this context, ecosystem functions refer to potential services, or to the ecosystems *capacity* to provide services, while the concept of ecosystem services entails that these have current *value* for society (Gómez-Baggethun & de Groot, 2010).

This research draws on the conceptual framework of the Millennium Ecosystem Assessment (MA), which distinguishes four different categories of ecosystem services: life-support, regulating, cultural and provisioning services (MA, 2003). Nevertheless, the delineation between the categories of *regulating* and *life-support* services is often ambiguous (MA, 2003;

Martín-López et al., 2009). Furthermore, as has been argued by Hein et al. (2006), the consideration of life-support services as a separate category might lead to double-counting problems with other categories of services (Boyd & Banzaff, 2007; Fisher et al., 2009). For this reason, large-scale ecological processes such as primary production, water cycle or biogeochemical cycles have been conceptualized in our study as core ecosystem processes, whose performance is considered a necessary precondition for the generation of the other categories of services that are relevant from a human perspective, namely regulating, cultural and provisioning services (Figure 1). Therefore, *life-support* services, included in the MA’s conceptual framework, have not been directly addressed in this study. As shown in Figure 1, almost every form of social wealth, as well as the different aspects of human well-being is in some way nurtured by, or dependent on, the ecosystems tangible and intangible services. This is the basis of the approach we use in this paper, which emphasizes the role of ecosystems in human well-being, not only when subject to exploitation in order to obtain provisioning services, but also when they are preserved, since regulation functions are better maintained.

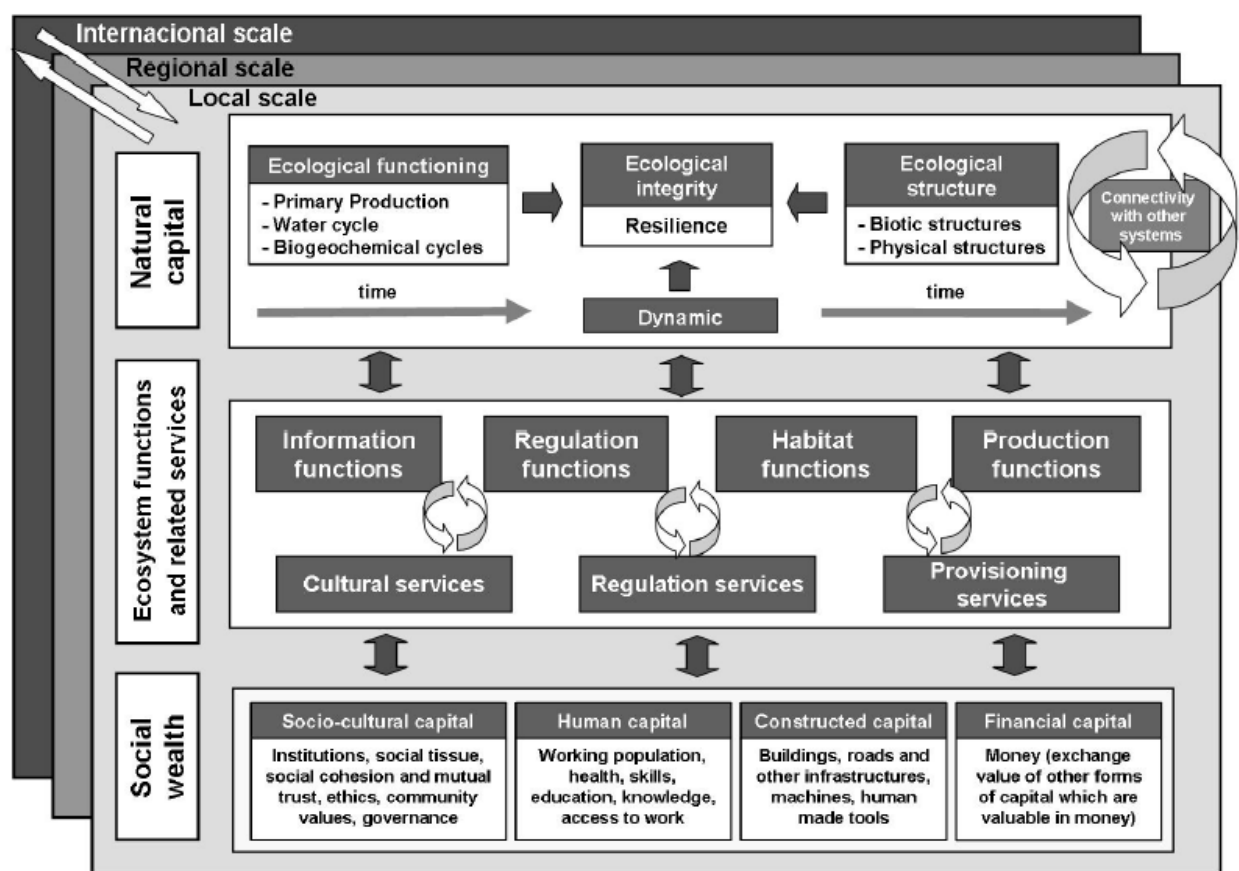


Fig. 1. Ecosystems can be conceptualised from an anthropocentric perspective as a form of natural capital, performing several functions that in turn generate multiple goods and services that are enjoyed by stakeholders at different scales. Ecosystem services nurture every form of social wealth, conceptualised in the figure as different forms of capital.

The main goal of this study is to explore state, trends, and trade-offs in the evolution of the ecosystem services flow provided by the ecosystems of Doñana (SW Spain), which is considered the most relevant wetland in Spain. With this aim, the current state of Doñana’s

ecosystem services as well as their trends during the last fifty years (1956-2006) have been approached. The studied period encompasses a critical phase due to the intensity of the transformations undergone in this area, as it covers the period within which Doñana transits from subsistence to a market-oriented economy, involving deep institutional changes in the way ecosystem services are produced and distributed (Gómez-Baggethun and Kelmen, 2008; Gómez-Baggethun, 2010; Martín-López et al., 2011).

2. The Mediterranean context

The Mediterranean basin is considered as a transitional climatic area between the subtropical desert belt and the more humid northern domain. Ecosystems at the Mediterranean basin have co-evolved through millennia with different cultures generating Mediterranean landscapes (Blondel, 2006). Resource use and transformation is so ancient in this region that Naveh & Lieberman (1993) suggested there are no strictly natural landscapes in the Mediterranean basin any more, arguing that it is more accurate to talk of cultural landscapes. In fact, today's Mediterranean landscapes have been shaped by more than eight millennia of an agro-silvo-pastoral way of life (Grove & Rackham, 2003; Butzer, 2005). This way of life has progressively modelled multi-functional landscapes, often based on agro-silvo-pastoral systems of polyculture. The fact that biodiversity hotspots have been able to emerge within highly humanized landscapes providing diverse ecosystem services, witnesses a successful long term nature-society co-evolutionary process in the Mediterranean basin.

Nevertheless, during the last decades, Mediterranean cultural landscapes have been subject to increasing pressures, and thus are being transformed at unprecedented rates of change (Pinto-Correia & Vos, 2002). Some of these changes are manifested in terms of the homogenization of landscape use and loss of ecosystem services (Brandt & Vejre, 2002). Cultural homogenization dynamics inherent to the globalization process are being accompanied by other large scale drivers such as industrialization or the introduction of economies of scale into productive land use functions, resulting in the transformation of multi-functional cultural landscapes into more simplified spatial patterns dominated by mono-functional land use (Brandt & Vejre, 2002) and thus, in impoverished flows of ecosystem services. It seems to be some consensus about the idea that the current process of global change is carrying landscape homogenization and an increasing conversion of natural and seminatural ecosystems. Nevertheless, this general idea should be tested in concrete case studies to better analyze their causes and impacts, as we do in this study.

3. The Doñana case study

We conceptualized Doñana region as a social-ecological system due to the tight cultural and economic links between its natural area and the human population of 16 municipalities of three different provinces of Andalusia: Seville, Huelva and Cadiz. Doñana is considered to be one of the most emblematic wetlands in Western Europe and encompasses two important protected areas, the Doñana National Park and the Doñana Natural Park (Figure 2), which are both highly appreciated for their ecological and cultural values. Doñana is a unique natural area in many aspects: it is a major stopover point in the migration route of birds moving between Europe and Africa, it provides habitat for one of the most endangered mammals in the world –the Iberian lynx (*Lynx pardinus*)–, as well as for many endemic,

threatened and ecologically interesting species; it constitutes perhaps the most outstanding and better studied wetland in western Europe (Fernández Delgado, 2005). As shown in Figure 2, the ecological limits of Doñana correspond with the fluvial-littoral ecosystem of Doñana (2,205 km²), a wide system of marshes, dunes and beaches, associated with the coastal dynamic of the Guadalquivir River's mouth (Montes et al. 1998). From a hierarchical analysis of their ecosystems (Klijn & Haes, 1994), the Greater fluvial-littoral ecosystem of Doñana encompasses four different types of ecosystem units: marshes (1,591 km²), aeolian mantles (505 km²), coastal system (39 km²) and estuary (69 km²).

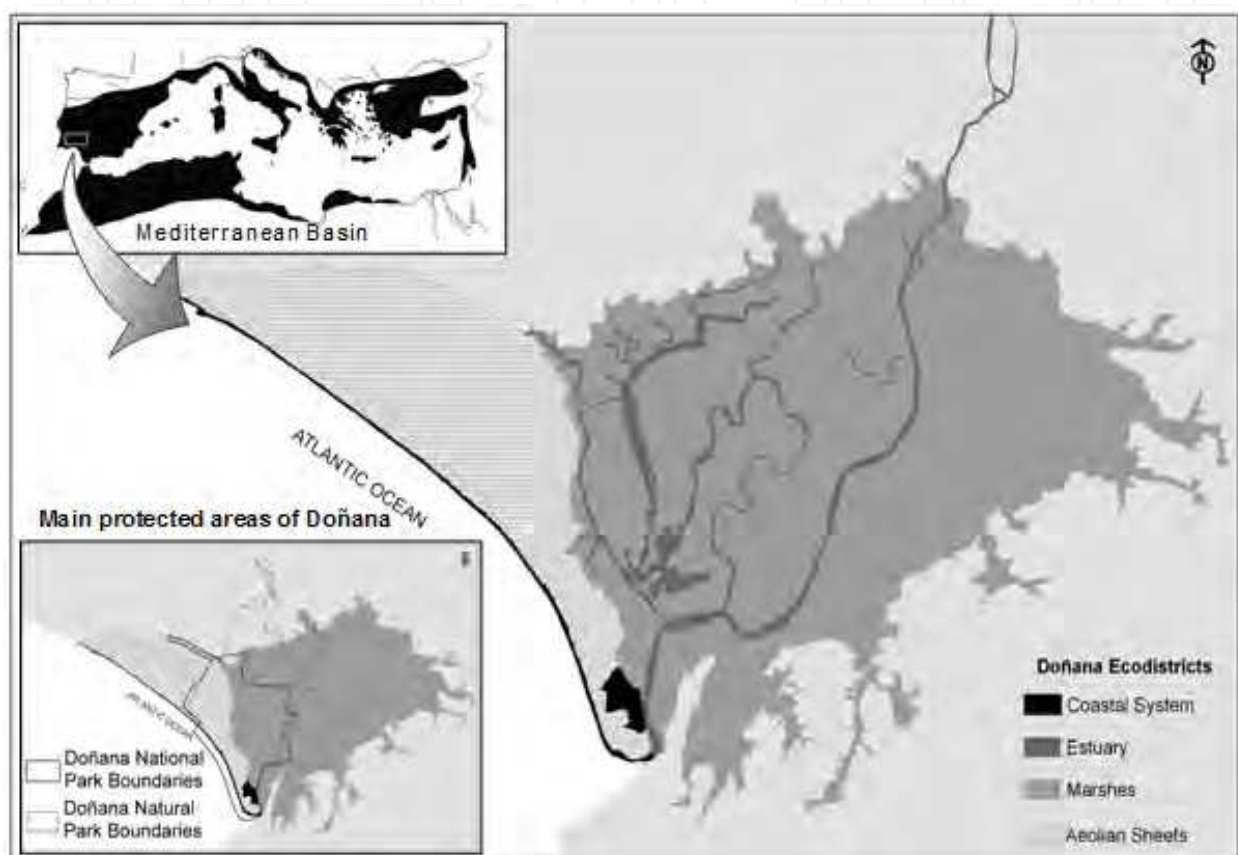


Fig. 2. The fluvial-littoral ecosystem of Doñana is located in the western part of the Mediterranean basin. It embeds four different ecosystems at scale of ecodistrict: coastal system, estuary, marshes and aeolian sheets as well as two important protected areas: Doñana National Park and Doñana Natural Park (unified in 2005 as Doñana Natural Area).

As stated by Rodríguez Merino & Cobo García (2002), Doñana has historically been subject to a wide range of traditional economic uses coupled to local ecosystem's dynamics (Ojeda-Rivera, 1987; Gómez-Baggethun, 2010). The shifting mosaic (*sensu* Forman, 1995), based on multiple uses of the territory has been the dominant landscape management model in Doñana until a few decades ago (Ojeda-Rivera, 1987). Due to its isolation and the marginal character of its land (nutrient poor sandy soils and braquish marshlands), large-scale territorial transformation arrived late to this area (González-Arteaga, 1993). While in most European countries large wetlands had been dried out during the 18th and 19th centuries in order to control malaria and increase land productivity, all trials of reclamation of Doñana's marshes until the 20th century had failed due to lack of technology and capital investment

(González-Arteaga, 1993). During the first decades of the 20th century, Doñana was therefore an almost unique case of wetland conservation in the European context. Furthermore, Doñana was at that time a feeble populated and almost isolated area, which actually had no access road, with a subsistence-oriented economy based on multiple landuses (Ojeda-Rivera, 1990; Villa-Díez et al., 2000). This situation started to change in 1929, with a transformation process that involved the progressive deployment of four, often conflicting, different management policies: agriculture, forestry, tourism and conservation (Montes, 2000).

Between 1929 and 1956, private companies started to drain parts of the marsh in order to cultivate rice (González-Arteaga, 1993). The transformation process was accelerated, through State reclamation projects during the 1956-1978 period, when the upper and part of the lower marsh was drained for further agricultural purposes. In the same period, the State implemented an extensive forest plan to replant the aeolian mantles with eucalyptus (*Eucalyptus* spp.), destroying more than half of the cork tree forest, and a major project to irrigate crop with groundwater was initiated, affecting the aeolian mantles' water regulating functions (Custodio, 1995; García-Novo & Marín-Cabrera, 2005). Development projects in the coast were deployed from 1969, when the beaches of the area were declared of national interest for tourism, resulting in the major urbanization of the coastal area of Matalascañas. Finally, during the 20th century, the Guadalquivir River branches were progressively channeled in order to shorten the navigation distance to Sevilla through the estuary (Menanteau, 1984; González Arteaga, 2005). The period considered in this study, 1956-2006, thus coincides with a transformation process that often involved the simplification of ecosystems by command and control management strategies aimed to increase the productivity by the enhancement of intensive mono-functional land uses.

As a response to this fast transformation process, at the end of the 1960's conservationist policies promoted by European institutions and national and international conservationists were deployed in Doñana. Since the declaration of Doñana as National Park in 1969, protected areas in Doñana have been extended up to now through the declaration of new protection categories and through the enlargement of the existing protected areas. The aim has been to preserve remaining habitats of flagship species in a context of powerful development interests (Figure 3).

Nevertheless, the arrival of strict conservationist policies to Doñana also entailed the prohibition of many socio-economic activities within the protected areas, except those related to ecotourism and a few traditional uses, affecting the flow of provisioning services and the stakeholders whose livelihoods were related to ecosystem production functions. As a consequence, during the last few decades Doñana has been subject to increasing subsidies in order to attenuate social conflicts emerging in relation to conservationist restrictions. Following Ojeda-Rivera (1993), the permanent flow of subsidies, often foreign to the existing local socio-economic tissue, has derived in the establishment of a subsidized culture in Doñana that discourages initiatives for endogenous development. The implementation of strict conservation strategies in Doñana has therefore had different effects. On the one hand, conservation policies have managed to slow down the ecosystem transformation process, for instance achieving to stop the urbanization of the coast, the further reclamation of remaining natural marshes, and the development of linear infrastructures with high impact on habitat fragmentation. On the other hand, by putting strict constraints to most socioeconomic activities, conservation policies (paradoxically like development policies) have also contributed to the erosion of the system of multiple uses in multifunctional landscapes.

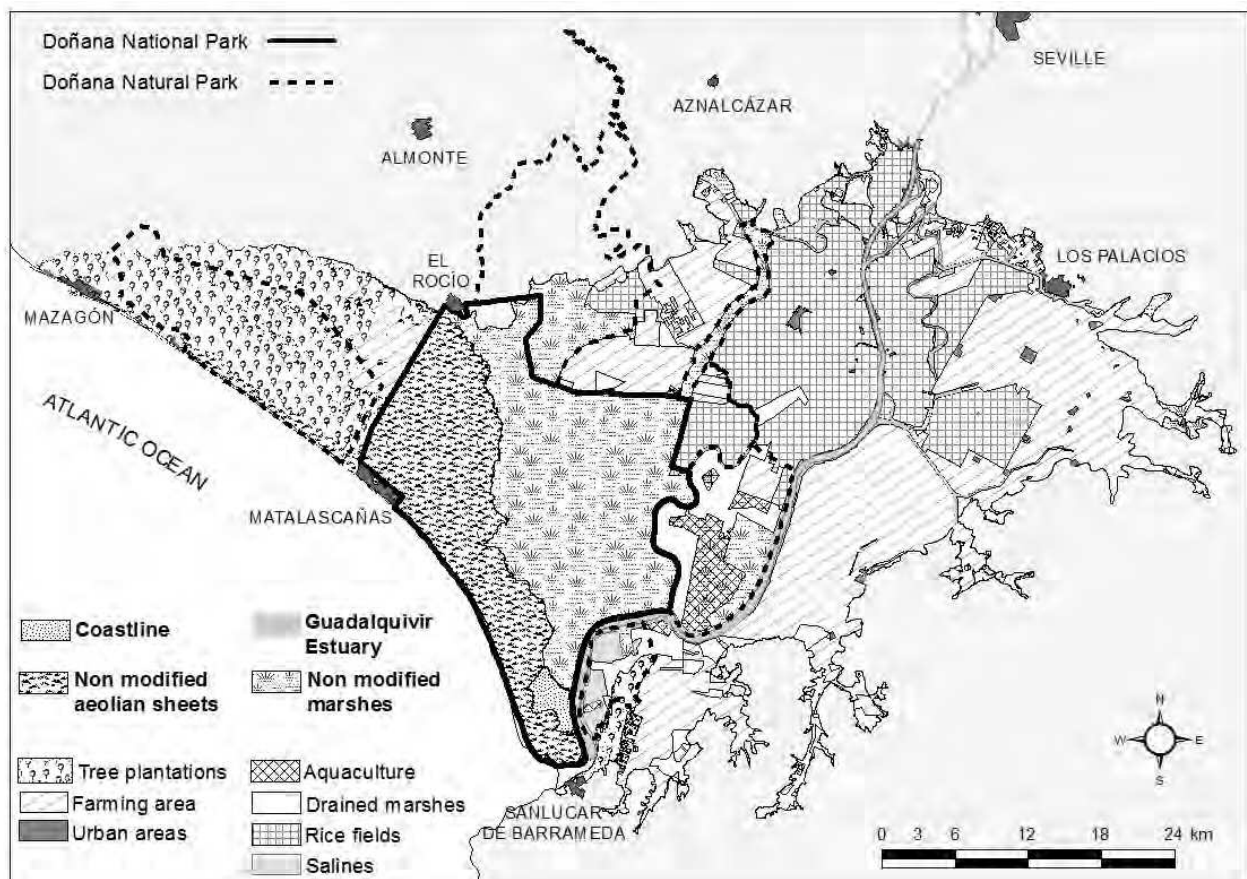


Fig. 3. Main land uses within the Greater fluvial-littoral ecosystem of Doñana. Almost every surface surrounding the protected areas has been transformed.

To sum up, four uncoordinated, and often competing policies (agriculture, forestry, tourism and conservation) were deployed during the 20th century. Conversion of natural ecosystems and subsequent effects on the flow of ecosystem services happened in the absence of an integrated territorial planning in Doñana. In this context Doñana has been portrayed as a clear example of the conservation versus development paradigm in territorial planning where green fortress-protected areas emerge in a matrix of degraded territories devoted to economic development (Gómez-Baggethun et al., 2010; Martín-López et al., 2011).

4. Methods

4.1 Characterization of drivers of change

An essential step of ecosystem services assessments is to characterize and measure through proxy data or indicators the main drivers of change operating in the area. Our characterization of drivers of change draws on quantitative data from official national (National Statistics Institute) and regional (Andalusian Statistics Institute, SIMA) statistics offices, as well as from GIS analysis of land cover changes in Doñana during the period 1956-2006 using aerial photographs and Landsat TM Imagery (Zorrilla et al., forthcoming). Four drivers of change were characterized using either quantitative data or proxy indicators: population growth, changes in labor structure, conservation policies, and development

policies. Each driver was quantified using one or more indicators as proxy measures. More specifically, population growth was measured as variation in the number of inhabitants, changes in labor structure was measured through changes in the relative importance of the agricultural, industrial and service sectors, conservation policies were approached through the variation in the total protected area as well as in the number of protected areas, and the importance of development policies was approached through the increase in the length of lineal infrastructures as well as through the increase in the total area covered with spatial infrastructures (mainly urban areas). When data were not available for the whole period, a representative period was selected.

4.2 Assessment of ecosystem services state and trend

State and trend in regulating, cultural and provisioning services were assessed separately for the four ecodistricts of Doñana. Relevant ecosystem services were characterized following previous research in the area (Gómez-Baggethun, 2010; Martín-López et al., 2010), and supported by an in-depth literature review, scanning of administrative documents, and fieldwork interviews with local resource users, managers, scientists and other key informants conducted during 2006.

As the assessment of changes in ecosystem services at the scale of ecodistrict required abundant data and expertise criteria, the assessment of the services state and trend was entrusted to a scientific expert panel. Ecosystem services of each ecodistrict were evaluated by a panel of 10 scientists, including researchers from five different Spanish universities as well as staff from the Spanish National Research Council (CSIC), which has carried out research in the Biological Reserve of Doñana since 1968. Every member of the panel had no less than 8 years of research experience in Doñana. This multidisciplinary panel, which included specialists in Biology, Ecology, Hydrology, Limnology, Geomorphology, Environmental Sciences, Economy and Social Sciences, assessed current state of Doñana's ecosystem services in a qualitative Likert scale: very degraded (0), degraded (1), adequate (2), good (3), and very good (4).

Next, trends in the ecosystem services were assessed in order to study their evolution in the period 1956-2006. As in the case of the assessment of state, trends were analyzed using a five step Likert scale ranging from strongly deteriorated to strongly improved performance as follows: strongly deteriorated (0), deteriorated (1), stable (2), improved (3) and strongly improved (4). Results were analyzed using statistical methods.

Finally, in both cases, we used non-parametric statistics (Kruskal-Wallis test) to determine differences of ecosystem services among ecodistricts. Additionally, we used Mann-Whitney tests to determine differences between short scale (locally orientated) and large scale (orientated at the national and the international scales) supply of provisioning and cultural services. This scale differentiation was done in order to check if the services flow was mainly orientated to the Doñana community or if it was rather orientated to satisfy the demand from stakeholders at broader scales.

5. Results

5.1 Drivers of change

Tendencies in the four drivers of change considered in this study, i.e. population growth, economic transition towards the services sector, deployment of conservationist policies, and infrastructure development, are shown in Figure 4.

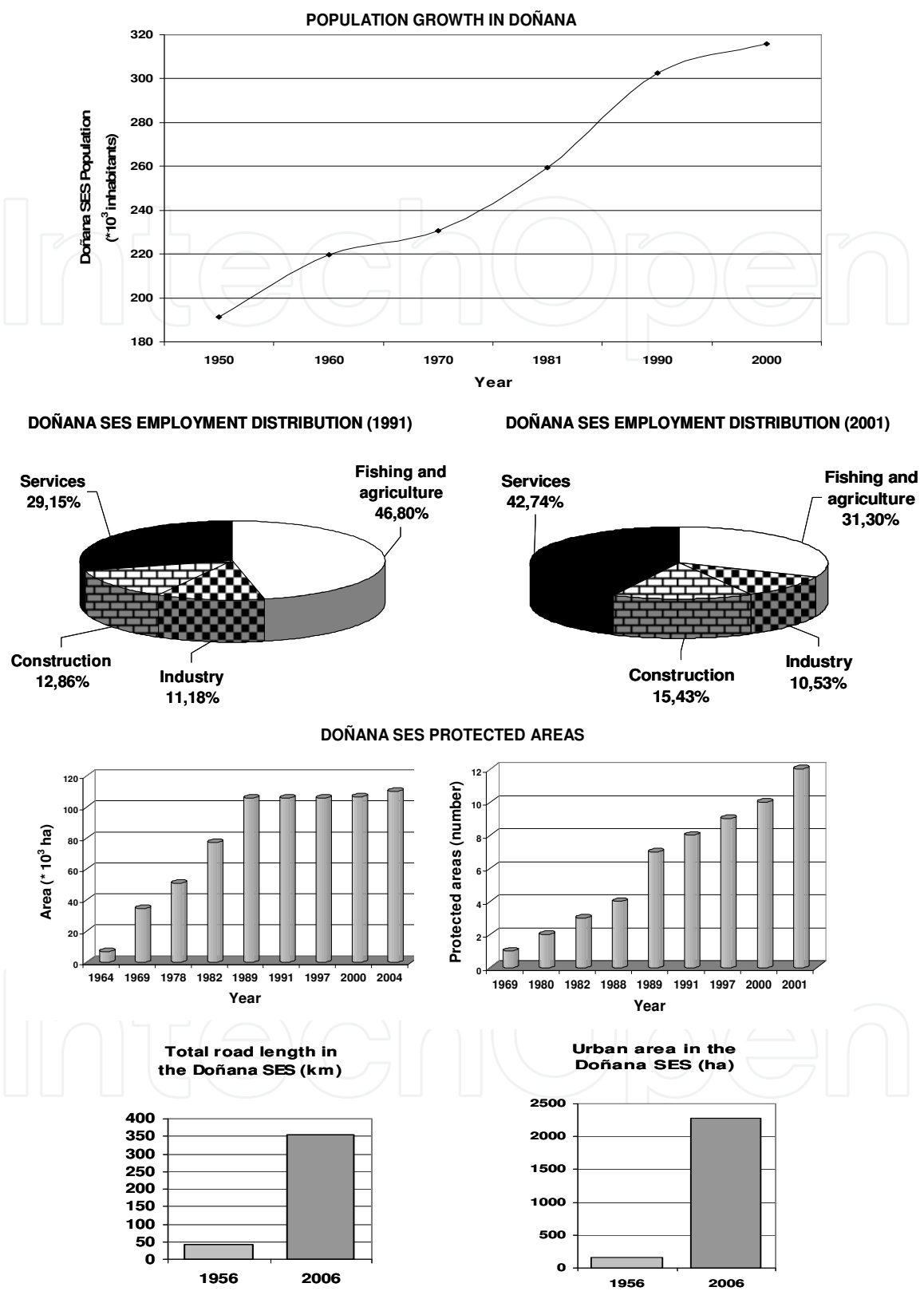


Fig. 4. Population growth, economic transition towards services sector, conservation policies and infrastructure development are among the most powerful drivers acting on the transformations in land use and ecosystem services in Doñana during the studied period. Source: Own development from data of the Andalusian Statistics Institute.

First, population trends show a steady growing trend throughout the studied period, growing from less than 200,000 inhabitants by the 1950s to more than 300,000 inhabitants in the 2000s.

Second, the data show a fast growth of the secondary (industrial plus housing) and tertiary (services) sectors at the expense of the primary sector (agriculture and fishery). Only in the 1991-2001 period, the relative importance of the primary sector in the economy of Doñana (proxied through share of employment) diminished from 47% to 31% of the total number of employments. The secondary sector increased moderately from 24% to 26% of total employment, whereas the tertiary sector increased from 29% to 43% of total employment, showing a marked tertiarization of Doñana’s economy throughout the studied period.

Third, our data show the importance of nature conservation as a key driver of change throughout the studied period. Total protected area increased from about 6800 ha in 1964 to more than 115,000 ha in 2004, whereas the number of protected areas increased from zero to 12 throughout the studied period.

Finally, our data suggest a great importance of development policies as a critical driver of territorial change throughout the studied period. The variation in the length of lineal infrastructures shows an increase from less that 50 km in 1956 to more than 350 km in 2006, whereas the total surface of urban areas increased from less that 200 ha in 1956 to about 2300 ha in 2006.

5.2 Ecosystem services state and trend

At the ecodistrict scale, 23 relevant services were found to be provided by the marshes, 24 by the aeolian mantles, 16 by the coastal system, and 22 by the estuary (Table 1). The assessment of the ecosystem services state and trend was conducted independently for each ecodistrict. The assessment responds therefore to a general picture of the ecosystem services of each ecodistrict, irrespective of which part of them was inside the protected areas and which was not.

Marsh		
Regulating services	Cultural services	Provisioning services
Sedimentary balance	Recreation and ecotourism	Food and fiber crops cosmetic plants
Nutrient regulation	Landscape beauty and aesthetical values	Livestock
Surface / ground water flow regulation	Cultural heritage and sense of place	Gathering
Flood buffering/	Didactic, educative and interpretative functions	Fishing
Climate control	Local ecological knowledge	Aquiculture
Breeding and refugee of migratory species	Scientific research	Medicinal / aromatic plants
Detoxification and pollution processing		Salt works
Maintenance of the saline equilibrium		Land for construction Employment

Aeolian sheets		
Regulating services	Cultural services	Provisioning services
Erosion control	Recreation and ecotourism	Fresh water
Peat formation / maintenance	Landscape beauty	Food crops and plantations
Maintenance of dune dynamic	Cultural heritage and sense of place	Livestock
Maintenance of wetlands	Didactic, educative and interpretative functions	Hunting
Surface / ground water flow and salt regulation	Scientific research	Gathering
Detoxification	Local ecological knowledge	Materials: wood, cork, resin
Nutrient regulation		Fuel: wood, coal, pines
Pollination		Honey and beekeeping
Soil formation		Land for construction
		Employment
Coastal system		
Regulating services	Cultural services	Provisioning services
Erosion control and sediment retention	Recreation and beach tourism	Seafood
Coastal stabilization	Landscape beauty and aesthetical values	Fishing
Storm and wave buffering	Cultural heritage and sense of place	Land for construction
Climate control	Didactic, educative and interpretative functions	Employment
Detoxification and pollution processing	Scientific research	
Maintenance of habitats and food webs	Local ecological knowledge	
Estuary		
Regulating services	Cultural services	Provisioning services
Erosion control	Recreation and ecotourism	Seafood
Coastal dynamic regulation: sediment retention / movement	Landscape beauty and aesthetical values	Fishing
Surface / ground water flow and salt regulation	Cultural heritage and sense of place	Aquiculture
Flood buffering	Didactic, educative and interpretative functions	Hunting
Regulating services	Cultural services	Provisioning services
Detoxification and pollution processing	Scientific research	Salt works
Nursery	Local ecological knowledge	Employment
Maintenance of habitats and food webs		
Maintenance of the saline equilibrium		

Table 1. Main ecosystem services provided by the ecosystems of Doñana.

Results showed the category of regulating services to be the most affected one, as mean values of state show some degree of degradation in all the four ecodistricts (Figure 5). Kruskal-Wallis test showed significant differences for the state of regulating services among ecodistricts ($\chi^2 = 8.01$, $p = 0.04$). State results of regulating services showed the estuary to be the most degraded ecodistrict, while those supplied by the coastal systems were adequate on average according to the scientific panel. While there was no significant difference among ecodistricts regarding trends in regulating services ($\chi^2 = 6.32$, $p = 0.09$), results also show generalized, though moderate, deterioration of regulating services except in the case of the coastal system, where trends suggest stability in performance. Deterioration is considerable in the case of the aeolian sheets and moderate in the marshes and the estuary (Figure 5).

The category of cultural services showed the most positive results in both state and trend. Mean state values are adequate to good in all the ecodistricts, without significant differences between them ($\chi^2 = 5.17$, $p = 0.16$). In contrast, there are differences among ecodistricts for the trend variable ($\chi^2 = 6.80$, $p = 0.07$). The estuary is the ecodistrict which has suffered the most significant deterioration of cultural services. It should be noted, however, that even though cultural services are the best maintained in Doñana, there are significant differences for the state ($U = 18.0$, $p = 0.014$) and trend ($U = 16.0$, $p = 0.04$) between those closely related to local culture and those whose use value is related to stakeholders at national and international scales (Figure 6). The cultural services related to the traditional ecological knowledge and sense of place are the most degraded, while services related to scientific research and tourism seem to have improved during the last decades as they have been permitted and promoted by conservation policies.

Concerning the provisioning services, results showed no significant differences among ecodistricts for state ($\chi^2 = 2.51$, $p = 0.47$) and trend ($\chi^2 = 5.25$, $p = 0.15$). Results of the state variable showed adequate levels of performance in all the ecodistricts, except in the case of the aeolian mantles, where mean state values suggest ecosystem services to be slightly degraded (Figure 5). Results in provisioning services trends were lower (more degraded) on average, as some deterioration is found in all the ecodistricts except the coastal system, where the trend seems to be of stability on average. Similarly to what our results showed for cultural services, within provisioning services we found significant differences for state ($U = 18.5$, $p = 0.013$) and trend ($U = 15.5$, $p = 0.047$) when provisioning services related to local consumption and those which are primarily demanded by stakeholders at broader scales were compared (Figure 7). In accordance with what could be expected, local use of provisioning services has suffered important deterioration, as opposed to the provisioning services aimed at stakeholders related to the national and the international market, such as cash crops, which have improved during the analyzed period.

6. Discussion

6.1 Trade-offs within the flow of ecosystem services: Changing the scale

Significant qualitative changes were identified in the flows of ecosystem services provided by the ecosystems of Doñana during the period 1956-2006. In order to find general trends to characterise these changes, the scale at which the supply of ecosystem services is fostered, and the scale at which services are being demanded and used, seems to be one of the most relevant aspects in order to analyze the qualitative shift undergone by the ecosystem services flow (see e.g. Martín-López et al., 2010). As stated by several authors (MA, 2003; Hein et al., 2006;

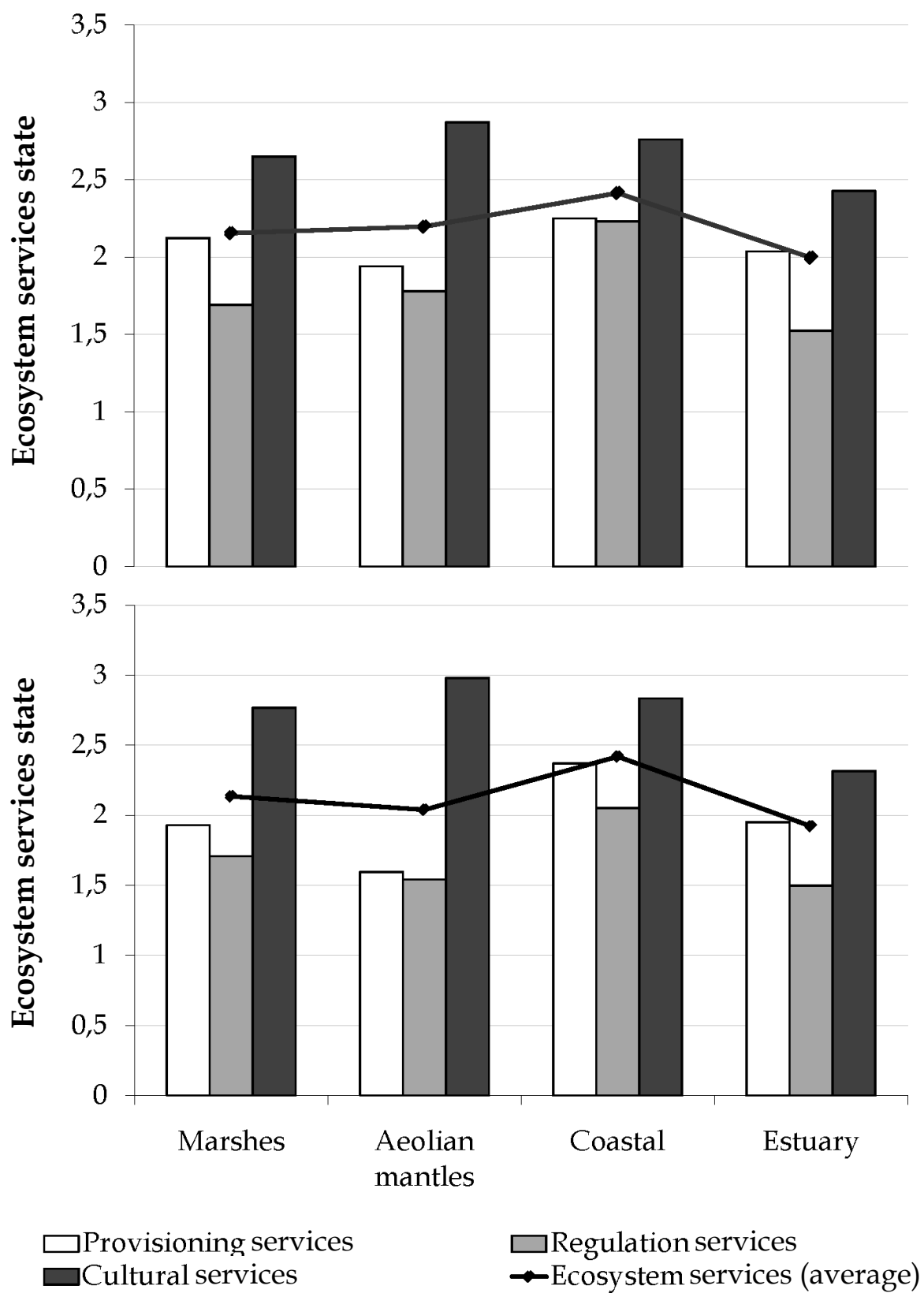


Fig. 5. Average values of the current state and trend (1956-2006 period) of the ecosystem services provided by the ecodistricts of Doñana. Cultural services are the category with best levels of performance, while regulating services appear to be the most degraded.

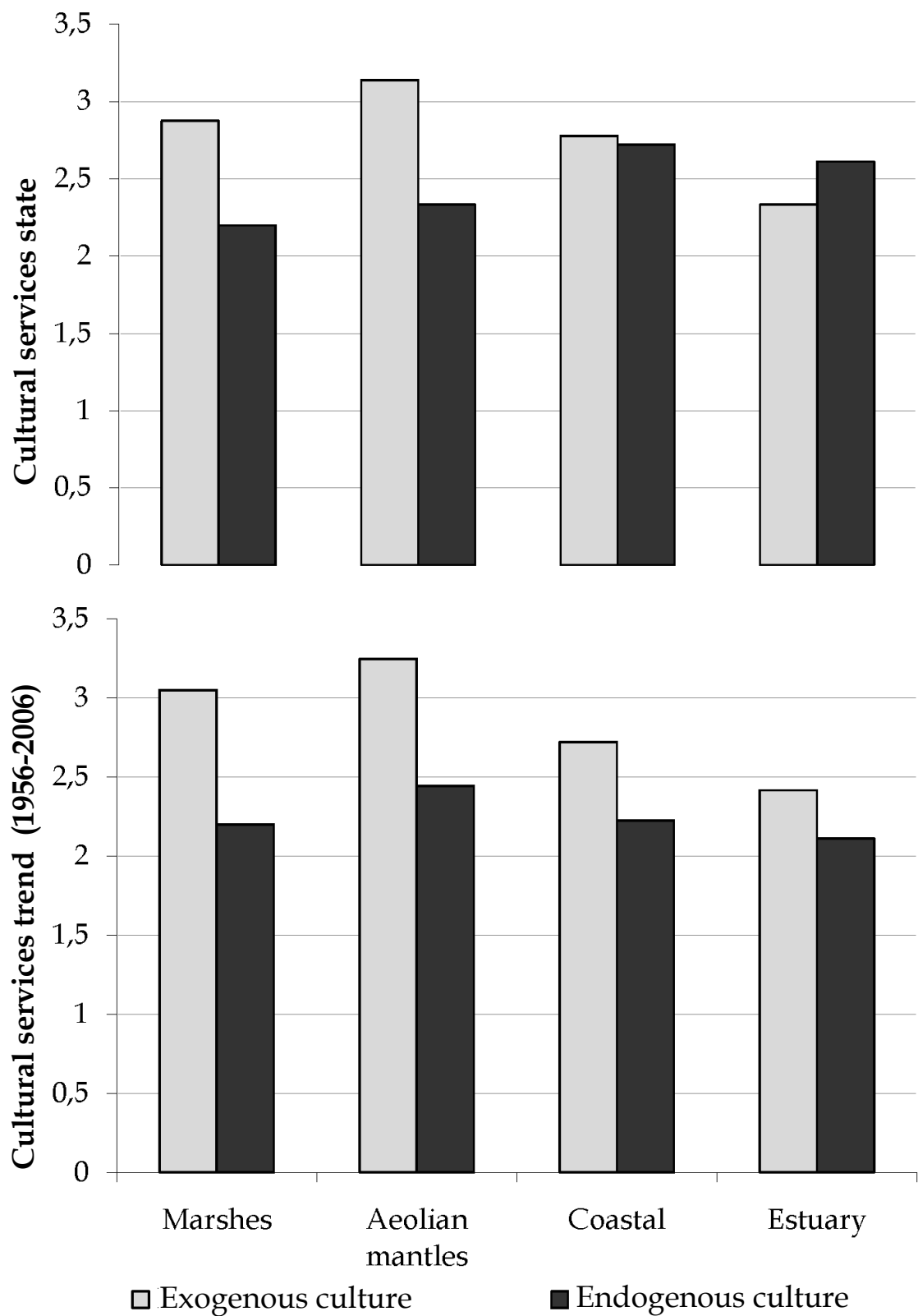


Fig. 6. Cultural service flows from Doñana’s ecosystems are experiencing a delocalization process. Cultural services flows, primarily oriented to the local inhabitants at the beginning of the study period are becoming progressively commodified and oriented towards (sold to) stakeholders at national and international scales.

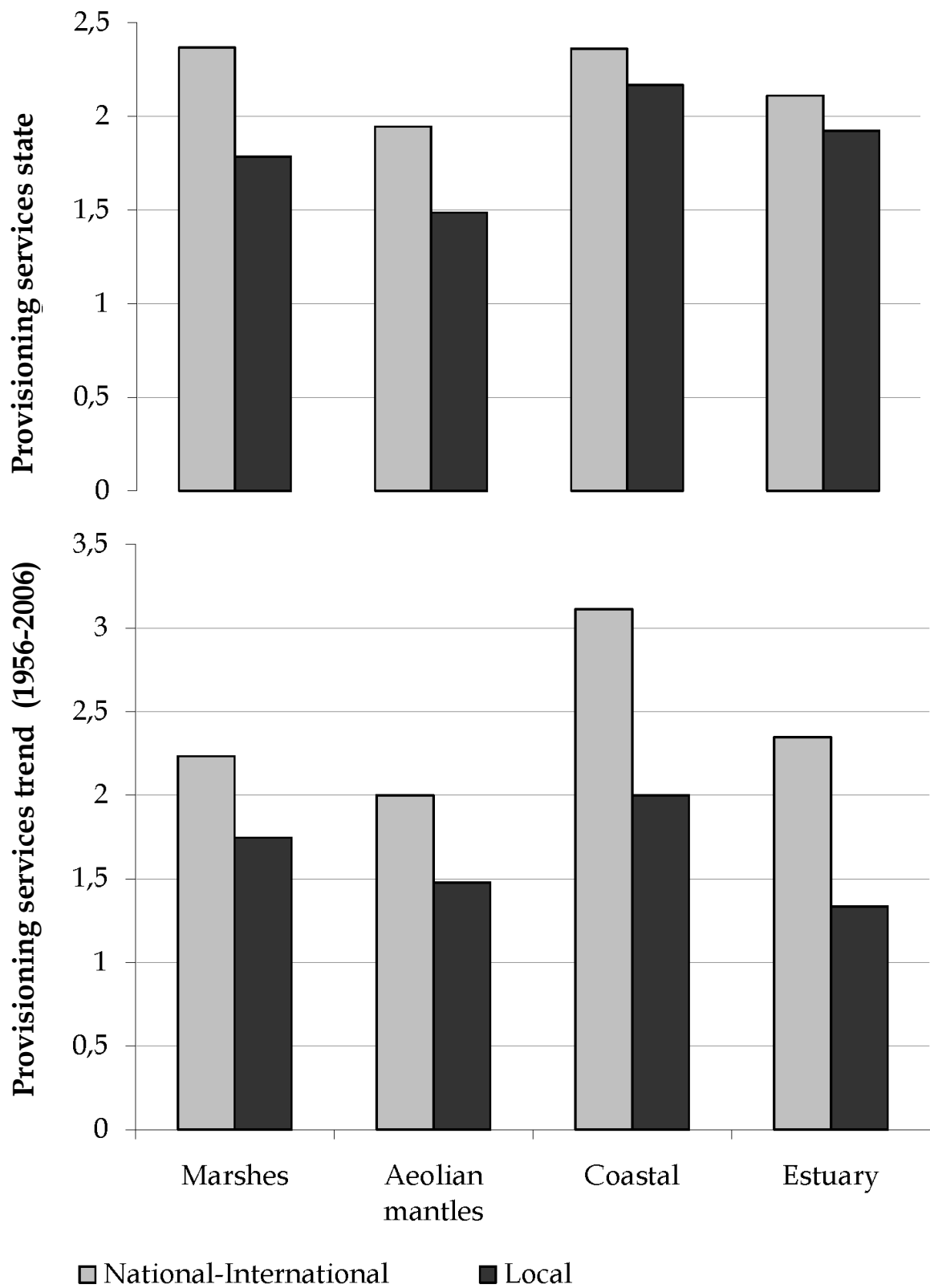


Fig. 7. Provisioning service flows from Doñana’s ecosystems are experiencing a delocalization process. Provisioning services flows, primarily oriented to the local inhabitants at the beginning of the study period are becoming progressively commodified and oriented towards (sold to) stakeholders at national and international scales.

Martín-López et al., 2011), there is a need to examine the different scales at which ecosystem services are provided and enjoyed, and how the supply of ecosystem services affects the interests of stakeholders from the local to the global scale.

In our study, this aspect becomes especially clear in the case of cultural and provisioning services. While general results of the cultural services valuation show adequate states and even improving trends, it is interesting to see how these services have evolved when the subcategories are analysed separately (Figure 6). In fact, when we zoom to cultural services subcategories, we can identify significant trade-offs. These trade-offs reflect a progressive transition from a management strategy primarily aimed at obtaining services to be used by the community of local stakeholders, towards a management strategy with special focus on services demanded by stakeholders at broader scales, such as national or international consumers, tourists, scientists or conservationists. Thus, while cultural identity, sense of place, traditional ecological and other cultural services orientated to the Doñana local community are being lost or degraded (see also Gómez-Baggethun et al., 2010), those cultural services orientated to actors outside the Doñana community such as science, research and environmental educational services, recreation and ecotourism, have improved.

As explained in section 5, something similar happens with the provisioning services (Figure 7). Hunting, gathering, forestry uses and other ecosystem services that historically were directly enjoyed by local communities show decreasing trends. This can be related, on one hand, to the decline of the community-based economy due to the increasing integration of Doñana in the national and international markets as a part as the current globalization process (Martín-López et al., 2010). On the other hand, conservationist related constrictions have also played a role in the decline of certain provisioning services, as they have not only affected industrial and intensive uses, but also small scale uses such as wood collection, hunting, gathering and other locally oriented services. In contrast, provisioning services demanded by stakeholders at broader scales such as rice crops and other forms of intensive agriculture and aquiculture are being enhanced (Figure 7). The results obtained by the expert panel concerning this issue, were consistent with the declarations of local resource users in fieldwork interviews. To sum up, the evolution of the ecosystem services flow generated by the ecosystems of Doñana during the half past century reflects the transition from a *community-based* economy, based on the needs of local stakeholders, towards a *market-based* economy, primarily orientated to satisfy the demands from stakeholders at broader scales.

Our results are consistent in these respect with findings from recent ecosystem services research conducted in Doñana using alternative data sets (biophysical accounts, monetary valuation, and other quantitative measures) (see e.g. Gómez-Baggethun et al., 2010; Martín López et al., 2010, 2011).

6.2 Considering the results within the weak vs. strong sustainability debate

In the context of the transition towards a market economy in Doñana stated above, marketed and high added value ecosystem services are increasing their performance at the expense of those that are not, which are being lost or have declined. Regulating services, usually non-marketed, show a pattern of generalized deterioration, as outside the protected areas cultural multi-functional landscapes have been widely converted into intensive exploitations. On the other hand, results of the assessment show similar patterns in the case of the cultural and the provisioning services. The direct enjoyment of the ecosystem services

of Doñana seems to move from the local community towards stakeholders at broader scales. We can see that the Doñana community seems to be obtaining increasing income from their local ecosystems, while the direct enjoyment of the services provided by local ecosystems is decreasing. In other words, as Doñana integrates national and international markets, the benefits that the local population obtains from their ecosystems seem to be moving from the enjoyment of their *use value* towards obtention of *exchange value* from them (see also Gómez-Baggethun & Kelemen, 2008). It should be noted that this does not necessarily entail a decrease in the use value finally obtained (at least indirectly) by the community stakeholders from their local ecosystems. The shift lies in the fact that the Doñana community does not manage anymore its ecosystems with the aim of satisfying local needs directly from local ecosystem services. Rather, ecosystem services management strategies have become increasingly oriented towards obtaining increased income from commodified ecosystem services, that in turn is used by local beneficiaries to purchase (through the markets) goods and services provided by ecosystems worldwide. This transition in the exploitation model from a *community-based* to a *market-based* economy has implications in terms of social-ecological decoupling, increased ecological debt and increased ecological footprint. While the analysis of these implications is far beyond the scope of this paper (for a thorough analysis of this phenomenon at the scale of the Spanish economy see Carpintero, 2005 and Lomas et al., 2008), we argue that the transition stated above fosters consumption patterns in the Doñana community that are increasingly foreign to the opportunities and limitations related to local ecosystems.

This tendency has promoted the conversion of multi-functional landscapes providing diverse and often non marketed services, into mono-functional landscapes based on the maximization of one or few ecosystem services embodying high added value (pulp, rice, tourism). Put it differently, our results show a steady trend towards the commodification of ecosystem services in Doñana. On one hand, homogenization dynamics related to this conversion might have significant consequences in terms of resilience loss (Martín-López et al., 2010). On the other hand, the assumed economic rationale behind these conversions would be probably challenged if the so-called negative environmental externalities were taken into account. The transformation of multi-functional into mono-functional landscapes generates increased private benefits (Balmford et al., 2002; de Groot, 2006), whereas the often higher costs, in terms of pollution, biodiversity extinction, and natural capital depletion are externalised to society at large or to future generations, thus not being considered in conventional economic accounting (Kapp 1983).

The transition process mentioned above can also be relevant within the weak versus strong sustainability debate (Neumayer, 1999). A thorough analysis in terms of weak and strong sustainability, would require further function analyses in which ecosystem services were evaluated and quantified in physical terms (see Martín-López et al., 2010, 2011 for substantial advances in this direction). Nevertheless, it is a fact that Doñana has lost important extensions of its natural capital stock since 1956, as outside the protected areas, ecosystems and cultural landscapes have been turned into simplified cultivated capital (i.e. monocultures of rice and eucalyptus plantations) and to a smaller extent also into constructed capital (industrial and urban areas) (González-Arteaga, 1993, Zorrilla et al., forthcoming). Furthermore, the picture of generalized deterioration of the regulating services reflected by the assessment of the expert panel shows how natural capital functions are being degraded. We can therefore argue that physical structures and processes of the

Doñana's natural capital are being degraded, while the monetary income obtained from Doñana's natural capital seems to be increasing. In this context, we could argue that Doñana is moving towards a weak sustainability path as its natural capital is replaced by financial and human-made capital.

7. Conclusions

During the last half century, the Doñana region has been subject to a process of deep structural transformation, in which the rates of change have been significantly accelerated. Demographic, socioeconomic, political and cultural drivers have played an important role in this process, resulting in the homogenization of functions and uses in the landscapes of Doñana, thereby affecting the capacity of local ecosystems to provide diversified ecosystem services flows.

This paper adds to recent efforts to transcend traditional natural resource studies previously done in Doñana, in order to delineate landscape management strategies based on the ecosystem services approach (see e.g. Gómez-Baggethun, 2010; Martín-López et al., 2010, 2011; Uhl et al., 2010). Results of the state of the ecosystem services of Doñana show a general picture of moderate deterioration in the case of regulating services. Mean state values seem to be adequate in the provisioning services and rather good in the cultural services. Concerning the trend in the period 1956-2006, the results obtained show levels of deterioration slightly higher than those of the state. Main results obtained through the ecosystem services assessment show a picture of deterioration in the state and trend of the regulating services, certain stability in the provisioning services, and an improvement in the case of the cultural services.

However, important trade-offs can be identified when subcategories of services are analyzed separately based on the scale at which the beneficiaries used them, showing a qualitative shift in the ecosystem services flows. Two aspects of the trade-offs characterizing this shift have been highlighted. First, the enhancement of cultural services that are demanded by stakeholders at national and international scales (e.g., tourism, science, research) at the expense of those that have been historically attached to local stakeholders (e.g., sense of place, local ecological knowledge, gathering, hunting). Second, the improvement in the capacity to provide marketed and high added value services at the expense of non-marketed services. It has been argued that this tendency has promoted the conversion of multi-functional landscapes providing diverse and often non-marketed services into mono-functional landscapes trying to maximize the yield of single marketed services (e.g., strawberry greenhouses, rice crops). Finally, we have pointed out that Doñana might be moving towards a weak sustainability path, as natural capital stocks and functions are being degraded in physical terms while the monetary income obtained from Doñana's natural capital seems to be increasing.

8. Acknowledgements

The authors are grateful to all expert panel members, to S. Sastre, C. Louit and A. Verdú for having provided some cartographical data and to Doñana National and Natural Park for providing facilities to obtain data. This study has been possible with financial support of the Andalusian Ministry of the Environment (project NET413308/1), the Spanish Ministry of Environment (project Doñana 2005-13/2006), and the Autonomic Organism of National Parks (018/2009).

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Biodiversity

Edited by Dr. Adriano Sofo

ISBN 978-953-307-715-4

Hard cover, 138 pages

Publisher InTech

Published online 10, October, 2011

Published in print edition October, 2011

Biodiversity is strongly affected by the rapid and accelerating changes in the global climate, which largely stem from human activity. Anthropogenic activities are causing highly influential impacts on species persistence. The sustained environmental change wildlife is experiencing may surpass the capacity of developmental, genetic, and demographic mechanisms that populations have developed to deal with these alterations. How biodiversity is perceived and maintained affects ecosystem functioning as well as how the goods and services that ecosystems provide to humans can be used. Recognizing biodiversity is essential to preserve wildlife. Furthermore, the measure, management and protection of ecosystem biodiversity requires different and innovative approaches. For all these reasons, the aim of the present book is to give an up-to-date overview of the studies on biodiversity at all levels, in order to better understand the dynamics and the mechanisms at the basis of the richness of life forms both in terrestrial (including agro-ecosystems) and marine environments.

How to reference

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Erik Gómez-Baggethun, Berta Marfín-López, Pedro L. Lomas, Pedro Zorrilla and Carlos Montes (2011). Evolution of Ecosystem Services in a Mediterranean Cultural Landscape: Doñana Case Study, Spain (1956-2006), Biodiversity, Dr. Adriano Sofo (Ed.), ISBN: 978-953-307-715-4, InTech, Available from: <http://www.intechopen.com/books/biodiversity/evolution-of-ecosystem-services-in-a-mediterranean-cultural-landscape-don-ana-case-study-spain-1956->

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Phone: +86-21-62489820
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