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Assessing the balance between biodiversity conservation and coastal and estuarine management of the Sado Estuary Natural Reserve, Portugal, using BIO-SAFE

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PREFACE

The Sado Estuary in Portugal is one example of estuarine and coastal environments where human impacts have led to a whole range of changes with considerable variation in their degree of impact. Part of the Sado estuary has the designation of Natural Reserve, but its location near to industrialised and urban zones led to policy conflicts between conservation and development. This master thesis integrates ecological knowledge and legal instruments concerning the Sado Estuarine area. In this study, the balance between biodiversity conservation and management of the Sado Estuary Natural Reserve (RNES) is assessed, using the novel Spreadsheet Application For Evaluation of impacts of physical reconstruction measures on BIOdiversity (i.e. BIO-SAFE). BIO-SAFE is a model that integrates ecological knowledge and information with political and legal considerations concerning biodiversity. This model was already applied to north-western European riverine sites (Lenders *et al.,* 2001; De Nooij *et al.,* 2001, 2004; Wozniak *et al.,* 2009) and now with this study BIO-SAFE was improved. A new version was created for the Sado Estuary Natural Reserve in Portugal, in the south-west of Europe, with different environmental and ecological conditions. Further in this study, these differences were analysed, where the studies were compared.

This study has been carried out during seven months at the Environmental Science department of the Radboud University (RU) Nijmegen, fulfilling my Master Degree in Environmental Engineering - Ecological Engineering profile - at the Sciences and Technology Faculty from the New University of Lisbon (FCT/UNL, Faculdade de Ciências e Tecnologia da Universidade Nova de Lisboa), in Portugal.

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O Prefácio que se encontra nesta página foi escrito em Julho de 2010, aquando da entrega da primeira versão deste documento, ainda em Nijmegen, na Holanda. Com esta versão final, não podia deixar de escrever algumas palavras direccionadas particularmente a várias pessoas e entidades:

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É que, para variar, está quase na hora de entregar a tese e deixei isto mesmo para o fim ☺

Por último, pelo lugar especial que têm no meu coração, e porque infelizmente não poderão estar fisicamente presentes no dia em que oficialmente terminar o curso, mas sei que estarão sempre comigo, aos meus avós, uma saudade muito grande.

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ABSTRACT

Coastal and Estuarine management is one emergent topic nowadays. Physical reconstruction and management plans are currently being executed where the major goals are flood risk reduction, ecological rehabilitation and economic development. The ecological consequences of these measures must be evaluated in a way that ensures attuning of policy goals concerning conservation of biodiversity. The estuarine systems are important for the conservation and restoration of biodiversity, since they are one of the most productive ecosystems on the planet. Recently, a novel Spreadsheet Application For Evaluation of impacts of physical reconstruction measures on BIOdiversity (i.e. BIO-SAFE) in riverine habitats has been developed (Lenders *et al.,* 2001, De Nooij *et al.,* 2004, De Nooij, 2006). In this study, BIO-SAFE has been adapted to the Portuguese Sado River Estuary, with the direct application on the Natural Reserve of the cited estuarine area.

BIO-SAFE is a policy and legislation based assessment model that quantifies biodiversity values in riverine areas for several taxonomic groups and landscape ecological units (ecotopes) on the basis of the policy status and habitat demands of riverine characteristic species. The model uses data on presence of species and riverine landscape ecological units for different levels of spatial scale. In this study, a new version of the model was developed for the Sado Estuary Natural Reserve (RNES), called BIO-SAFE Sado. To develop the Sado version, it was necessary to adapt the three main components of the conceptual framework of BIO-SAFE. These comprise (1) a database with the relevant policy and/or legislation RNES indigenous species, (2) a specific ecotope typology for the RNES area and (3) a weighted set of policy and legislation based valuation criteria for biodiversity. In addition to these research activities, the model has been implemented in the MS Excel spreadsheet.

After implementation of these three components and the programming of the different types of indices and algorithms in MS Excel, the program calculated all relevant indexes and scores. The BIO-SAFE Sado model was used for two types of analysis: (a) valuations of ecotopes (potential situation) and transitions between ecotopes and (b) valuation of the actual situation. Both approaches were made on the level of species individually and taxonomic groups at two scale levels (ecotopes and levels). The taxonomic groups higher plants, birds, fish and mammals are amongst the most important taxa regarding endangered and protected biodiversity in the study area. The ecotope valuation show that the most important ecotope types regarding protected and endangered biodiversity in the RNES are the Waterlines for the aquatic ecotope types and the *Dune bushes* and the indigenous forestry ecotope types *Pinewood* and *Cork oak system* for the terrestrial systems. The valuation of the actual situation shows the same results for the most important taxa and ecotopes

present in the RNES, which was expected since the saturation indices showed high values, indicating that most of the potential species are actually present on the area.

A comparison with the previous BIO-SAFE applications to the European north-western rivers Meuse and Rhine (The Netherlands, Germany, France and Belgium) and Vistula river (Poland) was also made, where the Portuguese BIO-SAFE assessment presents the highest number of species implemented on the model and the highest figures of the taxonomic biodiversity saturation index, extolling the high importance of the Sado Estuary in terms of biodiversity values.

The development and application of BIO-SAFE Sado demonstrated that the BIO-SAFE concept can easily be adapted to another ecosystem type, specifically to an estuarine area. The BIO-SAFE assessment appeared to be a good method to quickly determine political and legal biodiversity and ecotope values, showing the relative importance of the ecotopes occurring in the RNES following the linkage to valuation of species with specific legislation criteria.

RESUMO

A gestão de sistemas costeiros e estuarinos tornou-se actualmente num tema emergente. Alterações biofísicas e planos de gestão são executados, onde os principais objectivos são a redução do risco de cheias, reabilitação ecológica e desenvolvimento económico. As consequências ecológicas destas medidas devem ser avaliadas, de forma a assegurar a implementação das metas legais em termos de conservação da biodiversidade. Os sistemas estuarinos são importantes para a conservação e restauração da biodiversidade, uma vez que são um dos mais produtivos ecossistemas do planeta. Recentemente, foi desenvolvido um novo aplicativo de modelação que avalia a dimensão dos impactes de alterações biofísicas sobre a biodiversidade de um determinado local, denominado "BIO-SAFE" (Spreadsheet Application For Evaluation of impacts of physical reconstruction measures on BIOdiversity) (Lenders *et al.,* 2001, De Nooij *et al.,* 2004, De Nooij, 2006). Neste estudo, o modelo foi adaptado para o Estuário do rio Sado, com a sua aplicação concreta na área da Reserva Natural deste ecossistema estuarino.

A aplicação BIO-SAFE é um modelo de análise que se baseia em legislações e outros instrumentos de índole política, quantificando os valores da biodiversidade presente numa determinada área ribeirinha. A aplicação é feita a diferentes grupos taxonómicos e unidades ecológicas biofísicas (ectótopos), baseada no estatuto legal de conservação e nas necessidades ecológicas das espécies características dessa área em estudo. O modelo incorpora e relaciona os dados existentes sobre a presença das espécies características de uma determinada área ribeirinha e as unidades ecológicas biofísicas específicas desse local em diferentes níveis de escala. Neste estudo, uma nova versão deste modelo foi desenvolvida para a Reserva Natural do Estuário do Sado (RNES), sendo denominada BIO-SAFE Sado. Para a criação da nova versão desta aplicação, foi necessário adaptar os três principais componentes do quadro conceptual do modelo. Isto inclui (1) uma base de dados das espécies relevantes em termos legais e indígenas da RNES, (2) uma tipologia específica para os ecótopos da RNES e (3) um critério de avaliação para a biodiversidade em estudo, baseado numa ponderação atribuída aos instrumentos políticos e legais utilizados. Depois destes três passos, os dados adquiridos são implementados no modelo BIO-SAFE, desenvolvido no programa Excel da Microsoft.

Após a execução destas três componentes e da implementação dos dados no modelo em Excel, os diferentes índices e algoritmos foram calculados, tendo-se obtido os valores dos índices e constantes para análise. O modelo BIO-SAFE Sado foi usado para dois tipos de avaliação: (a) análise à importância dos ecótopos (situação potencial) e transições entre ecótopos e (b) análise da situação actual. Ambas as análises foram realizadas para os níveis de espécies individualmente e grupos

taxonómicos em dois distintos níveis de escala (ecótopos e habitats). Os grupos Plantas Superiores, Aves, Peixes e Mamíferos são dos mais importantes taxa tendo em conta a biodiversidade ameaçada e protegida da RNES. A análise aos ecótopos mostra que os mais valorados, tendo em conta a biodiversidade ameaçada e protegida por legislação, são as *Linhas de água*, referente aos ecótopos aquáticos, e os *Matos dunares* e as florestas indígenas *Pinhal* e *Montado de sobro*, referente aos ecótopos terrestres. A análise da situação actual apresenta sensivelmente os mesmos resultados de valoração para os grupos taxonómicos e ecótopos mais importantes presentes na RNES. Estes resultados eram esperados, dado que os índices de saturação demonstraram valores muito elevados, indicando que a grande maioria das espécies potenciais para a área em estudo se encontram actualmente presentes.

Foi realizada também uma comparação com os anteriores estudos da aplicação do modelo BIO-SAFE nos rios Meuse e Rhine (Holanda, Alemanha, França e Bélgica) e no rio Vistula (Polónia), onde os resultados da análise realizada ao caso de estudo português foram os mais elevados para o número de espécies seleccionadas para análise introduzidas no modelo BIO-SAFE, tal como o índice de saturação de biodiversidade também apresentou os valores mais altos, indicando uma elevada presença do número de diferentes espécies na área de estudo. Estes resultados enaltecem, uma vez mais, a importância do Estuário do Sado em termos de valores de biodiversidade.

O desenvolvimento e a posterior aplicação da análise BIO-SAFE demonstraram que o conceito do modelo BIO-SAFE pode ser facilmente adaptado a outros ecossistemas, concretamente a áreas estuarinas. A análise realizada através do modelo BIO-SAFE demonstrou ser um bom método para uma acessível determinação dos valores políticos e legais da biodiversidade e respectivos ecótopos, demonstrando a importância relativa dos ecótopos existentes na RNES baseada num critério específico de avaliação de espécies ameaçadas protegidas por legislação.

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1. INTRODUCTION

Coastal and Estuarine management is one emergent topic nowadays. Coastal zones are important areas that provide provisioning, regulating and recreational services to coastal populations and have a high economic value. However, the benefits that these ecosystems generate are threatened by society's own activity. Population settlement in coastal areas is responsible for increasing pressure on these ecosystems, resulting in severe consequences such as degradation of natural habitat areas (Ledoux & Turner, 2002). Rapid population growth and uncontrolled development in many coastal regions worldwide have intensified the multi-specific interests and activities which develop in and around estuaries (Vasconcelos *et al.,* 2007).

Estuaries are the main transition zones or ecotones between the riverine and marine habitats. They are geomorphologically very dynamic and ephemeral systems, influenced both by sea and land changes, forming a complex mixture of many different habitat types. These habitats do not exist in isolation, but rather have physical, chemical and biological links between them, for example in their hydrology, in sediment transport, in the transfer of nutrients and in the way mobile species move between them both seasonally and during single tidal cycles. Despite the many different habitat types, relatively large and unpredictable variations in salinity (physiological stress) and water movement or turbidity (physical stress) tend to limit the number of animal and plant species capable of adapting to these rigorous conditions. As a result, an estuary generally harbours less species than either the freshwater river above the tidal limit or the truly marine habitat outside the estuary. Although estuaries generally contain relatively few species, the abundance and biomass of organisms is usually very high (Meire *et al.*, 2005).

Estuaries are amongst the ecosystems on the planet with one of the highest primary productivity, mainly due to their low depth waters and nutrient richness (INAG, 1999). Being open systems, estuaries also serve as important connections between rivers and the sea for many anadromous (ocean dwelling but spawning in estuaries and rivers) and catadromous (freshwater dwelling but spawning in seawater) species (Meire *et al.*, 2005). The fact that estuaries have a relative protection against large predators makes the estuarine waters and its grounds privileged places for reproduction and growth of fish, molluscs, crustaceans and some other aquatic species. The importance of the estuarine areas is further evidenced in the significative number of populations form different bird species that they support. Estuaries also have an important role related with the depuration and decontamination of the environment, where the salt marsh vegetation has a special relevance as “filters” in the processes of deposition and particles retention (INAG, 1999). In contrast with their ecological importance, estuaries are amongst the most modified and threatened aquatic environments. Consequently, estuaries exhibit a wide array of human impacts that collide with their ecological function, threatening the long term viability and health of these important ecotopes (Vasconcelos *et al.,* 2007). The simultaneous occurrence of attractiveness for human use and natural values in estuarine ecosystems has led to policy conflicts between conservation and development. Part of the Sado estuary has the designation of Natural Reserve (RNES), but its location near to industrialised and urban zones led to this kind of conflicts (Caeiro *et al.,* 2003).

Biodiversity conservation in the context of ecosystem management

Over the last decades, almost all arguments about nature conservation have involved the issue of biological diversity and ways to preserve it. These discussions culminated in the 1992 Rio de Janeiro Convention on Biological Diversity and its implementation. The conservation of biodiversity is a vast undertaking, requiring the mobilization and management of wildlife on an unprecedented scale (Humphries *et al.,* 1995). The most widely used definition for biodiversity is the one used by the United Nations Convention on Biological Diversity, in Rio de Janeiro, which defines it as “The variability among living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems”. Based on this general definition of biodiversity, there is no doubt that all of its components are under threat from a variety of factors resulting from increasing human populations and resulting generation of waste and demand for food (Thompson & Starzomski, 2007). Biodiversity is one of the ecosystem services supported by ecosystem structures and processes that provide habitat for wild plant and animal species. Moreover, biodiversity is the basis for most ecosystem functions, which means, it contributes directly or indirectly to all ecosystem goods and services (de Groot *et al*., 2002).

The increased focus on ecosystem management has presented a number of challenges to conservation biology. Strategically targeted site conservation programs can tackle the main cause of extinctions by reducing the loss of natural habitats and of the species that they shelter (Eken *et al.,* 2004). Ecosystem management spans a range of activities at a range of spatial scales. Conservation activities range from site-focused activities to regional and national planning, reporting, and regulation. The resulting information needs are likewise varied in detail and scale (Overton *et al.,* 2002).

One of the central tasks of conservation biology is to prioritize places on the basis of their biodiversity value, selecting those that have the highest priority. For this objective, the biodiversity values of sites have to be assessed (Abellán *et al.,* 2005).

Protected areas and its limitations

Protected areas are the cornerstones of most national and international conservation strategies, providing refuges for species that cannot survive and ecological processes that cannot be maintained in intensely managed landscapes or seascapes (Dudley *et al.,* 2005). The International Union for Conservation of Nature defines a protected area as "A clearly defined geographical space recognized, dedicated and managed, through legal or other effective means to achieve the long-term conservation of nature with associated ecosystem services and cultural values" (Dudley, 2008). Protected areas that now exist worldwide do not reflect a single approach to conservation, but instead show an extraordinary variety of management objectives. They range from strictly controlled reserves, where only a handful of scientists are allowed to enter, to cultural landscapes with thousands of human inhabitants, where biodiversity conservation is integrated with many other activities (Mulongoy, 2004).

Protected areas are indisputably the primary tool for *in situ* biodiversity conservation across the world, with more than 100,000 sites covering nearly 11.7% of the land surface of the planet and about 1% of the marine environment (Mouillot *et al.,* 2008). This also means that almost 90% of the world's land surface still remains outside formal protected areas, themselves subject to varying degrees of biodiversity protection in practice. This would be less important in the context of biodiversity monitoring if the world's biodiversity was mainly concentrated in protected areas, but in fact the majority remains outside. Furthermore, protected areas surrounded entirely by radically altered habitat have limited usefulness in the long term for many species unless the areas are very large. Species trapped in protected area 'islands' risk genetic isolation and gradual decline (Dudley *et al.,* 2005). In addition, protected areas are not necessarily made up entirely of untouched habitat. Protected landscapes and seascapes and extractive reserves both may contain a considerable proportion of their area devoted to some kind of agricultural and/or forest management. These areas constitute a total of 28.9% of the total protected areas (Chape *et al*, 2005).

Terrestrial biodiversity is too widely dispersed to allow its measurement to be focused solely within strict protected areas. Managed landscapes will continue to play vital roles as buffer zones and corridors supporting protected areas and more generally as habitat for wild species, some of which are likely to never be adequately represented within the protected area network. If biodiversity is to be conserved outside protected area networks, in economically productive landscapes, this implies that biodiversity use is sustainable in the overall landscape and in addition that management is compatible with the survival of some or all of the biodiversity originally present. Protected areas only function effectively as tools for conservation if they are well managed and they retain their constituent species and habitats (Dudley *et al.,* 2005).

Problem formulation

In Portugal, not too many examples of coastal zone management exist where integrative studies were developed using different tools. The Sado Estuary is an example where environmental problems are not very well managed. Many studies have been and still are being developed for the Sado River estuary in the different environmental, economic and social components. However, just a few tried to evaluate the global status of the estuary and analyse the information in an integrated and synthetic way, aiming at establishing correct environmental management data for transmitting to the different stakeholders, including the decision-makers (Caeiro, 2004).

BIO-SAFE (Spreadsheet Application For Evaluation of BIOdiversity), a model that quantifies the relevance of species and ecotopes, on the basis of international treaties and directives and national Red Data Lists (Lenders *et al.,* 2001, De Nooij *et al.,* 2004, De Nooij, 2006), may be one useful tool to assess the portuguese Sado Estuary Natural Reserve biodiversity values, to help balance conservation with coastal and estuarine management and landscape planning.

1.1. BIO-SAFE approach

BIO-SAFE is developed as a management tool to optimise mutual attuning of nature conservation policies and other interests in spatial planning on the basis of political and legal criteria derived from national and international policy plans, laws, treaties and directives (Lenders *et al.,* 2001). Fields of application of BIO-SAFE comprise designs and evaluations of physical planning projects, environmental impact assessments and comparative landscape-ecological studies. BIO-SAFE can be applied for the purpose of (a) valuation of the actual situation (at the level of taxonomic groups, species, ecotopes and at the floodplain level), (b) evaluative analysis of different scenarios or designs for reconstruction of a floodplain, allowing assessment of impacts of different reconstruction measures and a ranking of reconstruction alternatives according to their value for biodiversity conservation (on the level of taxonomic groups, species and on the floodplain level), (c) valuations of ecotopes and transitions between ecotopes and (d) trend analysis, showing biodiversity value patterns in time (De Nooij *et al.,* 2001).

The conceptual framework of BIO-SAFE concerns the conservation policy and legal dimensions of biodiversity on the level of species (biological level of organisation) and the spatial levels of scale relevant to their habitats in floodplains. The basis of BIO-SAFE is therefore formed by the (inter)national conservation policy and legal protection status of species characteristic for river ecosystems (Lenders *et al.,* 2001). Based on this conceptual framework of the legislation aspects of biodiversity, BIO-SAFE can be divided in three main components: (1) a species database, (2) an ecotope classification typology and (3) species valuation criteria (De Nooij *et al.,* 2001).

Attuning biodiversity conservation and flood risk reduction measures, or (other) economic developments, is a major issue in applied ecology and spatial planning. Assessments with BIO-SAFE can help find an optimal balance. Because of its policy-based character, BIO-SAFE yields information that is complementary to ecological biodiversity indices, single-species habitat models and ecological network analysis. (De Nooij *et al.,* 2004).

1.2. Purpose and Objectives

The research aim of this project is to contribute to the development of an instrument for future management, assessing the biodiversity state of the Sado Estuary Natural Reserve (RNES). Thus, with the development of the new BIO-SAFE Sado version, a new tool will be created to foment the sustainable use and management of rivers in general and of the Sado Estuary in particular. In this way, the impact of the human influence in the natural system can be assessed, and thereby better management actions can be implemented for the protection and rehabilitation of the RNES ecosystem.

With this project, the central project question that is aimed to be answered is:

How can an operational version of BIO-SAFE for the Sado Estuary Natural Reserve be developed and applied, and to what extend is this BIO-SAFE version comparable to versions previously developed for the rivers Rhine, Meuse and Vistula?

The research questions are:

(1). Which are the species that may be selected for the Sado BIOSAFE version?

(2). Which are the ecotopes that may be selected for the Sado BIOSAFE version?

(3). How can the selected species be linked to the selected ecotopes?

(4). Which are the valuation criteria that will be used for the Sado BIO-SAFE version?

(5). Which indices of BIO-SAFE will be used to assess the Biodiversity conservation in the Sado River?

(6). What are the potential biodiversity values of the various riverine ecotopes of the Sado river and its estuary?

(7). What are the actual biodiversity values of the Sado river and its estuary?

(8). To what extend are the outcomes of the Sado version of BIO-SAFE comparable to those of BIO-SAFE versions for the rivers Rhine, Meuse and Vistula?

After development, BIO-SAFE Sado will be compared with other versions of the model for other rivers. The limitations will be analysed, due to the fact that, so far, the model only has been applied in north-western rivers of Europe Meuse and Rhine (The Netherlands, Germany, France and Belgium) and Vistula river (Poland), with different environmental conditions from Portugal (southwest of Europe). The input and results of the studies will be compared, in a way to assess the differences in the biodiversity conservation legislation in the different countries, also being a linkage between all the BIO-SAFE studies that have been done so far.

Therefore, this can also be a starting point to the implementation of the BIO-SAFE assessment in the southwest part of Europe, specifically in other very important rivers, like the Tejo (Tagus) and the Douro. These rivers originate in Spain and flow into the Atlantic Ocean in Portugal, crossing the Iberian Peninsula, having a considerable size and suffering many different anthropogenic pressures in the two different countries.

2. MATERIALS AND METHODS

2.1. Study Area

The Sado Estuary is the second largest in Portugal with an area of 23160 ha (Figure 2.1). It is located in the West Coast of Portugal, within a boundary box of 8°42’ W, 38°25’ N and 8°57’ W, 38°32’ N (Caeiro *et al.,* 2003).

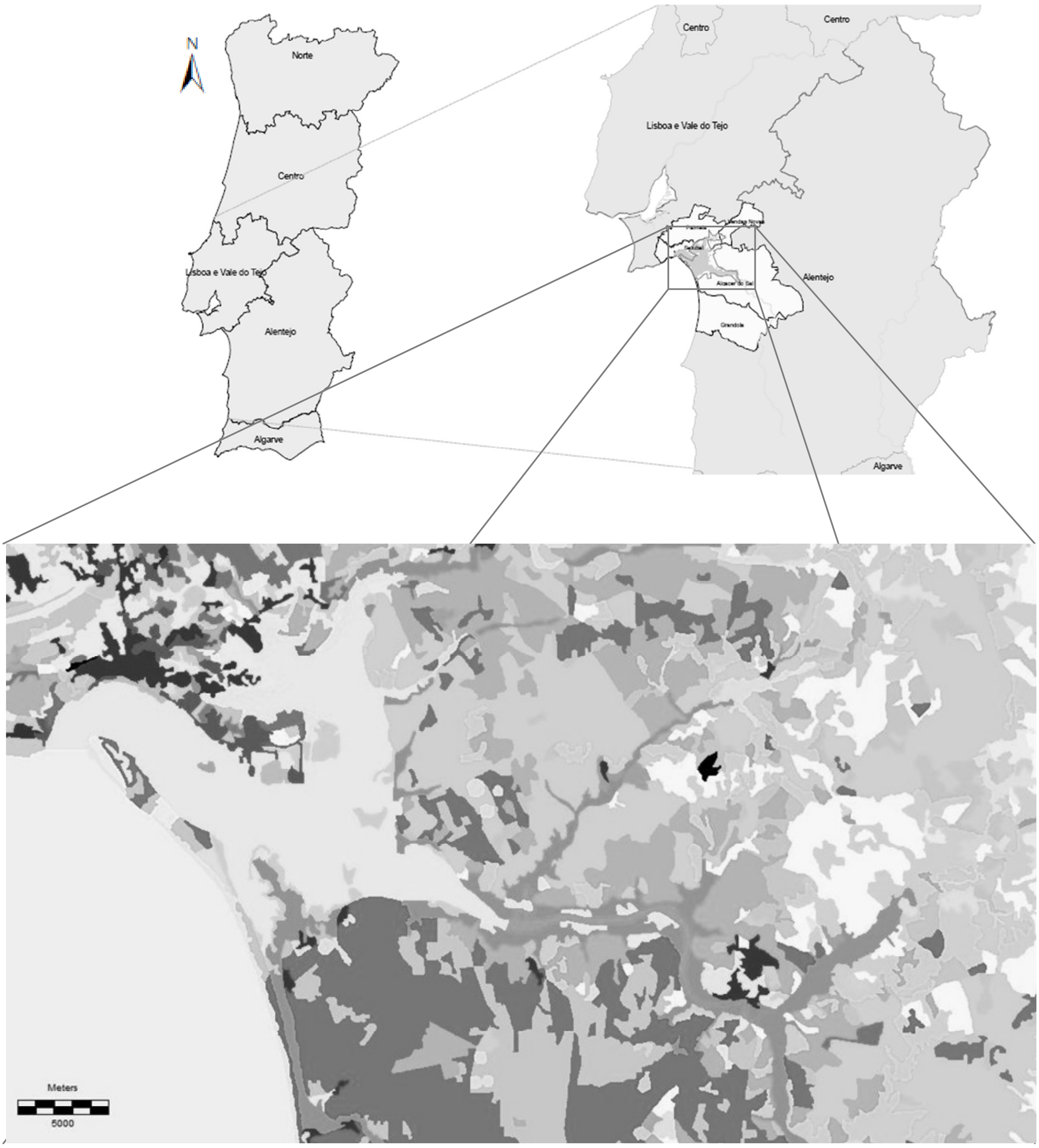

Figure 2.1: The Sado Estuary location in the national and local context (Adapted from ICN, 2007).

Most of the estuary is classified as a natural reserve but also has an important role in the local and national economy. There are many industries, mainly on the northern margin of the estuary (Caeiro *et al.,* 2002). The estuary is under the pressure of different pollution sources, including organic industries sources, thermal pollution, heavy metals pollution and chemical pollution like anti-fouling paintings on boats, urban wastewaters and agricultural water seepage with herbicides and pesticides (INAG, 1999). Furthermore, the harbour-associated activities and the city of Setúbal along with the copper mines on the Sado Watershed use the estuary for waste disposal purposes without suitable treatment. In other areas around the estuary, intensive farming, mostly rice fields, is the main land use together with traditional salt ponds and increasingly intensive fish farms (Caeiro *et al.,* 2002).

The Sado river estuary was selected as the FRAP (Framework for Biodiversity Reconciliation Action Plans) research area in Portugal, as it accounts for almost half of the existing marine fish farms in the country. The area supports an extremely important fauna, being highly valuable as wintering, nesting and feeding zone for migratory birds, also classified as a special bird protection area (EC Birds Directive) and as a Ramsar Site. Moreover, the area is included into the national list of Natura 2000 Sites (Freitas *et al.,* 2007).

The BIO-SAFE Sado version was applied the Sado Estuary Natural Reserve (RNES), which includes territories from four different counties: Setúbal, Palmela, Grândola and Alcácer do Sal (see Figure 2.2). The reserve was created by the Portuguese legislation *Decreto-Lei nº 430/80*, where the main fundamental objectives are the maintenance of his natural fitness, the correct exploitation of its resources and the protection of the cultural and scientific values (Neves *et al.,* 2004).

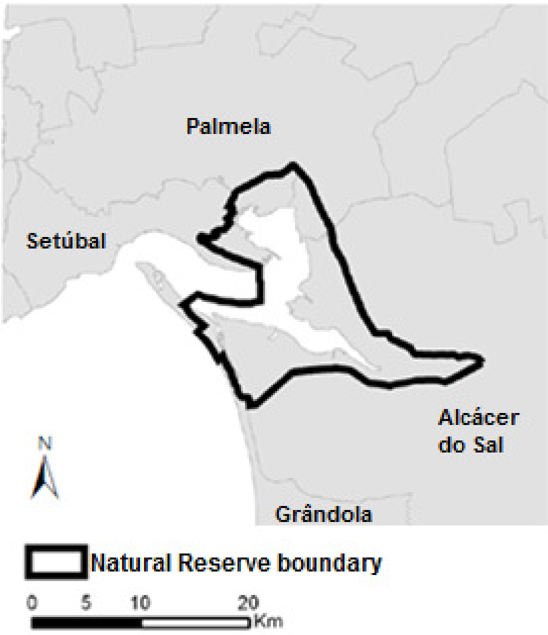

Figure 2.2: The Sado Estuary Natural Reserve boundary (adapted from Neves *et al.,* 2004)

2.2. Adaptation of the BIO-SAFE methodology to the Sado Estuary Natural Reserve

The research approach was based on the previous studies with BIO-SAFE assessment, presented in the next flow chart (Figure 2.3).

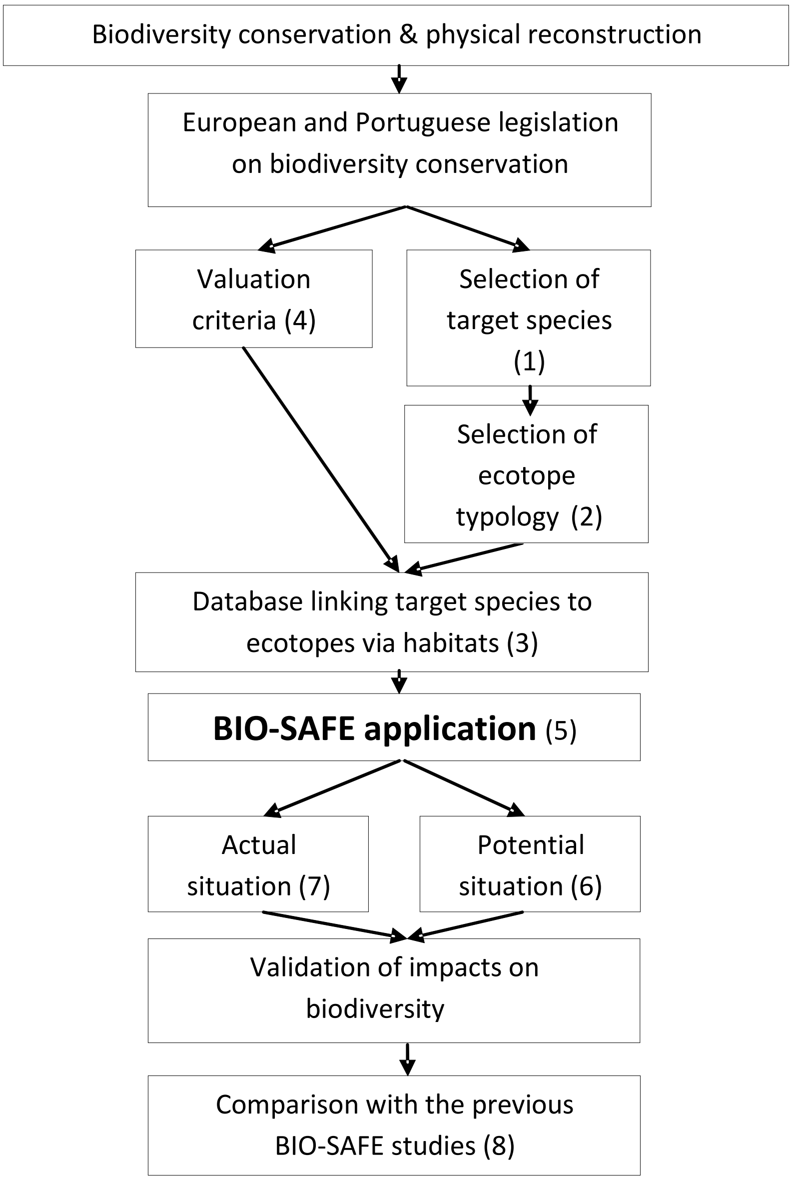

Figure 2.3: Conceptual framework of the BIO-SAFE model (adapted from De Nooij *et al.,* 2004). The numbers between brackets refer to the respective research question (see sub-chapter 1.2. "Objectives").

Following De Nooij *et al*. (2004), the first step in constructing BIO-SAFE comprises the selection of species *(1)*. Species to be selected have to be (a) relevant in terms of policy or legislation, and (b) indigenous to and characteristic of the riverine study area. The first line relates to species designated as 'protected' or 'special attention' species in international treaties and directives. This selection includes bird species mentioned in Annex I of the EU Birds Directive (Council Directive 79/409/EEC), species mentioned in Annexes II, IV or V of the EU Habitats Directive (Council Directive 92/43/EEC), species mentioned in Appendices I or II of the Bonn Convention (Intergovernmental Treaty, Bonn 1.XI.1983) and species mentioned in Appendices I, II or III of the Bern Convention (Council of Europe, Bern 19.IX.1979, European Treaty Series/104). The second line relates to nationally endangered species. In this study, this concerned species meeting the Portuguese Vertebrate Red List criteria (Cabral *et al.,* 2005) according to the International Union for Conservation of Nature (IUCN).

In order to define and value landscape ecological units within the study site, and to determine the potential value of a given area, a methodology for landscape ecological classification, an ecotope typology, is required *(2)*. This typology is used to define and value landscape ecological units within the study area. The used ecotope typology was present on ICN (2007), consisting in an ecotope typology map (1:25000) description made for the RNES. The typology is also used to link species to landscape ecological characteristics of ecosystems *(3)*. This description was mainly based on existing literature describing species characteristics and habitats. Species-specific habitat requirements were used to link the species with the ecotopes classes in the BIO-SAFE Sado ecotope typology in the database (MS Excel spreadsheet). This linkage of species to landscape–ecological units is also the basis for valuation of the biodiversity potential in a particular area since specific landscape–ecological units comprise potential habitats for (protected) species (Wozniak *et al.,* 2009).

The next step in the construction of BIO-SAFE Sado is the assignment of values to the selected species, i.e., the valuation criteria *(4)*. This qualification of the species is based on their relative differences in relevance to the policy instruments. These instruments comprised the same as for the species selection within this study. This values assignment was carried out based on the valuation made by ICN (2007), where a value was assigned to all the selected species in this study. This was made based on the instruments to which species has a conservation policy status and the applied weights to these instruments. When a policy instrument consisted of a categorical degree in the protection of species (e.g. Portuguese Vertebrate Red List, EU Habitats Directive), a distinction was made through a value distribution over these different categories.

BIO-SAFE Sado was constructed in the user-friendly spreadsheet application of Microsoft Excel®. Within this environment the species database, the ecotope typology, the valuation criteria and the indices where implemented into a functioning model. After the model had been completed, the program calculated all relevant indices and scores *(5)*.

Applying the valuation criteria led to the assignment of a *Species-specific score* (S-score) to each selected species. In order to make it possible to calculate taxonomic group level biodiversity assessments, the S-scores of species belonging to a particular taxonomic group were summed to yield a Potential Taxonomic group Biodiversity (PTB) constant *(6)*. This constant reflects the maximum score possible for the taxonomic group involved. The S-scores of the species actually present in an area were also summed, yielding an Actual Taxonomic group Biodiversity (ATB) score *(7)*. This score reflects the actual value of the area per taxonomic group. Changes of the actual and potential biodiversity values can be quantified using various indices of BIO-SAFE (Wozniak *et al.,* 2009). With the results of the indices S-score, PTB and ATB, several other types of indices that BIO-SAFE originally yields were used to valuate biodiversity potential for ecotopes (on two different levels of ecotope typology), species and taxonomic groups.

2.2.1. Biodiversity Database of the Sado Estuary Natural Reserve

The first main component of BIO-SAFE concerns the database on relevant flora and fauna species and their habitat. These species represent the nature conservation policy and legislative status of protected and endangered biodiversity. The instruments used to select the species were the Portuguese Vertebrate Red List, the EU Habitats and Birds Directives, and the Bonn and Bern Conventions.

2.2.1.1. Policy and legislation instruments used as selection criteria

The realisation of the legal framework for biodiversity conservation in Portugal and the legal scope of each specific valuation criterion will be described briefly below.

Portuguese Vertebrate Red List

On the 19th April 2006 the Portuguese Vertebrate Red List (660 pages) was presented, edited by ICN (available at portal.icn.pt). This new Red Book follows the new IUCN threatened species evaluation and classification system, as the recommendations for the application. This evaluation system by IUCN (2003) allows to estimate the probability of extinction of each species in a certain period, taking into account the past, present and future conditions. On this edition the migratory and fresh water Fishes, Amphibians, Reptiles, Birds and Mammals that live in the Portuguese territory are listed. For each species, the Red Book indicates the threat state and evaluates quantitatively the level of risk extension (Cabral *et al.,* 2005). Red Lists do not have a (direct) legal status, but are important instruments because they are readily used in day to day practice and have a strong a signal function and moral status regarding species protection. Furthermore, Red Lists form the basis for international species conservation agreements as is the case with EU Habitats Directive, Birds Directive and the Bern and Bonn Conventions (De Nooij *et al.,* 2001). The IUCN Red List methodology is described in IUCN (2001) and classifies species into eight categories on the basis of data on species abundance and trends. The Portuguese Red List was made following the Red List categories at a regional level (Figure 2.4).

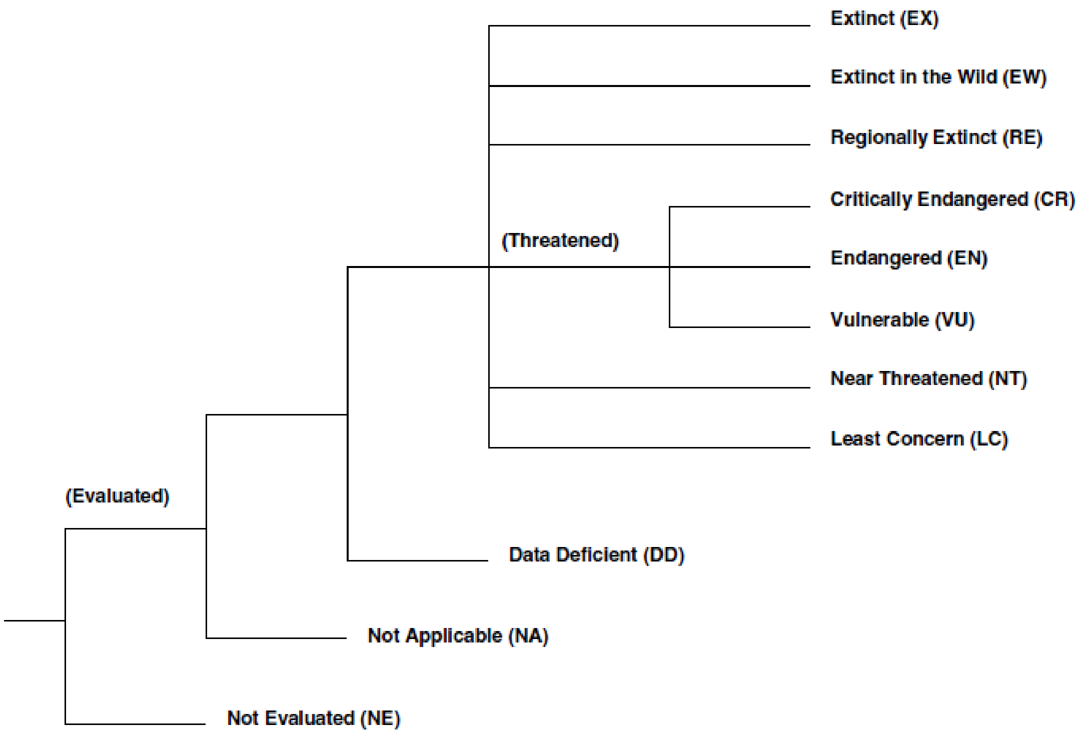

Figure 2.4: Framework of the Red List categories at a regional level, according to IUCN (2003).

The international instruments have varying legal power and scope and all of them have been transposed to the Portuguese legislation. In Table 2.1 they are characterised very roughly, in order to give some basic information.

European Habitats Directive

On the 22nd July 1992 the European Union (http://ec.europa.eu) adopted Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora, the EU Habitats Directive (EU, 1992). The provisions of the Directive require Member States to introduce a range of measures including the protection of species listed in the Annexes and to undertake surveillance of habitats and species and produce a report every six years on the implementation of the Directive.

European Birds Directive

On the 25th April 1979, the European Union adopted Council Directive 79/409/EEC on the conservation of wild birds, the EU Birds Directive (EU, 1979). The Directive provides a framework for the conservation and management of human interactions with wild birds in Europe. This document sets broad objectives for a wide range of activities, although the precise legal mechanisms for their achievement are at the discretion of each Member State. The main provision of the Directive is the maintenance of the favorable conservation status of all wild bird species across their distributional range.

Table 2.1: Some basic information on the international instruments for species conservation used in this study.

International Instrument	Publication year	Annexes	Habitat Protection	Transposition to the Portuguese legislation
European legislation				
EU Habitats Directive (Hard law)	1992	Annex II: species whose conservation requires the designation of special areas of conservation; Annex IV: species in need of strict protection; Annex V: species whose taking in the wild and exploitation may be subject to management measures.	yes	*Decreto-Lei nº 140/99* amended by *Decreto-Lei n.º 49/2005*
EU Birds Directive (Hard law)	1979	Annex I: species subject of special conservation measures concerning their habitat in order to ensure their survival and reproduction in their area of distribution.	yes	*Decreto-Lei nº 140/99*
International legislation				
Bonn Convention (Soft law)	1979	Appendix I: migratory species whose immediate protection is required; Appendix II: migratory species whose conservation and management should be covered by means of transnational agreements.	no	*Decreto nº 103/80*
Bern Convention (Soft law)	1979	Appendix I and II: strictly protected flora and fauna species, respectively; Appendix III: protected fauna species.	yes	*Decreto-Lei nº 316/89* amended by *Decreto-Lei n.º 196/90*

Bonn Convention

The Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention or CMS: www.cms.int) was adopted in Bonn, Germany, on the 23rd June 1979 and came into force in 1985. It has been amended by the Conference of the Parties in 1985, 1988, 1991, 1994, 1997, 1999, 2002, 2005 and 2008, being the last version effective since 5 March 2009, which has been the one used in this study. The aim of the Convention is to conserve migratory species and their habitats by providing strict protection for endangered migratory species (listed in Appendix I of the Convention), concluding multilateral Agreements for the conservation and management of migratory species which require or would benefit from international cooperation (listed in Appendix II), and by undertaking co-operative research activities.

Bern Convention

The Convention on the Conservation of European Wildlife and Natural Habitats (the Bern Convention: www.coe.int) was adopted in Bern, Switzerland on the 19th September 1979, and came into force in 1982. The principal aims of the Convention are to ensure conservation and protection of all wild plant and animal species and their natural habitats (listed in Appendices I and II of the Convention), to increase cooperation between contracting parties, and to afford special protection to the most vulnerable or threatened species (including migratory species), listed in Appendix III.

2.2.1.2. Selection of Species

The followed criteria for the species and habitats selection had to take into account the available data for the RNES, as well as the national and international legislations applied in Portugal. Based on Lenders *et al*. (2001) and De Nooij *et al*. (2004), the following instruments where chosen for species selection: Vertebrate Red Lists from Portugal (Cabral *et al.,* 2005), the EU Habitat Directive (Annexes II, IV or V of Council Directive 92/43/EEC), the EU Birds Directive (Annex I of Council Directive 79/409/EEC), the Bonn Convention (Appendices I and II of Intergovernmental Treaty, Bonn 1.XI.1983) and the Bern Convention (Appendices I or II of Council of Europe, Bern 19.IX.1979, European Treaty).

The selected fauna was restricted only to vertebrate species due to the scarce information and legislation related with invertebrates in Portugal and particularly in the RNES. In Table 2.2 the numbers of studied vertebrate and higher Plant species are shown, related with the legislation used as criteria for the implementation on the BIO-SAFE Sado assessment.

Higher plants

All the studied plant species were found in ICN (2007), where this taxonomic group was only evaluated by two international legal instruments due to the nonexistence of the Portuguese Red Book for Vascular Plants, which is still being conducted by ICNB.

Birds

The criterion for the selection of species was made following Elias *et al*. (2006), where a rigorous procedure was followed. Elias *et al*. (2006) have compiled information related with the birds that use the study area with one or more ecological functions (resident species and wintering, summering, nesting and feeding zone for migratory birds) with the records from successive visits to the study area, from November 1988 to April 2006, in all the different seasons. Also additional records from other observers from the same time period, as well as other old data, were added. Species that have not been seen more than 5 times in the period of study or only exist in registers previous to 1985 have been considered accidental or extinct in RNES, being considered as potential species in the BIO-SAFE Sado assessment.

Table 2.2: Legislation instrument used as criteria and number of species studied for each taxonomic group.

Taxonomic Group	Legislation instruments	Studied species
Higher plants	b, e	490
Birds	a, c, d, e	256
Reptiles	a, b, d, e	19
Amphibians	a, b, d, e	13
Mammals	a, b, d, e	42
Fish	a, b, d, e	130
Total	-	950

a: Portuguese Vertebrate Red List; b: Habitats Directive; c: Birds Directive; d: Bonn Convention; e: Bern Convention.

Reptiles and Amphibians

The herpetofauna of RNES included in ICN (2007) was studied following Loureiro *et al*. (2010), which is the most recent study done about all the reptiles and amphibians present in Portugal. This study consisted in a fieldwork from January 2003 until November 2005, where all the country was explored with the objective of mapping the distribution of amphibians and reptiles. The observations were registered by GPS in a database and applied to a map of Portugal projected in a UTM grid (10x10 km) in *Datum Europeum 1950.* The species present in the list by ICN (2007) were analysed, and considered currently present according to their presence or not on the grids where the study area is included.

Mammals

The species list was taken from ICN (2007), where the description of all the registered species was used in order to classify the actual presence in the RNES.

Fish

The historical registers of fish species that have been captured in the RNES is about 130 (Sobral, 1993; Sobral & Gomes, 1997; INAG, 1999; Cabral, 2000; ICN, 2007; Ribeiro *et al.,* 2007) but part of them are considered as accidental or occasional in the estuary (ICN, 2007).

2.2.2. Ecotope typology

A number of requirements regarding the functionality of the ecotope typology within the BIO-SAFE concept need to be met, which are (De Nooij *et al.,* 2001):

1. The typology must be underpinned by (landscape) ecological theory, because of the function of linking species to landscape;
2. The typology must provide the possibility to determine ecological potency at multiple levels of scale, following an unambiguous hierarchy;
3. The typology must be applicable in the context of estuarine and coastal management;
4. The typology must be compatible to other existing typologies in Portugal, to the typologies used in a European legislation context (e.g. for Habitats Directive) and to the CORINE Landcover project.

According to this requirements, the followed ecotope typology in the BIO-SAFE Sado was the ecotopes map (1:25000) description included in ICN (2007). This map was made based on the land use map that is also present on ICN (2007), where the different land use classes were aggregated according to the intended ecotopes. The result was the RNES ecotope typology map, with 24 different ecotopes belonging to 6 categories of habitats (see Table 2.3).

The most characteristic and important ecotopes present in the evaluation will be described briefly below.

A.2. Subtidal

The Subtidal area is the fraction of area which is influenced by the tides, but which is always covered with water, with a maximum of 5 meter of depth. This area is also characterized by the occurrence of a channels network in the low-tide (ICN, 2007). The total surface area covered by water in the estuary varies greatly during the day, depending on the tide cycle. These variations influence the distribution of some species, mainly birds whose are mainly in the water (Elias *et al.*, 2006).

Table 2.3: Ecotope typology used in BIO-SAFE Sado (following ICN, 2007).

Level 1 - Habitat type	Level 2 - Ecotopes	Description
A. Aquatic	A.1. Sea	Open sea (not included in the study area).
	A.2. Subtidal	Estuarine subtidal waters with maximum depth of 5 meters.
	A.3. Deep Waters	Estuarine subtidal waters with depth of 5 meters or over.
	A.4. Phanerogams sandbanks	Marine, intertidal and subtidal sandbanks with Phanerogams like *Zostera noltii*, *Zostera marina* and *Cymodocea nodosa*.
	A.5. Intertidal mud	Intertidal area (submerged on high tide, uncovered at low tide) without vegetation.
	A.6. Salt marsh	Halophyte vegetation that occurs mostly on the edge of the estuary.
	A.7. Salina pond	Ponds of salt production, most of them built where before there were salt marshes.
	A.8. Pisciculture	Ponds for fish farming built on old saline or other locations on the border of the estuary.
	A.9. Waterlines	Fresh water lines.
	A.10. Weirs and Fresh water bodies	Small artificial fresh water lakes.
B. Reed marsh	B.1. Reed marsh	Inland wetlands with reed vegetation (without willows).
C. Agricultural	C.1. Rice field	Fields for rice production on the edge of the estuary.
	C.2. Pasturelands and annual crops	Meadows and fields of annual crops.
	C.3. Gardens and vineyards	Fields for production of horticultural and vine.
D. Forestry	D.1. Riparian vegetation	Shrubby and/or tree vegetation around fresh water lines (mainly willows).
	D.2. Cork oak system	Fields mostly occupied by *Quercus suber* with shrubby vegetation.
	D.3. Pinewood	Fields mostly occupied by *Pinus pinaster* and *Pinus pinea* (monocultures or mixed) with shrubby vegetation.
	D.4. Permanent tree crops	Olive and fruit farms.
	D.5. Eucalypt and acacia woods	Fields with the presence of *Eucalyptus sp.* and/or acacia species (both are introduced species).
E. Dune	E.1. Dune bush	Coastal dunes with Mediterranean type bushes.
	E.2. Beach	Estuarine beaches.
F. Artificial	F.1. Buildings	Urban areas.
	F.2. Impacted	Inert-extraction areas.
	F.3. Port area	Port of Setúbal city.

A.3. Deep Waters

This ecotope differs from the previous one since it includes the areas that are always covered with water but with a depth higher than 5 meters. This also influences the distribution of species, mainly birds, since it is the area more perturbed by navigation (ICN, 2007).

A.4. Phanerogams sandbanks

This ecotope corresponds to the fraction of the water areas with marine, intertidal or subtidal phanerogams sandbanks. They are present mainly in the south part of the estuary (Tróia peninsula) and in some other sandy areas. In the intertidal areas mainly occurs *Zostera noltii*, while in the subtidal ones mainly occurs *Zostera marina* and *Cymodocea nodosa*. This ecotope has a high relevance since it is important for fish species and possibly for other faunal communities (ICN, 2007).

A.5. Intertidal mud

This ecotope includes all the area where the sediments become uncovered at the low tide. The area is mainly flat and shallow, being cut out by the deep water channels which cross the estuary. The main origin from the sediments in this ecotope is from fluvial muddy substrate (Elias *et al.*, 2006).

A.6. Salt marsh

This ecotope is characterized by shrubby vegetation which is influenced by the estuarine tides, being present in all the edge of the estuary at the intertidal areas. The shrubs are mainly composed by halophyte vegetation, which means plant species that hold up high saline waterlogging during high tide. This ecotope has an extreme high importance in depuration processes and flood retention, being also highly productive. It is used as nursery and feeding place by a great amount of fish and bird species (Elias *et al.*, 2006).

A.7. Salina pond

This is an artificial ecotope, being made mainly where before there were salt marshes, with the purpose of salt extraction. The salina ponds practically do not have any vegetation, where just a few salt marsh plant species still remain in the edge of the ponds. The major number of the salina ponds present in the Sado estuary is currently inactivated (from around 106 salina ponds only 10 are still working), and some of the abandoned ones are being used as pisciculture ponds. It was detected a large presence of invertebrate species, which leads to a huge presence of bird species using the ecotope as a feeding place, being also known as a nesting place for a large number of birds (Elias *et al.*, 2006).

A.8. Pisciculture

As said before, the pisciculture ponds are built where before there were salina ponds. Although, this ecotope do not provide the same conditions as the salina ponds, mainly because the human presence is larger and the water depth is higher. These differences lead to a slighter importance of the ecotope for bird species, where the presence of birds is much smaller than in the salina ponds. The presence of birds has been registered but only as a feeding place, where the reproduction conditions are not propitious (ICN, 2007).

A.9. Waterlines

This ecotope corresponds to the fresh water lines present in the entire study site, where the riparian vegetation is not present. The waterlines are the most important ecotope for the fresh water fish species at the RNES, also having a major importance for amphibians as a breeding place. The presence of some bird species at this ecotope is also reported as a feeding and nesting place (ICN, 2007). This ecotope has been reported as a habitat for aquatic reptiles and has a preferential feeding place for some bat species (INAG, 1999).

A.10. Weirs and fresh water bodies

This ecotope is present at the study site in different locations, having small and medium sizes (Elias *et al.*, 2006). These artificial lakes are mainly abandoned inert extraction areas full of water (ICN, 2007). Most of these fresh water lakes have been gradually colonized by small water vegetation, having a relative amount of different submerged plant species (INAG, 1999; ICN, 2007). The fauna present at the weirs vary depending on the year season, on the water level (there are records of some weirs that became completely dry in years with lower precipitation) and on the amount of vegetation (Elias *et al.*, 2006). This ecotope is the habitat of water reptiles, breeding place for amphibians and feeding and nesting place for a large amount of bird species. The presence of some mammal species has also been reported as a feeding place (INAG, 1999; ICN, 2007).

B.1. Reed marsh

The reed marsh is characterized for be present at the edge of the estuary, in the intertidal areas, where the water is less salty comparing with the salt marshes (INAG, 1999). The reed marsh does not include willows, since that vegetation is part of the edge of fresh water, being part of the ecotope *Riparian vegetation* (ICN, 2007). This ecotope is mainly composed by the reed species *Phragmites australis*, which has specific adaptation to brackish waters. This characteristic vegetation is usually dense and can reach 3 meters high. Insects are particularly frequent, partly because of the microclimatic conditions inside the dense vegetation where the temperature and humidity are higher and the wind and solar radiation are lower (Elias *et al.*, 2006). The reed marshes support a great amount of different species, with a higher importance for a great amount of bird species, using it as a nesting and/or feeding place, and the presence of some amphibian, reptile and mammal species has also been reported (INAG, 1999; Elias *et al.*, 2006; ICN, 2007).

C.1. Rice field

This ecotope is present in the edge of the estuary, in both of the margins, where irrigation channels are built to sustain this flooded cultivation. The rice fields have a huge amount of insects, becoming a great feeding place for a large number of bird species (INAG, 1999; ICN, 2007; Elias *et al.*, 2006). The use of chemicals and the abundance of the Louisiana red-crayfish *Procambarus clarki* make this ecotope less attractive for amphibians, while a major number of mammal species do not uses it frequently as a feeding place due to the absence of shelter zones (ICN, 2007).

C.2. Pasturelands and annual crops

This ecotope is also present in the edge of the entire estuary. It is mainly composed by plough and tilled soil and meadows for pasture, where some salt marsh vegetation is also present. There are records of bird species using the place as a nesting and feeding place, and some mammal species have also been reported in this ecotope (ICN, 2007).

C.3. Gardens and vineyards

The main characteristic of this ecotope is the crop of horticultural and vineyard. These fields are present in the same areas as the *pasturelands and annual crops*, being used as a feeding place by all the omnivore terrestrial vertebrate species, and specifically by species that have their diet based on fruits (ICN, 2007).

D.1. Riparian vegetation

The riparian vegetation is characterized for being at the border of fresh watercourses, mainly composed by willows. There are bird species that only reproduces at this place, among others that can also use it as a nesting place, and there are some mammal species highly related with this ecotope (ICN, 2007).

D.2. Cork oak system

This ecotope is mostly occupied by monocultures of *Quercus suber* with shrubby vegetation, occurring at all the study area, being extremely important for a huge amount of terrestrial vertebrate species. It is considered as one of the ecotopes at RNES with greatest species richness. A huge amount of bird species exclusively use this ecotope (as well as other forestry type ecotopes) as nesting and feeding place, and the shrubby vegetation has a high importance as habitat for some mammal and reptile species (INAG, 1999; Elias *et al.*, 2006; ICN, 2007).

D.3. Pinewood

The pinewood is mostly occupied by the pine species *Pinus pinaster* and *Pinus Pinea*, mainly monocultures occurring at all the study area, with the presence of shrubby vegetation (ICN, 2007). In some areas there are also mixed cultures with *Quercus suber*, although is not so common (Elias *et al.*, 2006). This ecotope also has an extremely high importance for a great amount of bird species as feeding and nesting place, being the shrubby vegetation also very important as habitat for some mammal and reptile species (INAG, 1999; Elias *et al.*, 2006; ICN, 2007).

D.4. Olive and fruit farms

This ecotope is characterized by fields with olive and fruit farms, occurring in some small areas at the study site. Like the gardens and vineyards, this ecotope is used by a large amount of omnivore terrestrial vertebrate species and particularly species that have their diet based on fruits (ICN, 2007).

D.5. Eucalypt and acacia woods

This ecotope represents the presence of the non-indigenous species *Eucalyptus sp.* and *Acacia sp.* at the study site. Although there are some large areas with this forestry type ecotope, it does not sustain a representative number of terrestrial vertebrate species (ICN, 2007). Since it is not indigenous, this ecotope was not considered as important in this study.

E.1. Dune bush

This ecotope corresponds to the Mediterranean bushes at the coastal dunes, containing the most diversified flora present in the study area (Elias *et al.*, 2006). It has an extremely high importance for some terrestrial reptile species, being also the habitat of small mammals. The diversity of bird species is lower in this ecotope (Elias *et al.*, 2006; INAG, 2007).

E.2. Beach

This ecotope is characterized for the estuarine beaches, with different kinds of sand, all located in the south part of the study area (Tróia peninsula). It contains just a few adapted plant species, where some reptiles have been reported. Bird species which use water as a feeding place need this ecotope to rest and the usage as a nesting place by other bird species have been reported (ICN, 2007).

F.1. Buildings

In the study area there are several human settlements with many different characteristics. The city of Setúbal and the touristic complex at Tróia sustain some bird species which use buildings as a nesting place. There are some other small villages present at RNES, but apparently they are not important for bird communities (Elias *et al.*, 2006).

2.3. BIO-SAFE model description

The BIO-SAFE assessments comprise four different types of analyses and use of input data: (a) valuations of ecotopes and transitions between ecotopes, (b) valuation of the actual situation, (c) scenario analysis and (d) trend analysis. In this study only the assessment types (a) and (b) were applied. BIO-SAFE Sado was developed from the latest *2.0* version of BIO-SAFE, of which the main improvement was the calculation inclusion of the ecotope importance value for each species, and not only for the group of species (taxon), which is present in both considered assessments (a) and (b). The two BIO-SAFE Sado types of assessments will be described briefly below.

2.3.1. Types of assessments

Valuations of ecotopes and transitions between ecotopes

Policy values were assigned to ecotopes on the basis of their importance as habitats for species individually, for the studied birds, fish, reptiles, amphibians, mammals and higher plants. This comprises the potential occurrence of species, meaning that a valuation can be performed without data on actual species presence. These values are calculated per taxon and, on the BIO-SAFE Sado version, also per species. Based on this quantified importance of the ecotopes, the effects of transitions between ecotopes can be calculated.

Valuation of the actual situation

Data on presence of species and ecotopes in the study area were valuated regarding the taxonomic group level, species level, ecotopes level and the landscape level. This assessment can be used in cases of spatial planning, for instance in the extension of harbour facilities (De Nooij *et al.,* 2001). For landscapes and ecotopes the degree of biodiversity saturation can be calculated. Aggregation of valuation results can be done across levels of biological organisation by averaging the values for the separate species groups to one index.

2.3.2. Index and score calculation

The two types of assessments that were done with BIO-SAFE Sado are primarily based on two constants. These constants comprise the *S-scores* of the species and the *Taxonomic group Ecotope Importance* constant (TEI) of the ecotopes.

To every species selected a value was assigned on the basis of its conservation policy status by summation of the values assigned to the criteria applicable to a species. Within BIO-SAFE the term that refers to this value concerns the *Species-specific* score or S-score (Lenders *et al.,* 2001).

In order to make it possible to calculate taxonomic group level biodiversity assessments, the S-scores of species belonging to a particular taxonomic group were summed to yield a *Potential Taxonomic group Biodiversity* (PTB) constant (Figure 2.5). This constant reflects the maximum score possible for the taxonomic group involved. Later, for each ecotope type, the S-scores were summed, yielding a *Potential Taxonomic group Ecotope* (PTE) constant (Figure 2.5). Subsequently, this PTE constant was related to the PTB constant, resulting in a *Taxonomic group Ecotope Importance* constant (TEI), ranging from 0 to 100 per ecotope type (Equation 1). This TEI constant reflects the importance of an ecotope type with respect to conservation values for species belonging to a particular taxonomic group. Aggregation across levels of spatial scale can be done using the hierarchy defined by the ecotope typology (see Table 2.3) or by summation of TEI constants (see Figure 2.5).

$$TEI_x = \frac{PTE_x \times 100}{PTB_x} \qquad (1)$$

TEI_x = Taxonomic group Ecotope Importance constant for ecotope type x

PTE_x = Potential Taxonomic group Ecotope constant for ecotope type x

PTB = Potential Taxonomic group Biodiversity constant for ecotope type x

The value of the *Species Ecotope Importance* score (SEI) represents the importance of an ecotope type with respect to conservation values for each species. In BIO-SAFE Sado this value ranges from 0 to 0.83 for the fauna taxonomic groups and ranges from 0 to 0.41 for the higher plants group. To calculate it, the S-score for each ecotope type was related with the summation of all PTB values for each taxonomic group (equation 2), in order to assess the ecotope importance for each species relatively to all the studied species (see Figure 2.5).

$$SEI_x = \frac{S\text{-}score_x \times 100}{\sum PTB} \quad (2)$$

SEI_x = Species Ecotope Importance for ecotope type x

$S\text{-}score_x$ = Species-specific score for ecotope type x

PTB = Potential Taxonomic group Biodiversity constant

Valuation of ecotopes and transitions between ecotopes

Using these TEI constants and SEI scores, ecotope values can be calculated for the two levels of ecotope typology (see Table 2.3). It can be done per species group or all groups (TEI) or per species individually (SEI).

Using TEI constants of the different ecotopes, it is possible to evaluate the transition of one ecotope into another. This can be done by calculating the value shift of the ecotopes as follows:

$$\Delta\, TEI_{ecotope\ 1 \rightarrow 2} = TEI_{ecotope\ 2} - TEI_{ecotope\ 1} \quad (3)$$

TEI_x = Taxonomic group Ecotope Importance constant for ecotope type x (where ecotope 1 became ecotope 2)

Valuation of the actual situation

Data on the actual presence of species in a particular area can be used to calculate two types of indices, one at the taxonomic group level and one at the ecotope level. These are respectively the *Actual Taxonomic group Biodiversity* score (ATB) and the *Actual Taxonomic group Ecotope score* (ATE).

For calculating the ATB score, the S-scores of the species actually present in an area are summed. This score reflects the actual value of the area per taxonomic group. This ATB constant and the Potential Taxonomic group Biodiversity (PTB) can be used to calculate the *Taxonomic group Biodiversity Saturation* (TBS) indices, that ranges from 0 to 100 (equation 4). The mean value of all the calculated TBS values gives the *Biodiversity Saturation index* (BS), representing the overall saturation value for all the considered biodiversity in the study area. The TBS and BS indices offer insight into the degree to which the maximum expected biodiversity value per taxonomic group has actually been achieved in a particular area (see Figure 2.5).

$$TBS_x = \frac{ATB_x \times 100}{PTB_x} \tag{4}$$

TBS_x = Taxonomic group Biodiversity Saturation index for taxonomic group x

ATB_x = Actual Taxonomic group Biodiversity score for taxonomic group x

PTB_x = Potential Taxonomic group Biodiversity constant for taxonomic group x

For the second index type, the S-scores for each taxonomic group, assigned to the preferred ecotopes of species actually present, were summed up per ecotope type, yielding an *Actual Taxonomic group Ecotope* score (ATE). The ATE score reflects the actual legal value of each ecotope present in an area with respect to its significance for individual taxonomic groups .This ATE score was related to the PTE constant, resulting in a *Taxonomic group Ecotope Saturation* (TES) index per ecotope type, ranging from 0 to 100 (equation 5). The TES index reflects the degree to which the maximum possible value of an ecotope for a particular taxonomic group has been achieved in the actual situation (see Figure 2.5).

$$TES_x = \frac{ATE_x \times 100}{PTE_x} \tag{5}$$

TES_x = Taxonomic group Ecotope Saturation index for ecotope x

ATE_x = Actual Taxonomic group Ecotope score for ecotope x

PTE_x = Potential Taxonomic group Ecotope constant for ecotope x

By multiplying TES with the Taxonomic group Ecotope Importance constant (TEI) of the concerning ecotope type, a score results that yields the *Actual Taxonomic group Ecotope Importance* score (ATEI). ATEI gives insight into the legal significance of a particular ecotope type for a specific taxonomic group and can never be higher than the TEI constant (see Figure 2.5)

$$ATEI_x = \frac{TES_x \times TEI_x}{100} = \frac{ATE_x \times 100}{PTB_x} \tag{6}$$

$ATEI_x$ = Actual Taxonomic group Ecotope Importance for ecotope x

TES_x = Taxonomic group Ecotope Saturation index for ecotope x

TEI_x = Taxonomic group Ecotope Importance constant for ecotope x

ATE_x = Actual Taxonomic group Ecotope score for ecotope x

PTB = Potential Taxonomic group biodiversity constant for ecotope type x

The value of the *Actual Species Ecotope Importance* score (ASEI) can also be reached, which represents the importance of an ecotope type with respect to conservation values for each species actually present In BIO-SAFE Sado this value ranges from 0 to 0.83 for the fauna taxonomic groups and ranges from 0 to 0.41 for the higher plants group. To calculate it, the S-score for each ecotope type, concerning just the species actually presents, was related with the summation of all PTB values for each taxonomic group (equation 7), in order to assess the ecotope importance for each actual species relatively to all the studied species (see Figure 2.5).

$$ASEI_x = \frac{S\text{−}score_x \times 100}{\sum PTB} \quad (7)$$

$ASEI_x$ = Actual Species Ecotope Importance for ecotope type x

S-$score_x$ = Species-specific score (for species actually present) for ecotope type x

PTB = Potential Taxonomic group Biodiversity constant

The biodiversity indices that BIO-SAFE Sado calculates and their mutual relationships are described below in Figure 2.5 (according to De Nooij *et al.,* 2001, 2004). The decisions and steps that must be taken during a BIO-SAFE Sado assessment are given in Figure 2.6.

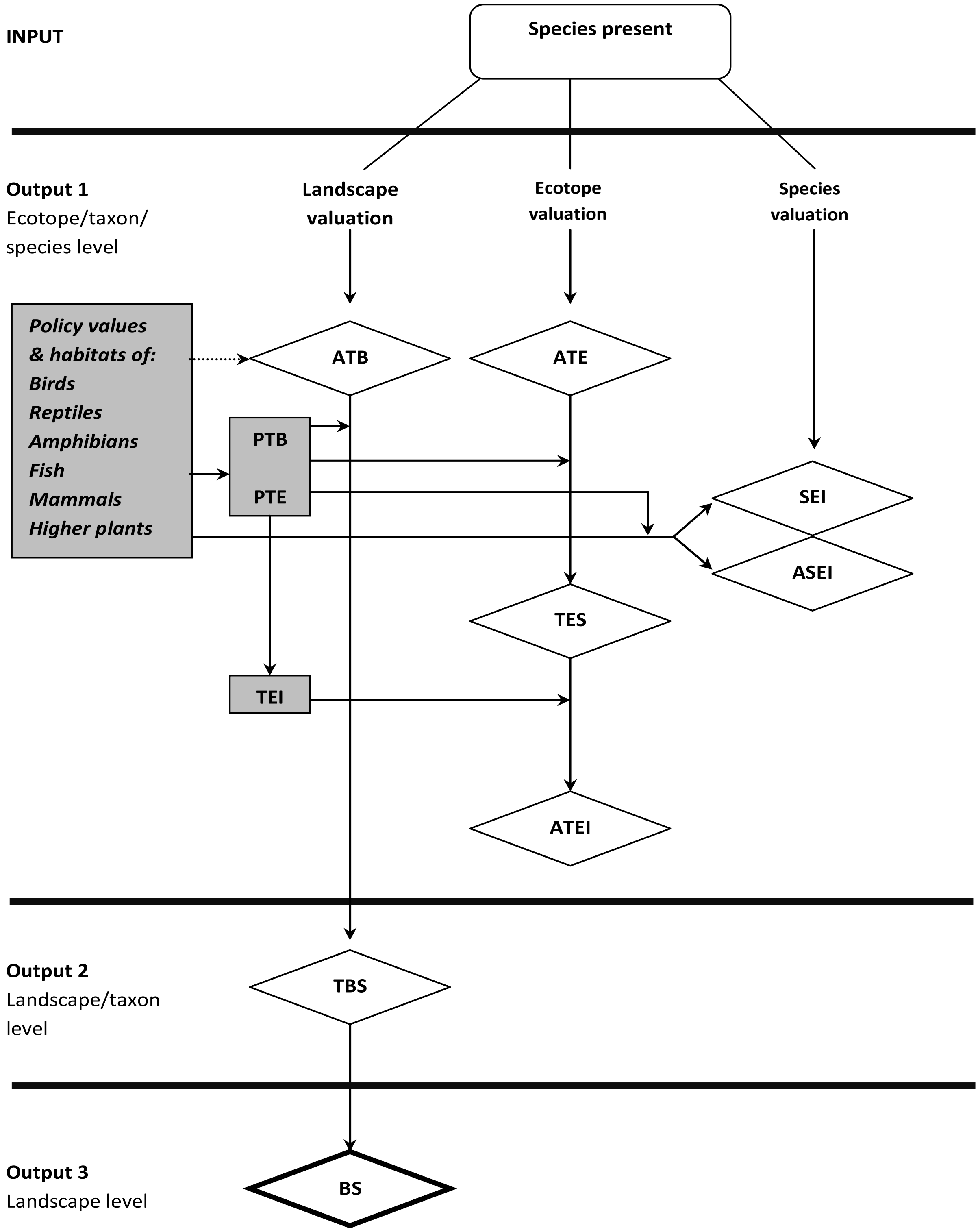

Figure 2.5: Input-output relationships and indices of BIO-SAFE Sado (modified after De Nooij *et al.,* 2001) (shaded boxes: constants in the database; diamonds: indices that result from BIO-SAFE calculations when input data is processed).

Abbreviations Figure 2.5

TEI: **T**axonomic group **E**cotope **I**mportance constant, importance of each ecotope per taxon (0-100)

ATB: **A**ctual **T**axonomic group **B**iodiversity score for a taxonomic group

PTB: **P**otential **T**axonomic group **B**iodiversity constant for a taxonomic group

TES: **T**axonomic group **E**cotope **S**aturation index for an ecotope

ATE: **A**ctual **T**axonomic group **E**cotope score for an ecotope

PTE: **P**otential **T**axonomic group **E**cotope constant for an ecotope

ATEI: **A**ctual **T**axonomic group **E**cotope **I**mportance score, actual importance each ecotope per taxon (0-100)

TBS: **T**axonomic group **B**iodiversity **S**aturation index, actual value of the area per taxon (0-100)

TES: **T**axonomic group **E**cotope **S**aturation index, actual value of each ecotope per taxon (0-100)

SEI: **S**pecies **E**cotope **I**mportance score, importance of each ecotope per species

ASEI: **A**ctual **S**pecies **E**cotope **I**mportance score, actual importance each ecotope per species

BS: **B**iodiversity **S**aturation index, degree of realisation of biodiversity potential of the area (0-100)

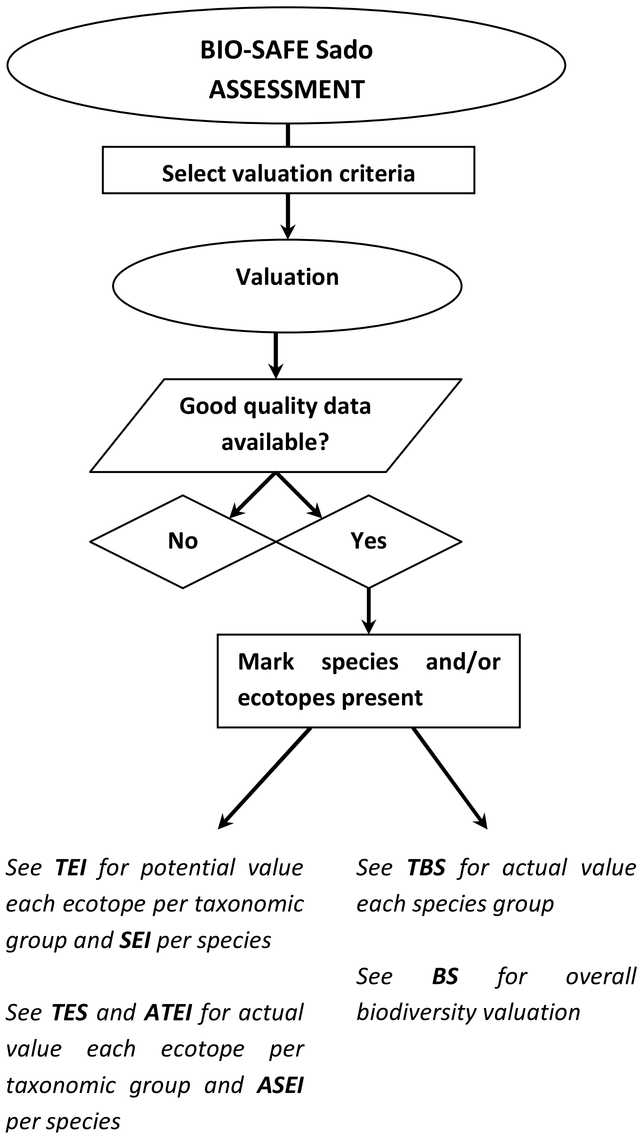

Figure 2.6: Flowchart for BIO-SAFE Sado assessments (after De Nooij *et al.*, 2001).

3. RESULTS

3.1. Species selection

The instruments used to select the species were the Portuguese Vertebrate Red List, the EU Habitats and Birds Directives, and the Bonn and Bern Conventions. The number of selected species by taxonomic group for the BIO-SAFE Sado evaluation, following the criteria previously described, can be found in Table 3.1, as well as the actual or potential presence in the RNES and the number of those species considered "Priority Conservation Species" in the Annex II of both EU Habitats and Birds Directives.

Table 3.1: Number of selected species meeting the selection criteria, their presence status (actual or potential) and their priority valuation on the Annex II of the EU Habitats and Birds Directives.

Taxonomic Group	Number of species meeting criteria	Priority species	Actual Species	Potential species
Higher plants	22	4	13	9
Birds	206	7	194	12
Reptiles	19	0	16	3
Amphibians	13	0	9	4
Mammals	32	1	26	6
Fish	16	1	15	1
Total	308	13	273	35

3.2. Weight distribution over valuation criteria

Following the BIO-SAFE procedures in De Nooij *et al*. (2001) and Lenders *et al*. (2001), the quantification of species policy status was based on policy instruments that are considered indicators for the status of the species selected in policy and legislation (valuation criteria). In order to express politically and legally based biodiversity values in quantitative terms and to compare biodiversity values for various species, relative weights were assigned to the conservation instruments (see Figure 3.1).

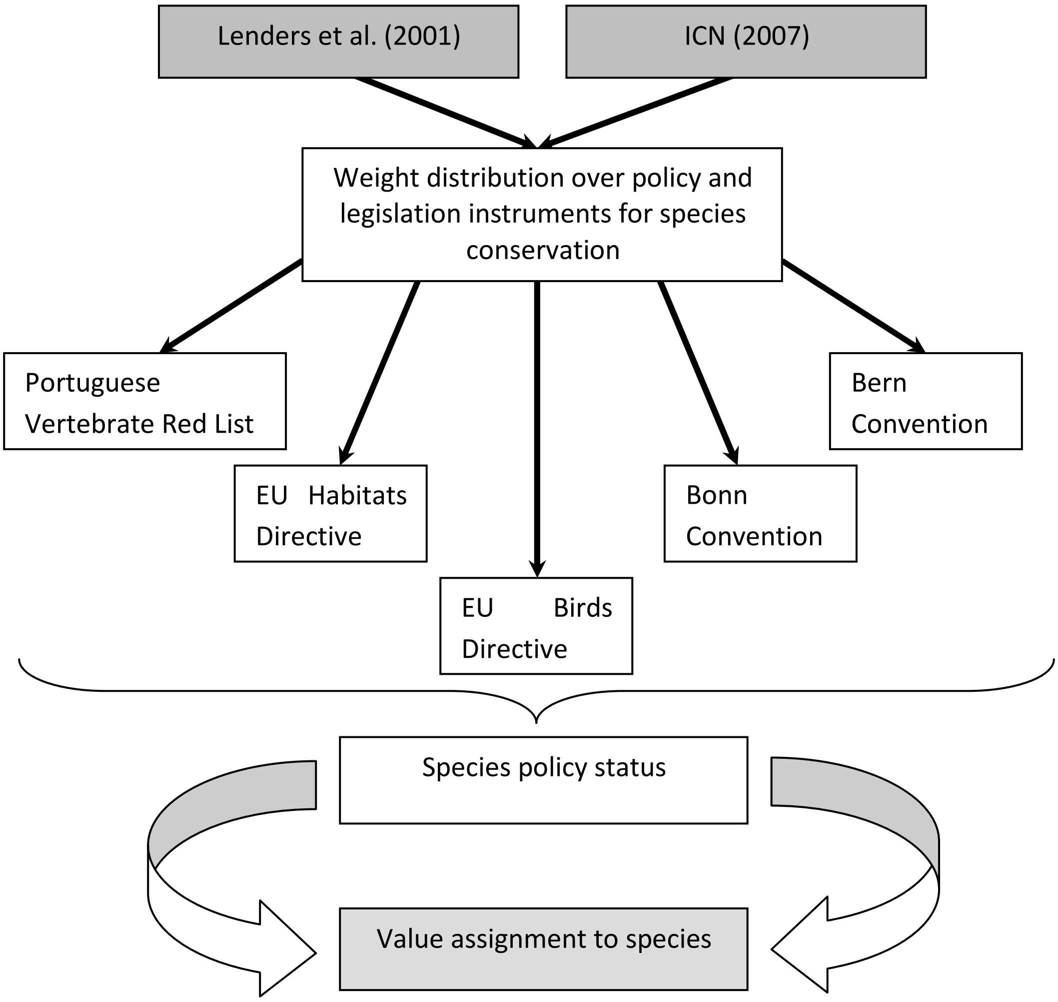

Figure 3.1: Schematic representation of weight distribution and value assignment to species used in BIO-SAFE Sado (adapted from De Nooij *et al.,* 2001).

The main weight distribution used in the BIO-SAFE Sado was adapted from the valuation made by ICN (2007), where the assigned values are present in Table 3.2. This evaluation considers the five different categories of the national Vertebrate Red List with distinct values assignment, dependently on the category of threat for the concerned species. The priority species (PS) on the Annex II of both EU birds and Habitats Directives are more valued than the other species in the same Annex. Species present on the Bern Convention are higher valued if present in Appendix I and II than those present in Appendix III. The valuation made by ICN (2007) does not take into account the Bonn Convention, so, following the criteria of the BIO-SAFE version by Lenders *et al*. (2001), the weight of the Bern and Bonn conventions are the same, so this criterion was used in the BIO-SAFE Sado version.

Based on this weight distribution, a total of 30 points was assigned to the different criteria, as presented in Table 3.2, implicating that the maximum score per species in the BIO-SAFE Sado version was set to be 30. However, the flora is not evaluated by the national Red List and is neither taken in consideration in the Bonn Convention. Due to this, it should be denoted that the higher plants can only have a maximum score per species of 15.

Table 3.2: The valuation criteria applied and their weight distribution (30 points) based on Lenders *et al.* (2001) and ICN (2007).

Criteria	Value assigned	Comments
Portuguese Vertebrate Red List[a]	(10 max)	Species are classified into different categories of threat based on data concerning rarity and trend.
EX, EW or RE	10	
CR	10	
EN	10	
VU	8	
NT	6	
EU Birds Directive[b]	(10 max)	Applicable to birds only, other species are mentioned in EU Habitats Directive.
Annex I (PS*)	10	
Annex I	8	
EU Habitats Directive[c]	(10 max)	Applicable to all species except birds, which are mentioned in EU Birds Directive.
Annex II only (PS*)	10	
Annex II only	9	
Annex IV only	7	
Annex V only	5	
Annex II (PS*) and IV or V	10	
Annex II and IV or V	9	
Annex IV and V	7	
Annex II (PS*), IV and V	10	
Annex II, IV and V	9	
Bonn Convention[d]		
Appendix I or II	5	
Bern Convention[e]	(5 max)	
Appendix I or II	5	
Appendix III	2	
Sum	*30*	*Maximum score according to fauna species policy status*
	15	*Maximum score according to flora species policy status*

*PS: Priority Species;

[a] Portuguese Vertebrate Red List criteria - EX: “Extinct", EW: "Extinct in the Wild", RE: “Regionally Extinct”, CR: "Critically endangered", EN: “Endangered“, VU: “Vulnerable” and NT: "Near Threatened".

[b] Annex I: species that are subject of special conservation measures concerning their habitat in order to ensure their survival and reproduction in their area of distribution.

[c] Annex II: species whose conservation requires the designation of special areas of conservation; Annex IV: species in need of strict protection; Annex V: species whose taking in the wild and exploitation may be subject to management measures.

[d] Appendix I: migratory species whose immediate protection is required; Appendix II: migratory species whose conservation and management should be covered by means of transnational agreements.

[e] Appendix I and II: strictly protected flora and fauna species, respectively**;** Appendix III: protected fauna species.

3.3. Linkage between species and the ecotope typology

Higher plants

The reports from ICN (2006) and INAG (1999) were used for the linkage between ecotopes and species.

Birds

The linkage between the actual species and their ecotopes was made following INAG (1999), and complemented with the study of Elias *et al*. (2006). The linkage for the potential species was made following INAG (1999) and complemented with the IUCN red data list available online (BirdLife International, 2008a, b, c, d; BirdLife International, 2009a, b, c, d, e, f, g, h).

Reptiles and Amphibians

The linkage between the reptiles species and their ecotopes was made following the study of Loureiro *et al*. (2010) and IUCN (2010) where the detailed information was found (ICN, 2006; Vogrin *et al.,* 2008; Slimani *et al.,* 2008; Pleguezuelos et tal., 2008a, b, c, d; Sá-Sousa, 2010; Carretero, 2010a, b; Miras *et al.,* 2008a, b, c, d; Sá-Sousa *et al.,* 2010; Pleguezuelos & Brito, 2010; Corti *et al.,* 2008; Santos, 2010; Martínez-Solano *et al.,* 2008). The linkage between the amphibians species and the ecotopes was made following the IUCN red data list available online (Beja *et al.,* 2008a, b, c, d; Kuzmin *et al.,* 2008; Arntzen *et al.,* 2008a, b; Bosch *et al.,* 2008a, b; Denoël *et al.,* 2008; Crespo *et al.,* 2010; Agasyan *et al.,* 2008; Soares, 2010; Kaya *et al.,* 2008; Donaire-Barroso *et al.,* 2008).

Mammals

The study of Franco (1996) was used to the linkage between bat species and their ecotopes, and the information from IUCN (2010) was used to complement it (Stubbe *et al.,* 2008; Hutson *et al.,* 2008a, b, c, d, e; Aulagnier *et al.,* 2008a; Juste *et al.,* 2008). The linkage of all the other species was made using the information of ICN (2007) and INAG (1999), and was also complemented by the IUCN data available online (Masseti & Mertzanidou, 2008; Aulagnier *et al.,* 2008b, c, d, e; Bertolino *et al.,* 2008; Amori *et al.,* 2008; Herrero & Cavallini, 2008; Cavallini & Palomares, 2008; Ruiz-Olmo *et al.,* 2008; Tikhonov *et al.,* 2008a, b; Kranz *et al.,* 2008; Fernandes *et al.,* 2008a, b; Smith & Boyer, 2008; Hammond *et al.,* 2008; Hutson *et al.,* 2008f, g, h; Jacobs *et al.,* 2008; Driscoll & Nowell, 2008; Smith & Johnston, 2008; von Arx & Breitenmoser-Wursten, 2008; Gonçalves, 2010).

Fish

The ecotope linkage for the species was made using the information from Ribeiro *et al*. (2007) and ICN (2007).

3.4. Results of BIO-SAFE Sado application

In this section the results of application of BIO-SAFE Sado to the RNES are presented. Application concerned policy and legislation based biodiversity assessment, taken all valuation criteria into account.

3.4.1. Valuation of ecotopes and transitions between ecotopes

BIO-SAFE Sado calculated the values for each ecotope that reflect the importance of an ecotope type with respect to nature conservation policy and legislation based values for species belonging to a particular taxonomic group (TEI; see equation 1). The results for TEI constant (0 - 100) per species group and for all groups (summation) are presented in Table 3.3 for the habitat type, the higher spatial level studied.

Table 3.3: TEI constants (0 - 100) for Habitat type per taxonomic group and for all groups (sum of correspondent TEI values) according to the valuation strategy (highest scores per taxonomic group are in bold).

Level 1 - Habitat type	TEI-HP	TEI-BI	TEI-HF	TEI-MA	TEI-FI	TEI-TOTAL
A. Aquatic	7	**82**	59	32	**100**	**281**
B. Reed marsh	22	19	58	30	0	129
C. Agricultural	0	60	**84**	61	0	205
D. Forestry	**57**	39	**94**	**90**	0	**280**
E. Dune	**56**	16	**89**	**92**	0	**253**
F. Artificial	0	2	17	40	0	59

Abbreviations: Taxonomic group Ecotope Importance (TEI), higher plants (HP), birds (BI), herpetofauna (HF), mammals (MA), fish (FI)

In this first assessment, it is possible to conclude which are the most important habitat types for each taxonomic group, where the mean value shows that in a general evaluation there are three most important habitats types. First, with the highest overall TEI value (281) the Aquatic types, since these include the most important ecotopes for the birds (TEI value of 82) and, obviously, the fish group (TEI value of 100). After, the Forestry habitat types, having almost the highest overall TEI value (280), where these includes the highest TEI values for the higher plants and herpetofauna (57 and 94 respectively) and being also very important for the mammals groups with one of the highest TEI values (90). The third most important habitat present in RNES is the Dune type, with the highest TEI value for mammals (92) and the second highest value for higher plants and herpetofauna (56 and 89 respectively). The Agricultural type also has a great importance for the herpetofauna, where the TEI value was quite high (84).

The first assessment gave one general idea of the type of habitats where the biodiversity is more endangered, but not specifically by each ecotope. Next, the results for TEI constants (0 - 100) per species group and for all groups are presented in Table 3.4 for the ecotopes level.

Table 3.4: TEI constants (0 - 100) for ecotopes level per taxonomic group and for all groups (sum of correspondent TEI values) according to the valuation strategy (highest scores are in bold).

Level 2 - Ecotope type	TEI-HP	TEI-BI	TEI-HF	TEI-MA	TEI-FI	TOTAL
A.2. Subtidal	0	55	2	6	58	122
A.3. Deep Waters	0	1	2	6	58	68
A.4. Phanerogams sandbanks	0	0	2	0	58	60
A.5. Intertidal mud	0	**73**	2	3	0	78
A.6. Salt marsh	7	**76**	2	18	0	103
A.7. Salina pond	0	**68**	0	11	0	79
A.8. Pisciculture	0	30	15	18	0	64
A.9. Waterlines	0	8	58	20	**91**	178
A.10. Weirs and Fresh water bodies	0	41	59	29	0	129
B.1. Reed marsh	22	19	58	30	0	129
C.1. Rice field	0	50	12	15	0	77
C.2. Pasturelands and annual crops	0	23	**84**	57	0	164
C.3. Gardens and vineyards	0	9	59	32	0	99
D.1. Riparian vegetation	19	13	62	42	0	136
D.2. Cork oak system	32	26	75	**87**	0	**220**
D.3. Pinewood	31	27	74	**87**	0	**218**
D.4. Permanent tree crops	0	17	0	32	0	49
D.5. Eucalypt and acacia woods	0	1	42	83	0	125
E.1. Dune bush	**56**	9	**89**	**92**	0	**245**
E.2. Beach	12	8	19	2	0	41
F.1. Buildings	0	2	17	40	0	59
F.2. Impacted	0	0	0	0	0	0
F.3. Port area	0	0	0	0	0	0

Abbreviations: Taxonomic group Ecotope Importance (TEI), Higher plants (HP), Birds (BI), Herpetofauna (HF), Mammals (MA), Fish (FI)

As said before, the most important habitat types for birds are the aquatic ones, and from Table 3.4 it is possible to conclude that this is particularly for the ecotopes Intertidal mud, Salt marsh and Salina ponds, since they have the highest TEI values (73, 76 and 68 respectively). For the fish group the higher importance in the aquatic ecotope goes to the Waterlines (TEI value of 91), which represents the fresh-water ecotopes present in the RNES.

For the higher plants, herpetofauna and mammals the Dune bushes have the highest importance with the highest values of the TEI constant in each taxonomic group (56, 89 and 92 respectively). It should also be denoted that for herpetofauna the ecotope Pasturelands and annual crops also has a high importance (TEI value of 84) and for mammals both ecotopes Cork oak system and Pinewood are also extremely important with the second highest TEI value (both 87).

In a general overview, the sum of the TEI values for each ecotope from all taxonomic groups shows that the most important ecotopes in the RNES are the Dune bushes (summation of 245) and the Cork oak system and Pinewood ecotopes also have a high importance (summation of 220 and 218, respectively).

Based on the given TEI values, the effect of a transition between ecotopes can be evaluated by calculating the change of the TEI values between ecotopes (see equation 3). As said before, two of the most important ecotopes for birds are the Salt marshes and the Salina ponds. In the RNES, most of the Salina ponds are built in Salt marshes, as well as the Pisciculture ponds and the Rice fields. These two are also made in old Salina ponds (INAG, 1999; Elias *et al.*, 2006). The ecotope transition assessment concerning the birds TEI values for the referred ecotopes is presented in Table 3.5.

Table 3.5: Valuation of ecotope transition concerning birds TEI values (positive changes are in bold).

Birds	**New ecotopes**			
Original ecotopes	A.6. Salt marsh	A.7. Salina pond	A.8. Pisciculture	C.1. Rice field
A.6. Salt marsh	-	-8	-46	-26
A.7. Salina pond	**8**	-	-38	-18
A.8. Pisciculture	**46**	**38**	-	**20**
C.1. Rice field	**26**	**18**	-20	-

The results presented in Table 3.5 shows that for birds every transition to Salt marshes has a positive effect, as well as the transitions from Pisciculture ponds and Rice fields to Salina ponds and from Pisciculture ponds to Rice fields. Contrastingly, the transitions into Pisciculture ponds always have a negative effect on the potentials for protected and endangered birds. Also the transitions from Salt marshes to Salina ponds and to Rice fields, as well as from Salina ponds to Rice fields have a negative effect on birds concerned in this study. It should also be remarked that the relative score differences regarding the transitions are more pronounced when referring to the transitions involving the ecotope Pisciculture (values equal and higher than 20) and are not so worrying in the transitions between Salina ponds and Salt marshes (value lower than 10).

The SEI score (equation 2) represents the importance of one ecotope type with respect to each species (ranging from 0 to 0.83 for the fauna taxonomic groups and from 0 to 0.41 for the higher plants group). Table 3.6 shows the most endangered and protected species per taxonomic group (highest S-score), which corresponds the highest SEI values.

Table 3.6: Species with the highest S-score per taxonomic group (0-15 for higher plants; 0-30 for vertebrate fauna groups) and the respective Species Ecotope Importance score (SEI; 0-0.83 for fauna, 0-0.41 for flora).

Taxonomic Group	**Species with the highest S-score**	**SEI**
Higher plants	*Armeria rouyana* (15) *Jonopsidium acaule* (15) *Linaria ficalhoana* (15) *Thymus camphoratus* (15)	0.41
Birds	*Aythya nyroca* (30) *Hieraaetus fasciatus* (30) *Aquila adalberti* (30) *Botaurus stellaris* (30)	0.83
Reptiles	*Mauremys leprosa* (14)	0.39
Amphibians	*Discoglossus galganoi* (20)	0.55
Mammals	*Rhinolophus mehelyi* (29) *Rhinolophus euryale* (29)	0.80
Fish	*Acipenser sturio* (27)	0.75

Abbreviations: Species-specific score (S-score)

The maximum S-score is reached in the higher plants group (15) by four different species, and in the birds group is reached (30) by four species as well. This indicates that the ecotopes where these higher plants and bird species are present obtain the highest SEI value (0.41 and 0.83, respectively). Herpetofauna does not reach high SEI values, being 0.39 for reptiles and 0.55 for amphibians, due to the low S-scores of reptiles and amphibians (14 and 20, respectively). Two Mammal species and one fish almost reach the maximum S-score possible (29 and 27, respectively) which leads to high SEI values (0.80 and 0.75 respectively).

In order to assess the critical species in each ecotope, table 3.7 shows the species with the highest SEI values per ecotope.

Table 3.7: Presence of the species with the highest Species Ecotope Importance score (SEI) in each ecotope.

Ecotope type	SEI value	Species name(s)	Taxonomic group
A.2. Subtidal	0.83	*Aythya nyroca*	Birds
	0.75	*Acipenser sturio*	Fish
A.3. Deep Waters	0.75	*Acipenser sturio*	Fish
A.4. Phanerogams sandbanks	0.75	*Acipenser sturio*	Fish
A.5. Intertidal mud	0.83	*Aythya nyroca* *Hieraaetus fasciatus*	Birds
A.6. Salt marsh	0.83	*Aythya nyroca* *Hieraaetus fasciatus*	Birds
A.7. Salina pond	0.83	*Hieraaetus fasciatus*	Birds
A.8. Pisciculture	0.83	*Hieraaetus fasciatus*	Birds
A.9. Waterlines	0.39	*Mauremys leprosa*	Reptiles
	0.55	*Discoglossus galganoi*	Amphibians
	0.75	*Acipenser sturio*	Fish
A.10. Weirs and Fresh water bodies	0.83	*Hieraaetus fasciatus* *Aquila adalberti* *Botaurus stellaris*	Birds
	0.39	*Mauremys leprosa*	Reptiles
	0.55	*Discoglossus galganoi*	Amphibians
B.1. Reed marsh	0.83	*Aquila adalberti* *Botaurus stellaris*	Birds
	0.39	*Mauremys leprosa*	Reptiles
	0.55	*Discoglossus galganoi*	Amphibians
C.1. Rice field	0.83	*Hieraaetus fasciatus*	Birds
C.2. Pasturelands and annual crops	0.83	*Botaurus stellaris*	Birds
	0.55	*Discoglossus galganoi*	Amphibians
	0.80	*Rhinolophus euryale*	Mammals
C.3. Gardens and vineyards	0.55	*Discoglossus galganoi*	Amphibians
	0.80	*Rhinolophus euryale*	Mammals
D.1. Riparian vegetation	0.83	*Aquila adalberti*	Birds
	0.39	*Mauremys leprosa*	Reptiles
	0.55	*Discoglossus galganoi*	Amphibians
D.2. Cork oak system	0.41	*Armeria rouyana* *Jonopsidium acaule*	Higher Plants
	0.83	*Aquila adalberti*	Birds
	0.80	*Rhinolophus euryale*	Mammals
D.3. Pinewood	0.41	*Armeria rouyana* *Jonopsidium acaule* *Thymus camphoratus*	Higher Plants

Ecotope type	SEI value	Species name(s)	Taxonomic group
D.3. Pinewood (cont.)	0.83	*Hieraaetus fasciatus* *Aquila adalberti*	Birds
	0.80	*Rhinolophus euryale*	Mammals
D.4. Permanent tree crops	0.83	*Aquila adalberti*	Birds
	0.80	*Rhinolophus euryale*	Mammals
D.5. Eucalypt and acacia woods	-	-	-
E.1. Dune bush	0.41	*Armeria rouyana* *Jonopsidium acaule* *Linaria ficalhoana* *Thymus camphorates*	Higher Plants
	0.83	*Aquila adalberti*	Birds
	0.55	*Discoglossus galganoi*	Amphibians
	0.80	*Rhinolophus mehelyi* *Rhinolophus euryale*	Mammals
E.2. Beach	0.41	*Linaria ficalhoana*	Higher Plants
F.1. Buildings	-	-	-
F.2. Impacted	-	-	-
F.3. Port area	-	-	-

Table 3.7 shows that the most endangered species at the aquatic ecotopes are clearly birds and, logically, fish species. The Weirs and fresh water bodies ecotope type is the one with the largest number of highly endangered species, with the presence of three different bird species, one reptile and one amphibian. Reed marshes are also important for four highly protected species (two birds, one reptile and one amphibian species), but the forestry type ecotopes Cork oak system and Pinewood support a total amount of six different highly endangered species (three higher plants, two birds and one mammal species). Although, the ecotope that sustain the largest number of highly endangered species at the study site is the Dune bushes type, with a total amount of eight different highly protected species (four higher plants, one bird, one amphibian and two mammal species).

3.4.2. Valuation of the actual situation

Valuations of the actual situation, on the basis of species data, concern the level of the whole study area (TBS and BS indices) as well as the level of ecotopes (TES index), corresponding to the results presented on Table 3.8 and Table 3.9, respectively.

Table 3.8: Taxonomic group Biodiversity Saturation indices (TBS; 0-100) for all studied taxonomic groups.

	Higher plants	Birds	Herpetofauna	Mammals	Fish	BS
TBS index	59	89	70	70	84	74

Abbreviations: Biodiversity Saturation index (BS), representing the mean value of all the TBS values

From Table 3.8 it can be concluded that the indices calculated differ greatly between fauna and flora. The higher plants index is the smaller (59), which indicates that the endangered and protected plant species have a bigger difference between the values of potential (PTB) and actually present species (ATB), comparing to the fauna taxonomic groups. The values for birds and fish are the highest (89 and 84 respectively), while the value for herpetofauna and mammals is the same, being slightly lower (70). The overall mean value of the biodiversity saturation indices (BS) in the RNES is 74.

Table 3.9 lists the TES indices and ATEI scores for the taxonomic groups involved. These figures give an impression of the degree to which the potential value of each ecotope type has been achieved (TES) and of the actual value of ecotopes (ATEI) in the RNES.

With the results presented in Table 3.9 it is possible to conclude that some ecotope types in the RNES are saturated up to a relatively high degree and should be conserved if possible. The presence of saturation index of 100 (maximum) for some ecotopes, in four different taxonomic groups (higher plants, birds, herpetofauna and mammals), indicates that only species actually present, belonging to that taxonomic group, are present in that ecotopes, and which means that the values of the TEI index and the ATEI score are the same. This shows that it is possible for at least some ecotopes and for some taxonomic groups to reach full saturation, where some special attention should be paid to that ecotope types. For instance, the ecotope Beach always has high values of the TES index (100 and 95) in the related taxonomic groups, but regarding the respective TEI/ATEI values it is not a very valuable ecotope type (low TEI/ATEI values). These example show that in assessing the political and legal value of ecotope types, both the ecotope saturation indices (TES) and the ecotope importance score (ATEI) should be taken into consideration.

Concerning higher plants, the ecotope types Pinewood and Beach have the maximum possible value of TES index (100), but the ATEI constant is low in both cases (31 and 12, respectively), so none of them has a high importance for this taxonomic group. The Dune bushes ecotope type is the most important ecotope type concerning the higher plants group with the highest ATEI value (48), which is regarded in its quite high saturation score (87).

Table 3.9: Taxonomic group related ecotope saturation indices (TES; 0-100) and actual taxonomic group related ecotope importance indices (ATEI; zero to corresponding TEI constant) of the RNES for all the taxonomic groups involved per ecotope type (highest ATEI scores are in bold).

	HP		BI		HF		MA		FI	
Ecotope type	**TES**	**ATEI**	**TES**	**ATEI**	**TES**	**ATEI**	**TES**	**ATEI**	**TES**	**ATEI**
A.2. Subtidal	0	0	96	53	100	2	100	6	73	43
A.3. Deep Waters	0	0	100	1	100	2	100	6	73	43
A.4. Phanerogams sandbanks	0	0	0	0	100	2	0	0	73	43
A.5. Intertidal mud	0	0	97	**71**	100	2	100	3	0	0
A.6. Salt marsh	50	4	97	**74**	100	2	100	18	0	0
A.7. Salina pond	0	0	97	**65**	0	0	100	11	0	0
A.8. Pisciculture	0	0	100	30	47	7	100	18	0	0
A.9. Waterlines	0	0	100	8	60	35	78	16	83	**75**
A.10. Weirs and Fresh water bodies	0	0	89	36	59	35	84	24	0	0
B.1. Reed marsh	0	0	82	16	60	35	100	30	0	0
C.1. Rice field	0	0	94	47	100	12	100	15	0	0
C.2. Pasturelands and annual crops	0	0	63	15	64	**53**	77	44	0	0
C.3. Gardens and vineyards	0	0	44	4	59	35	78	25	0	0
D.1. Riparian vegetation	39	7	91	12	61	38	76	32	0	0
D.2. Cork oak system	77	25	85	22	67	**50**	73	**64**	0	0
D.3. Pinewood	100	31	89	24	66	**48**	73	**64**	0	0
D.4. Permanent tree crops	0	0	56	10	0	0	78	25	0	0
D.5. Eucalypt and acacia woods	0	0	100	1	96	40	72	60	0	0
E.1. Dune bush	87	**48**	48	4	66	**58**	68	**62**	0	0
E.2. Beach	100	12	100	8	95	18	100	2	0	0
F.1. Buildings	0	0	100	2	100	17	85	34	0	0
F.2. Impacted	0	0	0	0	0	0	0	0	0	0
F.3. Port area	0	0	0	0	0	0	0	0	0	0

Abbreviations: Actual Taxonomic group Ecotope Importance (ATEI), Taxonomic group Ecotope Saturation (TES), Higher plants (HP), Birds (BI), Herpetofauna (HF), Mammals (MA), Fish (FI)

For birds, herpetofauna and mammals, a considerable number of ecotopes reach the maximum of the saturation value (TES), and a few more have higher values very close to the maximum. Nevertheless, it is very important to take into account the value of the ATEI score. For these three taxonomic groups, the most important ecotope types for the species actually present (higher ATEI scores) are in concordance with the previous TEI index values (Table 3.4). For birds and herpetofauna the highest ATEI score belongs to the Dune bushes (48 and 58, respectively) and it is the second highest in the mammals group (62). In this last taxonomic group, the most important ecotopes are the Cork oak system and Pinewood, which have the highest ATEI value (both 64).

As far as herpetofauna is concerned, the two most important ecotope types are the Dune bushes (as said before) and Pasturelands and annual crops (ATEI value of 53), which is in agreement with the TEI values (Table 3.4). However, it should be noticed that the ATEI scores for the ecotopes Pinewood and Cork oak system are also high (48 and 50, respectively), being close enough to the values of the two most important ecotopes for this taxonomic group to be considered as well as very important ecotope types, taking in consideration the actually present species of herpetofauna.

Saturation index of ecotopes concerning fish is highest for the Waterlines ecotope (83), as well as the value of the ATEI score (75). This is due to the fact that the more endangered and protected fish species are the fresh-water and the migratory ones, thus further valuing the fresh water ecotopes comparing to the saltwater ones.

The values which represent the importance of an ecotope type with respect to conservation values for each species actually present, the Actual Species Ecotope Importance score (ASEI), ranging from 0 to 0.83 in the fauna taxonomic groups and from 0 to 0.41 in the higher plants group, are presented in Table 3.10.

From Table 3.10 it is possible to conclude that the ASEI values are the same as the SEI scores (Table 3.6) for the taxonomic groups higher plants, birds and reptiles. Note that in the birds group two of the four species (*Aquila adalberti* and *Botaurus stellaris*) are not present in the ASEI results, since they are only potential species, not actually present.

Comparing with the SEI scores (Table 3.6), the amphibians, mammals and fish groups show a decrease on the value of the highest S-score, being 12, 27 and 21, respectively, which consequently decreases the value of the ATEI score (0.33, 0.75 and 0.58, respectively). This is due to the fact that the highly endangered and protected species in these three groups are potential species, not actually present in the RNES.

Table 3.10: Species with the highest S-score per taxonomic group (0-15 for higher plants; 0-30 for vertebrate fauna groups) and the respective Actual Species Ecotope Importance score (ASEI; 0-0.83 for fauna, 0-0.41 for flora).

Taxonomic Group	Species with the highest S-score	ASEI
Higher plants	*Armeria rouyana* (15) *Jonopsidium acaule* (15) *Linaria ficalhoana* (15) *Thymus camphoratus* (15)	0.41
Birds	*Aythya nyroca* (30) *Hieraaetus fasciatus* (30)	0.83
Reptiles	*Mauremys leprosa* (14)	0.39
Amphibians	*Bufo calamita* (12) *Hyla arborea* (12) *Pelobates cultripes* (12)	0.33
Mammals	*Miniopterus schreibersii* (27) *Myotis myotis* (27) *Rhinolophus ferrumequinum*(27)	0.75
Fish	*Petromyzon marinus* (19)	0.52
	Chondrostoma lusitanicum (21)	0.58

Abbreviations: Species-specific score (S-score)

In order to assess the critical species actually present in each ecotope, table 3.11 shows the species with the highest ASEI values per ecotope.

As said before, the ASEI values are the same as the SEI scores for the higher plants and reptiles groups, while the birds group does not contain two of the four species since they are not actually present. The amphibians, mammals and fish taxonomic groups have different actually present highly endangered protected species. Like this, table 3.11 shows once again that the most endangered species at the aquatic ecotopes are birds and fish species, but there are some amphibian species that are actual species which are present at some aquatic ecotopes. The Waterlines and the Weirs and fresh water bodies are the aquatic ecotope types with the largest number of highly endangered species, with the presence of six different species each one. Reed marshes and Riparian vegetation are also important ecotope types for four highly protected herpetofauna species (one reptile and three amphibian species), but the forestry type ecotopes Cork oak system and Pinewood support a total amount of seven different highly endangered species (three higher plants, one birds and three mammal species). Still, like in the previous assessment with the potential values, the ecotope that sustain the largest number of actually present highly endangered species at the study site is the Dune bushes type, with a total amount of ten different highly protected species (four higher plants, three amphibian and three mammal species).

Table 3.11: Presence of the species with the highest Actual Species Ecotope Importance score (ASEI) in each ecotope.

Ecotope type	ASEI value	Species name(s)	Taxonomic group
A.2. Subtidal	0.83	*Aythya nyroca*	Birds
	0.52	*Petromyzon marinus*	Fish
A.3. Deep Waters	0.52	*Petromyzon marinus*	Fish
A.4. Phanerogams sandbanks	0.52	*Petromyzon marinus*	Fish
A.5. Intertidal mud	0.83	*Aythya nyroca* *Hieraaetus fasciatus*	Birds
A.6. Salt marsh	0.83	*Aythya nyroca* *Hieraaetus fasciatus*	Birds
A.7. Salina pond	0.83	*Hieraaetus fasciatus*	Birds
A.8. Pisciculture	0.83	*Hieraaetus fasciatus*	Birds
	0.33	*Hyla arborea*	Amphibians
A.9. Waterlines	0.39	*Mauremys leprosa*	Reptiles
	0.33	*Bufo calamita* *Hyla arborea* *Pelobates cultripes*	Amphibians
	0.58	*Chondrostoma lusitanicum*	Fish
A.10. Weirs and Fresh water bodies	0.83	*Hieraaetus fasciatus*	Birds
	0.39	*Mauremys leprosa*	Reptiles
	0.33	*Bufo calamita* *Hyla arborea* *Pelobates cultripes*	Amphibians
B.1. Reed marsh	0.39	*Mauremys leprosa*	Reptiles
	0.33	*Bufo calamita* *Hyla arborea* *Pelobates cultripes*	Amphibians
C.1. Rice field	0.83	*Hieraaetus fasciatus*	Birds
	0.33	*Bufo calamita* *Hyla arborea*	Amphibians
C.2. Pasturelands and annual crops	0.33	*Bufo calamita* *Hyla arbórea*	Amphibians
	0.75	*Rhinolophus ferrumequinum*	Mammals
C.3. Gardens and vineyards	0.55	*Bufo calamita* *Hyla arbórea*	Amphibians

Ecotope type	ASEI value	Species name(s)	Taxonomic group
C.3. Gardens and vineyards (cont.)	0.80	*Rhinolophus euryale*	Mammals
D.1. Riparian vegetation	0.39	*Mauremys leprosa*	Reptiles
	0.33	*Bufo calamita* *Hyla arborea* *Pelobates cultripes*	Amphibians
D.2. Cork oak system	0.41	*Armeria rouyana* *Jonopsidium acaule*	Higher Plants
	0.75	*Miniopterus schreibersii* *Myotis myotis* *Rhinolophus ferrumequinum*	Mammals
D.3. Pinewood	0.41	*Armeria rouyana* *Jonopsidium acaule* *Thymus camphoratus*	Higher Plants
	0.83	*Hieraaetus fasciatus*	Birds
	0.75	*Miniopterus schreibersii* *Myotis myotis* *Rhinolophus ferrumequinum*	Mammals
D.4. Permanent tree crops	-	-	-
D.5. Eucalypt and acacia woods	0.75	*Miniopterus schreibersii* *Myotis myotis* *Rhinolophus ferrumequinum*	Mammals
E.1. Dune bush	0.41	*Armeria rouyana* *Jonopsidium acaule* *Linaria ficalhoana* *Thymus camphorates*	Higher Plants
	0.55	*Bufo calamita* *Hyla arborea* *Pelobates cultripes*	Amphibians
	0.75	*Miniopterus schreibersii* *Myotis myotis* *Rhinolophus ferrumequinum*	Mammals
E.2. Beach	0.41	*Linaria ficalhoana*	Higher Plants
F.1. Buildings	0.75	*Rhinolophus ferrumequinum*	Mammals
F.2. Impacted	-	-	-
F.3. Port area	-	-	-

3.5. BIO-SAFE Sado assessment with the Portuguese Red Data List as valuation criteria

In order to assess the biodiversity of the RNES from the perspective of the Portuguese Red Data List only, the BIO-SAFE Sado assessment was applied to the same species and ecotope typology, but only using the Portuguese Vertebrate Red List as valuation criteria (see Table 3.2). Right away, this causes the omission of the higher plants taxonomic group, and in the five vertebrate taxonomic groups the number of assessed species decreases (Table 3.12).

Table 3.12: Number of selected species meeting the new valuation criteria and their presence status (actual or potential).

Taxonomic Group	Number of species meeting criteria	Actual Species	Potential species
Birds	68	57	11
Reptiles	4	4	0
Amphibians	2	0	2
Mammals	10	5	5
Fish	8	7	1
Total	92	73	19

Table 3.12 shows the number of endangered species that are included in the Vertebrate Red Data List of Portugal in the near threatened (NT), threatened (VU, CR or EN) or extinct categories (RE, EW or EX) with a valuation weight (see Table 3.2). This means that a considerable number of Vertebrates, although included in the international instruments that were transposed to the Portuguese legislation, are not considered endangered in the RNES. There are also species not included in the Vertebrate Red Data List of Portugal, which were only evaluated by the previously applied international legislation instruments. This comprises just 13 bird species and 5 fish species of all the vertebrates in RNES, also meaning that all the herpetofauna and mammal species assessed in BIO-SAFE Sado are included in the Portuguese Red Data List for Vertebrates.

For this valuation criteria only the TEI index at the ecotope level (Table 3.13) and the TES and ATEI scores (Table 3.14) were calculated, where the results are in concordance with the main applied valuation criteria, previously presented. The results for TEI constant (0 - 100) per species group and for all groups are presented in Table 3.13 for the ecotopes level, following the new valuation criteria.

Table 3.13: TEI constants (0 - 100) for ecotopes level per taxonomic group and for all groups (sum of correspondent TEI values) according to the Red List valuation strategy (highest scores are in bold).

Level 2-Ecotope type	TEI-BI	TEI-HF	TEI-MA	TEI-FI	TOTAL
A.2. Subtidal	59	0	0	85	144
A.3. Deep Waters	3	0	0	62	65
A.4. Phanerogams sandbanks	0	0	0	62	62
A.5. Intertidal mud	**78**	0	0	0	78
A.6. Salt marsh	**79**	0	0	0	79
A.7. Salina pond	**67**	0	0	0	67
A.8. Pisciculture	28	15	0	0	43
A.9. Waterlines	6	30	10	**100**	146
A.10. Weirs and Fresh water bodies	49	30	10	0	89
B.1. Reed marsh	24	30	0	0	54
C.1. Rice field	49	0	0	0	49
C.2. Pasturelands and annual crops	26	80	48	0	153
C.3. Gardens and vineyards	11	30	19	0	60
D.1. Riparian vegetation	9	30	31	0	70
D.2. Cork oak system	23	**100**	**88**	0	**211**
D.3. Pinewood	25	**100**	**88**	0	**213**
D.4. Permanent tree crops	17	0	19	0	36
D.5. Eucalypt and acacia woods	0	50	88	0	138
E.1. Dune bush	10	**100**	**100**	0	**210**
E.2. Beach	6	70	0	0	76
F.1. Buildings	0	0	19	0	19
F.2. Impacted	0	0	0	0	0
F.3. Port area	0	0	0	0	0

Abbreviations: Taxonomic group Ecotope Importance (TEI), Higher plants (HP), Birds (BI), Herpetofauna (HF), Mammals (MA), Fish (FI)

Despite the absence of the international legislation as part of the valuation criteria, the results for the BIO-SAFE Sado assessment presented in Table 3.13, taking in consideration just the Vertebrate Red Data List as valuation strategy, are mostly the same for the TEI values comparing with the previous used valuation criteria (see Table 3.4). For the birds group the three most important ecotopes remain the Intertidal mud, salt marshes and Salina ponds (TEI values 78, 79 and 67, respectively), for mammals also remain the Dune bushes, Cork oak system and Pinewood (TEI values 100, 88 and 88, respectively) and for fish species the Waterlines ecotope remain the most important one (TEI value of 100). The herpetofauna is the only group were the most important ecotope types changed lightly, remaining the Dune bushes (TEI value of 100) but where the Cork oak system and Pinewood ecotopes gained a slight importance, being also the TEI value of both the maximum score (100). The existence of the highest possible TEI score (100) in some ecotope types indicates that those ecotopes are linked to all the studied species of the related taxonomic group where the value is found. In a general overview, the sum of the TEI values for each ecotope, from all taxonomic groups, shows that the most important ecotopes in the RNES are the Dune bush, the Cork oak system and Pinewood types (summation of 210, 211 and 213, respectively).

In a way to assess the actual situation, following the new valuation criteria for the taxonomic groups involved, the results for the TES indices and ATEI scores were determined and are presented in Table 3.14.

Comparatively with the ATEI scores from the main BIO-SAFE Sado assessment criteria (Table 3.9), the ATEI values present in Table 3.14 indicate that the most important ecotope types in the RNES remain the same for the actually present bird species, where the ecotopes Intertidal mud, Salt marshes and Salina ponds have the highest ATEI values (72, 73 and 61, respectively), consequently having high TES values (93, 93 and 92, respectively). The Subtidal ecotope type had an importance increase, having now a ATEI score of 56 and TES value of 95, owning an high importance in this valuation strategy assessment concerning with the birds group. For the fish group the ecotope Waterlines remains the ecotope with the highest ATEI score (86) to which corresponds the same TES value.

Concerning the groups mammals and herpetofauna, the ATEI and TES scores have a lower embracement, since it only include 5 mammal species and 4 reptiles species (see Table 3.12), which led to a very small ecotope type coverage. Because of this, these results should be analyzed carefully. For herpetofauna only six ecotopes were assessed, where the ecotope types Cork oak system, Pinewood, Dune bush and Beach have the highest presented ATEI score (70). For the mammals group only nine ecotopes were covered, where the Cork oak system, Pinewood and Dune bush types obtained the highest ATEI score (45).

Table 3.14: Taxonomic group related ecotope saturation indices (TES; 0-100) and actual taxonomic group related ecotope importance indices (ATEI; zero to corresponding TEI constant) of the RNES for all the taxonomic groups involved per ecotope type following the Red List valuation strategy (highest ATEI scores are in bold).

	BI		HF		MA		FI	
Ecotope type	**TES**	**ATEI**	**TES**	**ATEI**	**TES**	**ATEI**	**TES**	**ATEI**
A.2. Subtidal	95	**56**	0	0	0	0	57	49
A.3. Deep Waters	100	3	0	0	0	0	78	49
A.4. Phanerogams sandbanks	0	0	0	0	0	0	78	49
A.5. Intertidal mud	93	**72**	0	0	0	0	0	0
A.6. Salt marsh	93	**73**	0	0	0	0	0	0
A.7. Salina pond	92	**61**	0	0	0	0	0	0
A.8. Pisciculture	90	25	0	0	0	0	0	0
A.9. Waterlines	100	6	0	0	0	0	86	**86**
A.10. Weirs and Fresh water bodies	75	37	0	0	0	0	0	0
B.1. Reed marsh	70	17	0	0	0	0	0	0
C.1. Rice field	82	40	0	0	0	0	0	0
C.2. Pasturelands and annual crops	33	8	63	50	55	26	0	0
C.3. Gardens and vineyards	10	1	0	0	38	7	0	0
D.1. Riparian vegetation	64	5	0	0	31	10	0	0
D.2. Cork oak system	48	11	70	**70**	51	**45**	0	0
D.3. Pinewood	55	14	70	**70**	51	**45**	0	0
D.4. Permanent tree crops	30	5	0	0	38	7	0	0
D.5. Eucalypt and acacia woods	0	0	100	50	51	45	0	0
E.1. Dune bush	29	3	70	**70**	45	**45**	0	0
E.2. Beach	100	6	100	**70**	0	0	0	0
F.1. Buildings	0	0	0	0	50	10	0	0
F.2. Impacted	0	0	0	0	0	0	0	0
F.3. Port area	0	0	0	0	0	0	0	0

Abbreviations: Actual Taxonomic group Ecotope Importance (ATEI), Taxonomic group Ecotope Saturation (TES), higher plants (HP), birds (BI), herpetofauna (HF), mammals (MA), fish (FI)

4. DISCUSSION

4.1. Components of BIO-SAFE Sado

Species selection

The species selected for incorporation into BIO-SAFE Sado have a certain status in policy and legislation, and are characteristic for the Sado Estuary Natural Reserve area. For this list only indigenous species were selected, as well as species which the RNES has been confirmed as a migratory, feeding and/or nesting area.

The amount of higher plants species that were assessed by BIO-SAFE Sado is extremely low (22) taking into account the total number of species that is reported for the area (490). This is mainly due to the absence of the Portuguese Red Data List for Plants, which led to the selection and valuation criteria for this taxonomic group based only on the international policy and legislation instruments.

The fauna taxonomic groups assessed in BIO-SAFE Sado was restricted to Vertebrate species only, since the national Red Data List is, so far, applied only to the vertebrate fauna. Furthermore, the lack of data on the records of invertebrate species in the RNES area is also relevant. Still there are some important groups, like the macro-invertebrates (e.g. polychaetes, crustaceans, bivalves, molluscs, dragonflies and damselflies), of which species are not mentioned in present Portuguese Red Data List.

The fish group has a higher number of species recorded, but the estuary is considered as an occasional or accidental local for a large number of these species. Only marine species that have been confirmed to use the estuary as a migratory or reproductive place were included in the BIO-SAFE Sado assessment. All the fresh-water protected species reported were also assessed in this study.

The higher number of bird species reflects the importance of the RNES area concerning this taxonomic group, being the most representative vertebrate group present in the study area. This great number of bird species, compared with the species number of all the other groups, means that it is relatively easy to score some points, but difficult to obtain a full saturation. An assessment using birds is therefore less sensitive to data quality and has more resolution when comparing areas or ecotopes. Model output concerning this group has a high resolution as compared to the other species groups. However, biodiversity assessments cannot be restricted to birds alone, since other taxonomic groups use different habitats which would be disregarded if not taken into consideration in the assessments.

Ecotope typology

The landscape classification typology used in the study was the ecotopes map (1:25000) description present in the Sado Estuary Natural Reserve Management Plan (ICN, 2007). This typology was chosen since it is in agreement with all the requisites of the BIO-SAFE approach for the ecotope typology, being also a very recent specific classification for the study area. In addition, the categorization of the area was in agreement with the main literature review that was made for the linkage between species and the ecotopes, which was a point of extreme importance for the choice of this classification map. The ecotope Sea (A.1.) was not included in the study area, and the Eucalypt and acacia woods (D.5.) was not taken in consideration for the final valuation since it is not an indigenous ecotope type in the RNES.

Within BIO-SAFE, the typology is used to link species to landscape ecological characteristics. The linkage between the species and the ecotope typology was made based on an extensive literature review, where for some taxonomic groups, namely mammals, herpetofauna and some bird species, the consulted literature (IUCN, 2010) has a general character for the related species. In the other cases, the higher plants, most of the bird species and the fish groups were linked using specific literature for the Sado Estuary (INAG, 1999; ICN, 2006, 2007; Elias *et al.,* 2006; Ribeiro *et al.,* 2007). However, the determination of these relationships should be validated by specialists in the field of the relevant taxonomic groups and/or the Sado Estuary ecology.

Valuation criteria

The weights assigned to the selected policy and legislation instruments (valuation criteria) were primarily based on the valuation made in the Sado Estuary Natural Reserve Management Plan (ICN, 2007). In this report a different valuation method was used, but also using some legislation and policy instruments with weighted evaluation criteria. Afterwards, to complement and adapt correctly the valuation criteria to the BIO-SAFE assessment, the procedure and the missing values present in Lenders *et al*. (2001) were used.

The two lines of valuation of policy status (Red List and international instruments) are complementary. For instance, if a species is protected by the Habitats Directive, this means there is an international agreement regarding the conservation of this species. It does not mean the species is actually rare, endangered or shows a negative trend concerning population size and/or area of distribution in the country of concern. On the other hand, a rare and/or endangered species is not always necessarily protected. Therefore the fact that a species is also on the Red List, or not, provides extra information that should be included in the assessment (De Nooij *et al.,* 2001).

BIO-SAFE can easily support a multiple approach of valuation criteria to a single case study, enabling different views according to different objectives. With the assessment made only with the national legislation used in this study (Portuguese Vertebrate Red Data List) as valuation criteria, it was possible to have a different perspective about the legislation that concerns endangered species in Portugal.

4.2. Application of BIO-SAFE Sado

First of all, it must be remarked that the BIO-SAFE indices reflect legal values and must therefore be regarded as a societal index and not as a biological index, although it uses the same input as a biological index (De Nooij *et al.,* 2001). However, biological indices cannot give insight into the potentials of taxonomic groups and ecotopes or the consequences of reconstruction measures. Therefore, BIO-SAFE Sado can be regarded as a complementary instrument to the biological methods. The BIO-SAFE indices reflect to which a situation corresponds with existing policies and legislation. The concept provides insight into the importance of an area or ecotopes in this area for protected and endangered species. The model gives no valuation of ecosystem function, ecosystem integrity or ecosystem health. BIO-SAFE output gives information on biodiversity in landscape on four types of scale (see also Figure 2.5):

1. Species/ ecotope level: these indices (SEI, ASEI) reflect the importance of an ecotope for each species studied.
2. Taxonomic group/ ecotope level: these indices reflect the importance of an ecotope for a species group (TEI, ATEI) and the degree to which the maximum potential value of an ecotope for a species group has been achieved in an actual situation (TES).
3. Taxonomic group/ habitats level: this index (TBS) gives information on the degree to which the biodiversity potential of a particular species group has been realised in the habitat.
4. All groups/ habitats level: this index (BS) is an aggregation of the indices of type 3, representing an overall image of the biodiversity situation of the floodplain and the overall values of scenarios.

For the valuation of ecotopes carried out in this study no surface area of the ecotopes were taken into account. However, the real importance of an ecotope is strongly determined by its size. Should be taken into account that ecological rehabilitation should be focussed on the construction of areas with a gradient in different environmental factors and enough surface. Therefore, the information that BIO-SAFE yields regarding sustaining biodiversity only refers to the diversity of ecotopes and not its potency to sustain a viable population (De Nooij *et al.,* 2001). Moreover, the different taxonomic groups have different ecotopes of importance, meaning that also ecotope diversity is very important.

Results concerning valuation of a number of landscapes using BIO-SAFE shows that the model enables the user to see for which species group an area already is important. Also the link with area potential can be made (De Nooij *et al.,* 2001). From valuation of ecotopes on the basis of data on species actually present in the study area, it becomes clear that there are large differences within landscapes regarding the biodiversity values of different ecotopes. In some cases, ecotopes reach full saturation, meaning that all the potential species are actually present on that ecotope. However when only one species is linked to this ecotope, it is not very remarkable. Therefore, it is the combination of the ecotope saturation index (TES) and the actual ecotope importance (ATEI) that constitutes the information on actual biodiversity values. Biodiversity saturation and ecotope saturation indices calculated for different taxonomic groups do not necessarily indicate for *ecological relevant* parameters and variances between these indices do not necessarily indicate for ecological differences (De Nooij *et al.,* 2001).

Actual information on the presence of species is useful regarding the consequences of reconstructions on the values already present, where several ecotopes have very high biodiversity values and should be regarded as conservation priority ecotopes in early stages of the planning process. This could also prevent problems with legislation that can lead to obstruction of implementation of management measures (De Nooij *et al.,* 2001). By linking actual information with information on the potentials of the area, it is possible to develop most appropriate reconstruction designs.

The other possible BIO-SAFE assessments are the scenario and trend analysis, not applied in this study. In the scenario analysis values of different scenarios or designs for reconstruction of the landscape are assessed. By comparison of these values with a reference scenario (no measures taken, autonomous development) it is possible to assess impacts of reconstruction measures. The input data required is the ecotopes present in the area and their surface area, according to the different scenarios or alternatives for reconstruction concerning the area. For the trend analysis, data on species and ecotopes presence and the surface areas of the ecotopes at several moments in time is used to analyse trends, where a series of calculations is executed. The results can be plotted in time, showing the biodiversity value patterns in time (De Nooij *et al.,* 2001).

4.3. Comparison with the previous versions of BIO-SAFE studies

In a way to assess the different BIO-SAFE studies that have been done so far, the number of species, taxonomic groups and the results for the biodiversity saturation index per taxonomic group (TBS) in each country are described below. Table 4.1 presents the number of species per taxonomic group in each country where BIO-SAFE assessment has been applied.

Table 4.1: Number of protected and endangered species included in BIO-SAFE. Results for the Vistula River after Wozniak *et al*. (2009) and for the Rhine and Meuse rivers after De Nooij *et al*. (2004) (highest value per taxonomic group is in bold).

Taxonomic Group	Country					
	PT **Sado Estuary**	**PL** **River Vistula**	**NL** **Rhine-Meuse Delta**	**G** **River Rhine**	**F** **River Meuse**	**B** **River Meuse**
Higher plants	22	49	**136**	60	12	90
Birds	**206**	64	60	58	113	38
Reptiles and Amphibians	**32**	11	9	11	7	4
Mammals	**32**	17	6	5	4	5
Fish	16	**17**	9	11	7	5
Butterflies	-	**20**	**20**	17	10	16
Dragon- and damselflies	-	6	**17**	9	7	15
Total	**308**	177	257	171	160	173

Abbreviations: PT, Portugal; PL, Poland; NL, The Netherlands; G, Germany; F, North-eastern France; B, Belgium. (–) Lack of data.

From Table 4.1 is possible to conclude that, even without the inclusion of invertebrate species in the BIO-SAFE Sado assessment, the Portuguese application has the highest number of included species (308), where in the remaining study sites the species number are lower (ranging from 160 to 257). This fact is mainly due to the higher presence of birds species (206), indicating the high potential that the RNES area represents to this taxonomic group. The high number of birds in all six countries also catches the eye. This can easily be explained by the fact that birds are a species group that receives much attention in species conservation policy (De Nooij *et al.,* 2001). Also in the Portuguese assessment the herpetofauna and mammals have the highest number of represented species (both 32) and the number of fish species is the second highest (16), only overcome by the Polish Vistula

River assessment (17 species). On the other hand, the higher plants species number is extremely low (22) mainly due, as already has been said, to the absence of the Portuguese Red Data List for Vascular Plants. Only in the French assessment for the Meuse River the number is lower (12 species). Amongst other reasons, this can be explained by the fact that the Meuse area covers only a very small area (De Nooij *et al.,* 2001).

General differences between countries can be explained by biogeographical aspects and differences in environmental pressure on species in each country. In addition, the criteria for selection of Red-listed species differ between countries (Wozniak *et al.,* 2009).

The biodiversity saturation values per taxonomic group (TBS index) of the RNES were compared with the previous BIO-SAFE assessments for the Vistula, Rhine and Meuse Rivers. Table 4.2 shows the results of the TBS values (0-100) for seven taxonomic groups in five different study areas.

Table 4.2: Taxonomic group Biodiversity Saturation indices (TBS; 0–100) for seven taxonomic groups for various lowland river reaches in Europe. Results for the Vistula River after Wozniak *et al*. (2009) and for the Rhine and Meuse rivers after De Nooij *et al*. (2004) (highest value per taxonomic group is in bold).

Taxonomic Group	**Sado Estuary Natural Reserve**	**Middle Vistula river valley**	**River Rhine**	**River Meuse**	
	Sado Estuary Natural Reserve, Portugal (23160 ha)	**Kazimierski Landscape Park, Poland (482 ha)**	**Rijnwaarden, The Netherlands (1100 ha)**	**Mouzay, France (570 ha)**	**Common Meuse, Belgium (2365 ha)**
Higher plants	59	**67**	19	50	58
Birds	**89**	50	63	57	58
Reptiles and Amphibians	**70**	43	42	36	–
Mammals	70	**71**	52	0	–
Fish	**84**	31	24	–	23
Butterflies	–	**15**	0	–	–
Dragon- and damselflies	–	–	**9**	0	–
Mean value	74	46	30	29	46

(–) Lack of data.

The mean TBS value for the Portuguese RNES is prominently the highest, with a figure of 74. This indicates that, comparing to the other study areas, the percentage of potential species that are actually present is really high, where the main reason is the remarkable acreage difference between the RNES area (23160 ha) and the other study sites areas (ranging from 482 to 2365 ha). Also remarkable is the fact that birds species is far and wide the most representative group in the RNES area having at the same time the highest TBS value (89), which extols the importance of this area for this taxonomic group. The RNES area shows highest TBS-scores for birds, herpetofauna and fish groups, but, the Vistula river valley, in spite of a small acreage, shows highest TBS-scores for higher plants and mammals, indicating a high ratio between the actual and potential values of the landscape for protected species.

The rivers Rhine and Meuse are roughly under the same temperate climate regime, but differ remarkably in habitat availability for protected species (Wozniak *et al.,* 2009). Part of the differences between taxonomic groups for the rivers Meuse and Rhine may be due to possibly incomplete distribution surveys of some groups, especially butterflies, damselflies and dragonflies, and fishes (De Nooij *et al.,* 2001).

5. CONCLUSIONS

The BIO-SAFE concept as presented by Lenders *et. al.* (2001) and De Nooij *et al*. (2001, 2004) can easily be adapted to other types of ecosystems. By altering the species selection, ecotope typology and valuation criteria, the BIO-SAFE Sado has been developed and applied for the Sado Estuary Natural Reserve. The BIO-SAFE assessment appeared to be a good method to quickly determine political and legal biodiversity and ecotope values, showing the relative importance of the ecotopes occurring in the RNES following the linkage to valuation of species with specific legislation criteria.

BIO-SAFE Sado can be used to valuate actual and potential situations, regarding 308 species from six different taxonomic groups (higher plants, birds, reptiles, amphibians, mammals and fish) and their habitat demands, with a linkage to 24 different ecotopes belonging to 6 different categories of habitats. These species were selected from national and international nature conservation policies and legislation as the Portuguese Vertebrate Red List, the EU Habitats and Birds Directives and the Bonn and Bern Conventions. However, these instruments do not yet encompass the taxonomic group of macro-invertebrates, which is very characteristic and important for the coastal and estuarine ecosystems like the RNES. Also the absence of the Portuguese Red Data List for Plants is a great lack in terms of national flora protection and conservation.

BIO-SAFE Sado is a policy and legislation based ecological effect model that yields information that is complementary to more established biological diversity indices. The model helps to meet goals set in (inter)national legislation, by translating legislative obligations regarding species to legal values for ecotopes in the Sado Estuary Natural Reserve. These values give information regarding the degree to which physical measures have an impact on the actual or potential legal importance of the landscape.

Based on the assignment of the valuation criteria (weighted policy and legislation instruments) to the species and ecotopes it can be concluded that in the RNES area the taxonomic groups of birds, fish and mammals are amongst the most important taxa regarding endangered and protected biodiversity. In spite the lack of the national Red List for Plants, the higher plants group also showed the presence of extremely endangered and internationally protected species, indicating that the Red List is an urgent requirement in Portugal. The importance of these four groups ultimately results in the assignment of the Waterlines as the most valuable aquatic ecotope present in the RNES and the Dune bushes and the indigenous forestry ecotope types Pinewood and Cork oak system as the most valuable landscape units within terrestrial systems. In the birds group case, the most valuable ecotope types are the (semi)aquatic Intertidal mud, Salt marshes and Salina ponds, where a special attention should be paid since it is largely the most representative group in the RNES area with 206 species, and presenting one TBS score of 89.

The results in the appreciation of the ecotope types were the same in both potential and actual situations, which was quite expected since the biodiversity saturation indices (TBS and TES) show high values. In some ecotopes the TES value is the maximum (100), showing that the total saturation is possible to reach. Based on the ecotopes valuation results, already valuable ecotopes can be conserved and an increase of diversity of less valuable ecotopes can be pursued during the planning process of management measures.

In the comparison with the previous BIO-SAFE assessments to the north-western Rivers Meuse, Rhine and Vistula, the Portuguese version for the RNES area showed the highest number of species implemented on the model, as well as the highest actual presence of potential species in the area (highest TBS mean value). This shows the importance of the Sado Estuary area in the local, national and international context, concerning that a high level of protection and conservation is required.

6. RECOMMENDATIONS AND FUTURE WORK

- The determination of species characteristic of the Sado Estuary Natural Reserve and the linkages of the species to ecotopes (habitat) needs to be validated on the basis of expert judgement.
- Macrobenthic invertebrates (e.g. polychaetes, crustaceans, bivalves) and other invertebrate groups (e.g. butterflies, damselflies and dragonflies, molluscs) are very important in the estuarine ecosystem food webs. Therefore, it is advisable to incorporate also these taxonomic groups into the BIO-SAFE Sado assessment.
- The publication of the Portuguese Red List for Vascular Plants will become one great improvement in the valuation of endangered higher plants species in Portugal and, therefore, will increase and improve the BIO-SAFE Sado flora valuation.
- It is recommended to set minimum values for surface areas, derived from the areas required to sustain viable populations of species and to introduce some principal requirements regarding food web relationships.
- The Scenario and Trend analysis is still possible to do in the BIO-SAFE Sado assessment, where the only requirement is the introduction of the required data with that purpose. For the scenario analysis the surface area for actual situation and scenario for future area change is required, while in the trend analysis the requirement is also the surface area values and the historical records of the species presence in the area in several moments in time.
- The ecotope typology used in this study is in agreement with the CORINE Land Cover system, being possible to link the BIO-SAFE Sado output directly into a GIS environment.
- After further development of this version, BIO-SAFE Sado can be used as a tool for various policy and management purposes in the Sado Estuary area, such as underpinning spatial planning reports, environmental impact assessments for physical activities and evaluations of the impact of former reconstructions. Furthermore, the information derived from assessments of actual situations can prevent a lot of resistance from legislation and helps to set up the most optimal reconstruction designs.

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GLOSSARY

ASEI: Actual Species Ecotope Importance score, actual importance of each ecotope per species individually (0-0.83 for fauna, 0-0.41 for flora).

ATEI: Actual Taxonomic group Ecotope Importance score, actual importance of each ecotope per taxon (0-100).

BIO-SAFE Sado: Spreadsheet Application for Evaluation of BIOdiversity in the Sado Estuary Natural Reserve.

Biodiversity: The variability among living organisms from all sources, including, 'inter alia', terrestrial, marine, and other aquatic ecosystems, and the ecological complexes of which they are part: this includes diversity within species, between species and of ecosystems.

BS: Biodiversity Saturation index area, degree of realisation of biodiversity potential of the area (0-100).

Conservation instrument: Policy and legislation that can/must be used to underpin activities aimed conservation of nature. In this report: Portuguese Vertebrate Red List, EU Habitats Directive, EU Birds Directive, Bonn Convention, Bern Convention..

Ecotope: Relatively homogeneous, spatially-explicit landscape unit that is defined by the interaction of biotic and abiotic components, useful for stratifying landscapes into ecologically distinct features.

Ecotope typology: A classification of ecotopes in which the ecotopes of importance in an area (in this report the Dutch estuarine and coastal water systems) are arranged in an orderly way.

Estuary: Semi-enclosed coastal body of brackish till saline water under tidal influence, with one or more rivers or streams flowing into it, and with a free connection to the open sea.

Habitat: The (physical) environment that surrounds (influences and is utilized by) a species. A habitat consists of several ecotopes or parts of an ecotope.

ICNB: Instituto da Conservação da Natureza e da Biodiversidade (Portuguese National Institute for the Biodiversity and Nature conservation).

IUCN: International Union for the Conservation of Nature and Natural Resources.

Red List: World's most comprehensive inventory of the global conservation status (disappeared, declining or rare) of plant and animal species according to IUCN criteria, also known as Red Data List/Book.

RNES: Reserva Natural do Estuário do Sado (Sado Estuary Natural Reserve).

Species status: The conservation status of a species concerning Portuguese Vertebrate Red List, EU Habitats Directive, EU Birds Directive, Bonn Convention and Bern Convention

SEI: Species Ecotope Importance score, importance of each ecotope per species individually (0-0.83 for fauna, 0-0.41 for flora).

TBS: Taxonomic group Biodiversity Saturation index, showing the degree to which the maximum expected biodiversity value per taxonomic group has been actually achieved in a particular area (0-100).

TEI: Taxonomic group Ecotope Importance constant, importance of each ecotope per taxon (0-100).

TES: Taxonomic group Ecotope Saturation index, degree of realisation of biodiversity potential of each ecotope per taxon (0-100).

ANNEX 1- SPECIES SELECTED FOR IMPLEMENTATION IN BIO-SAFE SADO

1.1 Higher Plant species selected for implementation in BIO-SAFE Sado

Higher plants				
	Nomenclature		**Legislation**	
Nr	Scientific name	Portuguese name	HD	Bern
1	*Armeria rouyana*	-	*II, IV, V	I
2	*Euphorbia transtagana*	-	II, IV, V	-
3	*Herniaria maritima*	-	II, IV, V	I
4	*Jonopsidium acaule*	Cocleária-menor	*II, IV, V	I
5	*Limonium lanceolatum*	-	II, IV	-
6	*Linaria ficalhoana*	-	*II, IV, V	I
7	*Malcolmia lacera*	Goiveiro-da-praia	V	-
8	*Myosotis lusitanica*	-	II, IV	-
9	*Salix salviifolia*	Salgueiro-branco	II, IV	-
10	*Santolina impressa*	-	II, IV, V	-
11	*Thymus camphoratus*	Tomilho-do-mar	*II, IV	I
12	*Thymus capitellatus*	-	IV	-
13	*Thymus carnosus*	Tomilho-das-praias	II, IV, V	I
14	*Halimium verticillatum*	-	II, IV, V	-
15	*Hyacinthoides vicentina*	-	II, IV, V	-
16	*Juncus valvatus*	-	II, IV, V	I
17	*Marsilea batardae*	Trevo-de-quatro-folhas	II, IV, V	I
18	*Melilotus segetalis*	Anafe	II, IV, V	-
19	*Myosotis retusifolia*	-	II, IV	-
20	*Silene longicilia*	-	II, IV	-
21	*Spiranthes aestivalis*	-	IV	I
22	*Thorella verticillatinundata*	-	II, IV, V	I

EU Habitats Directive (HD) - *: Priority Species; Annex II: species whose conservation requires the designation of special areas of conservation; Annex IV: species in need of strict protection; Annex V: species whose taking in the wild and exploitation may be subject to management measures.
Bern Convention (Bern) - Appendix I: strictly protected flora species.

1.2 Bird species selected for implementation in BIO-SAFE Sado

Birds						
	Nomenclature		**Legislation**			
Nr	Scientific name	Portuguese name	PRDLV	BD	Bonn	Bern
1	*Accipiter nisus*	Gavião	LC	-	II	II
2	*Acrocephalus arundinaceus*	Rouxinol-grande-dos-caniços	LC	-	II	II
3	*Acrocephalus schoenobaenus*	Felosa-dos-juncos	-	-	II	II
4	*Acrocephalus scirpaceus*	Rouxinol-pequeno-dos-caniços	NT	-	II	II
5	*Actitis hypoleucos*	Maçarico-das-rochas	VU	-	II	II
6	*Aegithalos caudatus*	Chapim-rabilongo	LC	-	-	III
7	*Alauda arvensis*	Laverca	LC	-	-	III
8	*Alca torda*	Torda-mergulheira	LC	-	-	III
9	*Alcedo atthis*	Guarda-rios	LC	I	-	II
10	*Alectoris rufa*	Perdiz	LC	-	-	III
11	*Anas acuta*	Arrábio	LC	-	II	III
12	*Anas clypeata*	Pato-trombeteiro	LC	-	II	III
13	*Anas crecca*	Marrequinho	LC	-	II	III
14	*Anas penelope*	Piadeira	NE	-	II	III
15	*Anas platyrhynchos*	Pato-real	LC	-	II	III
16	*Anas querquedula*	Marreco	-	-	II	III
17	*Anas strepera*	Frisada	NT	-	II	III
18	*Anser anser*	Ganso-bravo	NT	-	II	III
19	*Anthus campestris*	Petinha-dos-campos	LC	I	-	II
20	*Anthus pratensis*	Petinha-dos-prados	LC	-	-	II
21	*Anthus richardi*	Petinha de Richard	-	-	-	III
22	*Anthus spinoletta*	Petinha-ribeirinha	LC	-	-	II
23	*Anthus trivialis*	Petinha-das-árvores	NT	-	-	II
24	*Apus apus*	Andorinhão-preto	LC	-	-	III
25	*Apus melba*	Andorinhão-real	NT	-	-	II
26	*Apus pallidus*	Andorinhão-pálido	LC	-	-	II
27	*Aquila adalberti*	Águia-imperial-ibérica	CR	I*	I / II	II
28	*Ardea cinerea*	Garça-real	LC	-	-	III
29	*Ardea purpurea*	Garça-vermelha	EN	I	II	II

Birds						
	Nomenclature		**Legislation**			
Nr	Scientific name	Portuguese name	PRDLV	BD	Bonn	Bern
30	*Ardeola ralloides*	Papa-ratos	CR	I	-	II
31	*Arenaria interpres*	Rola-do-mar	LC	-	II	II
32	*Asio flammeus*	Coruja-do-nabal	EN	I	-	II
33	*Asio otus*	Bufo-pequeno	DD	-	-	II
34	*Athene noctua*	Mocho-galego	LC	-	-	II
35	*Aythya ferina*	Zarro-comum	VU	-	II	III
36	*Aythya fuligula*	Zarro-negrinha	VU	-	II	III
37	*Aythya nyroca*	Zarro-castanho	RE	I*	I / II	III
38	*Botaurus stellaris*	Abetouro-comum	CR	I*	II	II
39	*Bubulcus ibis*	Garça-boieira	LC	-	-	II
40	*Burhinus oedicnemus*	Alcaravão	VU	I	II	II
41	*Buteo buteo*	Águia-de-asa-redonda	LC	-	II	II
42	*Calandrella brachydactyla*	Calhandrinha	LC	I	-	II
43	*Calidris alba*	Pilrito-sanderlingo	LC	-	II	II
44	*Calidris alpina*	Pilrito-comum	LC	-	II	II
45	*Calidris canutus*	Seixoeira	VU	-	II	III
46	*Calidris ferruginea*	Pilrito-de-bico-comprido	VU	-	II	II
47	*Calidris minuta*	Pilrito-pequeno	LC	-	II	II
48	*Calidris temminckii*	Pilrito-de-Temminck	-	-	II	II
49	*Caprimulgus europaeus*	Noitibó-cinzento	VU	I	-	II
50	*Caprimulgus ruficollis*	Noitibó-de-nuca-vermelha	VU	-	-	II
51	*Carduelis cannabina*	Pintarroxo	LC	-	-	II
52	*Carduelis carduelis*	Pintassilgo	LC	-	-	II
53	*Carduelis chloris*	Verdilhão	LC	-	-	II
54	*Carduelis spinus*	Lugre	LC	-	-	II
55	*Casmerodius albus (Egretta alba)*	Garça-branca-grande	-	I	-	II
56	*Certhia brachydactyla*	Trepadeira-comum	LC	-	-	II
57	*Cettia cetti*	Rouxinol-bravo	LC	-	II	II
58	*Charadrius alexandrinus*	Borrelho-de-coleira-interrompida	LC	I	II	II
59	*Charadrius dubius*	Borrelho-pequeno-de-coleira	LC	-	II	II

Birds						
	Nomenclature		**Legislation**			
Nr	Scientific name	Portuguese name	PRDLV	BD	Bonn	Bern
60	*Charadrius hiaticula*	Borrelho-grande-de-coleira	LC	-	II	II
61	*Chlidonias hybridus*	Gaivina-dos-pauis	CR	I	-	II
62	*Chlidonias niger*	Gaivina-preta	-	I	II	II
63	*Ciconia ciconia*	Cegonha branca	LC	I	II	II
64	*Ciconia nigra*	Cegonha-preta	VU	I	II	II
65	*Circaetus gallicus*	Águia-cobreira	NT	I	II	II
66	*Circus aeruginosus*	Tartaranhão-ruivo-dos-pauis	VU	I	II	II
67	*Circus cyaneus*	Tartaranhão-azulado	VU	I	II	II
68	*Circus pygargus*	Tartaranhão-caçador	EN	I	II	II
69	*Cisticola juncidis*	Fuinha-dos-juncos	LC	-	II	II
70	*Clamator glandarius*	Cuco-rabilongo	VU	-	-	II
71	*Coccothraustes coccothraustes*	Bico-grossudo	LC	-	-	II
72	*Columba oenas*	Pombo-bravo	DD	-	-	III
73	*Coracias garrulus*	Rolieiro	CR	I	II	II
74	*Corvus corax*	Corvo	NT	-	-	III
75	*Coturnix coturnix*	Codorniz	LC	-	II	III
76	*Cuculus canorus*	Cuco	LC	-	-	III
77	*Cyanopica cyanus*	Pega-azul	LC	-	-	II
78	*Delichon urbicum*	Andorinha-dos-beirais	LC	-	-	II
79	*Dendrocopos minor*	Pica-pau-galego	LC	-	-	II
80	*Dendrocopus major*	Pica-pau-malhado-grande	LC	-	-	II
81	*Egretta garzetta*	Garça-branca-pequena	LC	I	-	II
82	*Elanus caeruleus*	Peneireiro-cinzento	NT	I	II	II
83	*Emberiza (Miliaria) calandra*	Trigueirão	LC	-	-	III
84	*Emberiza cirlus*	Escrevedeira-de-garganta-preta	LC	-	-	II
85	*Emberiza schoeniclus*	Escrevedeira-dos-caniços	LC	-	-	II
86	*Erithacus rubecula*	Pisco-de-peito-ruivo	LC	-	II	II
87	*Estrilda astrild*	Bico-de-lacre	NE	-	-	III
88	*Euplectes afer*	Bispo-de-coroa-amarela	NE	-	-	III
89	*Falco columbarius*	Esmerilhão	VU	I	II	II

Birds						
	Nomenclature		**Legislation**			
Nr	Scientific name	Portuguese name	PRDLV	BD	Bonn	Bern
90	*Falco naumanni*	Peneireiro-das-torres	VU	I*	I / II	II
91	*Falco peregrinus*	Falcão-peregrino	VU	I	II	II
92	*Falco subbuteo*	Ógea	VU	-	II	II
93	*Falco tinnunculus*	Peneireiro-de-dorso-malhado	LC	-	II	II
94	*Ficedula hypoleuca*	Papa-moscas-preto	-	-	II	II
95	*Fringilla coelebs*	Tentilhão-comum	LC	-	-	III
96	*Fulica atra*	Galeirão	LC	-	II	III
97	*Galerida cristata*	Cotovia-de-poupa	LC	-	-	III
98	*Galerida theklae*	Cotovia-do-monte	LC	I	-	II
99	*Gallinago gallinago*	Narceja-comum	LC	-	II	III
100	*Gallinula chloropus*	Galinha-d'água	LC	-	-	III
101	*Glareola pratincola*	Perdiz-do-mar	VU	I	II	II
102	*Haematopus ostralegus*	Ostraceiro	NT	-	-	III
103	*Hieraaetus fasciatus*	Águia de Bonelli	EN	I*	II	II
104	*Hieraaetus pennatus*	Águia-calçada	NT	I	II	II
105	*Himantopus himantopus*	Perna-longa	LC	I	II	II
106	*Hippolais polyglotta*	Felosa-poliglota	LC	-	II	II
107	*Hirundo (Ptyonoprogne) rupestris*	Andorinha-das-rochas	LC	-	-	II
108	*Hirundo daurica*	Andorinha-dáurica	LC	-	-	II
109	*Hirundo rustica*	Andorinha-das-chaminés	LC	-	-	II
110	*Ixobrychus minutus*	Garça-pequena	VU	I	II	II
111	*Lanius meridionalis*	Picanço-real	LC	-	-	II
112	*Lanius senator*	Picanço-barreteiro	NT	-	-	II
113	*Larus melanocephalus*	Gaivota do Mediterrâneo	LC	I	II	II
114	*Larus michahellis*	Gaivota-de-patas-amarelas	-	-	-	III
115	*Larus minutus*	Gaivota-pequena	-	I	-	II
116	*Larus ridibundus*	Guincho-comum	LC	-	-	III
117	*Limosa lapponica*	Fuselo	LC	I	II	III
118	*Limosa limosa*	Maçarico-de-bico-direito	LC	-	II	III
119	*Locustella luscinioides*	Felosa-unicolor	VU	-	II	II
120	*Locustella naevia*	Felosa-malhada	-	-	II	II

Birds						
	Nomenclature		Legislation			
Nr	Scientific name	Portuguese name	PRDLV	BD	Bonn	Bern
121	*Lullula arborea*	Cotovia-arbórea	LC	I	-	III
122	*Luscinia megarhynchos*	Rouxinol-comum	LC	-	II	II
123	*Luscinia svecica*	Pisco-de-peito-azul	LC	I	II	II
124	*Lymnocryptes minimus*	Narceja-galega	DD	-	II	III
125	*Melanitta nigra*	Pato-negro	EN	-	II	III
126	*Mergus serrator*	Merganso-de-poupa	EN	-	II	III
127	*Merops apiaster*	Abelharuco	LC	-	II	II
128	*Milvus migrans*	Milhafre-preto	LC	I	II	II
129	*Milvus milvus*	Milhafre-real	VU	I	II	II
130	*Motacilla alba*	Alvéola-branca	LC	-	-	II
131	*Motacilla cinerea*	Alvéola-cinzenta	LC	-	-	II
132	*Motacilla flava*	Alvéola-amarela	LC	-	-	II
133	*Muscicapa striata*	Papa-moscas-cinzento	NT	-	II	II
134	*Netta rufina*	Pato-de-bico-vermelho	NT	-	II	III
135	*Numenius arquata*	Maçarico-real	LC	-	II	III
136	*Numenius phaeopus*	Maçarico-galego	VU	-	II	III
137	*Nycticorax nycticorax*	Goraz / Garça nocturna	EN	I	-	II
138	*Oenanthe oenanthe*	Chasco-cinzento	LC	-	II	II
139	*Oriolus oriolus*	Papa-figos	LC	-	-	II
140	*Pandion haliaetus*	Águia-pesqueira	EN	I	II	II
141	*Parus caeruleus*	Chapim-azul	LC	-	-	II
142	*Parus cristatus*	Chapim-de-poupa	LC	-	-	II
143	*Parus major*	Chapim-real	LC	-	-	II
144	*Passer hispaniolensis*	Pardal-espanhol	LC	-	-	III
145	*Passer montanus*	Pardal-montês	LC	-	-	III
146	*Petronia petronia*	Pardal-francês	LC	-	-	II
147	*Phalacrocorax carbo*	Corvo-marinho-de-faces-brancas	LC	-	-	III
148	*Philomachus pugnax*	Combatente	EN	I	II	III
149	*Phoenicopterus (ruber) roseus*	Flamingo-comum	VU	I	II	II
150	*Phoenicurus ochruros*	Rabirruivo-preto	LC	-	II	II
151	*Phoenicurus phoenicurus*	Rabiruivo-de-testa-branca	LC	-	II	II

Birds						
	Nomenclature		**Legislation**			
Nr	Scientific name	Portuguese name	PRDLV	BD	Bonn	Bern
152	*Phylloscopus bonelli*	Felosa-de-Bonelli	LC	-	II	II
153	*Phylloscopus collybita*	Felosa-comum	LC	-	II	II
154	*Phylloscopus ibericus*	Felosa-ibérica	LC	-	II	II
155	*Phylloscopus trochilus*	Felosa-musical	-	-	II	II
156	*Picus viridis*	Pica-pau-verde	LC	-	-	II
157	*Platalea leucorodia*	Colhereiro	VU	I	II	II
158	*Plegadis falcinellus*	Maçarico-preto (Íbis-preta)	RE	I	II	II
159	*Pluvialis apricaria*	Tarambola dourada	LC	I	II	III
160	*Pluvialis squatarola*	Tarambola cinzenta	LC	-	II	III
161	*Podiceps cristatus*	Mergulhão-de-crista	LC	-	-	III
162	*Podiceps nigricollis*	Mergulhão-de-pescoço-preto	NT	-	-	II
163	*Porphyrio porphyrio*	Caimão	VU	I*	-	II
164	*Prunella modularis*	Ferreirinha	LC	-	-	II
165	*Pyrrhula pyrrhula*	Dom-fafe	LC	-	-	III
166	*Rallus aquaticus*	Frango-d'água	LC	-	-	III
167	*Recurvirostra avosetta*	Alfaiate	LC	I	II	II
168	*Regulus ignicapilla*	Estrelinha-de-cabeça-listada	LC	-	II	II
169	*Remiz pendulinus*	Chapim-de-faces-pretas	NT	-	-	III
170	*Riparia riparia*	Andorinha-das-barreiras	LC	-	-	II
171	*Saxicola rubetra*	Cartaxo-nortenho	VU	-	II	II
172	*Saxicola torquatus*	Cartaxo-comum	LC	-	II	II
173	*Scolopax rusticola*	Galinhola	DD	-	II	III
174	*Serinus serinus*	Chamariz	LC	-	-	II
175	*Sitta europaea*	Trepadeira-azul	LC	-	-	II
176	*Sterna albifrons*	Andorinha-do-mar-anã	VU	I	II	II
177	*Sterna caspia*	Gaivina-de-bico-vermelho	EN	I	II	II
178	*Sterna hirundo*	Andorinha-do-mar	EN	I	II	II
179	*Sterna nilotica*	Gaivina-de-bico-preto	EN	I	II	II
180	*Sterna sandvicensis*	Garajau	NT	I	II	II
181	*Streptopelia decaocto*	Rola-turca	LC	-	-	III
182	*Streptopelia turtur*	Rola-comum	LC	-	-	III

Birds						
	Nomenclature		**Legislation**			
Nr	Scientific name	Portuguese name	PRDLV	BD	Bonn	Bern
183	*Strix aluco*	Coruja-do-mato	LC	-	-	II
184	*Sturnus unicolor*	Estorninho-preto	LC	-	-	II
185	*Sylvia atricapilla*	Toutinegra-de-barrete-preto	LC	-	II	II
186	*Sylvia borin*	Felosa-das-figueiras	VU	-	II	II
187	*Sylvia communis*	Papa-amoras-comum	LC	-	II	II
188	*Sylvia hortensis*	Toutinegra-real	NT	-	II	II
189	*Sylvia melanocephala*	Toutinegra-dos-valados	LC	-	II	II
190	*Sylvia undata*	Felosa-do-mato	LC	I	-	II
191	*Tachybaptus ruficollis*	Mergulhão-pequeno	LC	-	-	II
192	*Tadorna tadorna*	Pato-branco	-	-	-	II
193	*Tetrax tetrax*	Sisão	VU	I*	-	II
194	*Tringa erythropus*	Perna-vermelha-escuro	VU	-	II	III
195	*Tringa glareola*	Maçarico-bastardo	-	I	II	II
196	*Tringa nebularia*	Perna-verde-comum	VU	-	II	III
197	*Tringa ochropus*	Maçarico-bique-bique	NT	-	II	II
198	*Tringa totanus*	Perna-vermelha-comum	CR	-	II	III
199	*Troglodytes troglodytes*	Carriça	LC	-	-	II
200	*Turdus iliacus*	Tordo-ruivo	LC	-	II	III
201	*Turdus merula*	Melro-preto	LC	-	II	III
202	*Turdus philomelos*	Tordo-comum	LC	-	II	III
203	*Turdus viscivorus*	Tordoveia	LC	-	-	III
204	*Tyto alba*	Coruja-das-torres	LC	-	-	II
205	*Upupa epops*	Poupa	LC	-	-	II
206	*Vanellus vanellus*	Abibe	LC	-	II	III

Portuguese Red Data List for Vertebrates (PRDLV) - EX: “Extinct", EW: "Extinct in the Wild", RE: “Regionally Extinct”, CR: "Critically endangered", EN: “Endangered“, VU: “Vulnerable”, NT: "Near Threatened", LC: “Least Concern”, DD: “Data Deficient”, NA: “Not Applicable” and NE: “Not Evaluated.

EU Birds Directive (BD) - *: Priority Species; Annex I: species that are subject of special conservation measures concerning their habitat in order to ensure their survival and reproduction in their area of distribution.

Bonn Convention (Bonn) - Appendix I: migratory species whose immediate protection is required; Appendix II: migratory species whose conservation and management should be covered by means of transnational agreements.

Bern Convention (Bern) - Appendix II: strictly protected fauna species; Appendix III: protected fauna species.

1.3 Reptile species selected for implementation in BIO-SAFE Sado

Reptiles						
	Nomenclature		**Legislation**			
Nr	Scientific name	Portuguese name	PRDLV	HD	Bonn	Bern
1	*Acanthodactylus erythrurus*	Lagartixa-de-dedos-denteados	NT	-	-	III
2	*Blanus cinereus*	Cobra-cega	LC	-	-	III
3	*Chalcides bedriagai*	Cobra-de-pernas-pentadáctila	LC	IV	-	II
4	*Chalcides striatus*	Cobra-de-pernas-tridáctila	LC	-	-	III
5	*Coluber hippocrepis / Hemorrhois hippocrepis*	Cobra-de-ferradura	LC	IV	-	II
6	*Coronella girondica*	Cobra-bordalesa	LC	-	-	III
7	*Elaphe scalaris*	Cobra-de-escada	LC	-	-	III
8	*Lacerta lepida / Timon lepidus*	Sardão	LC	-	-	II
9	*Macroprotodon (cucullatus) brevis*	Cobra-de-capuz	LC	-	-	III
10	*Malpolon monspessulanus*	Cobra-rateira	LC	-	-	III
11	*Mauremys leprosa*	Cágado	LC	II, IV	-	II
12	*Natrix maura*	Cobra-de-água-viperina	LC	-	-	III
13	*Natrix natrix*	Cobra-de-água-de-colar	LC	-	-	III
14	*Podarcis hispanica*	Lagartixa-ibérica	LC	IV	-	III
15	*Podarcis carbonelli*	Lagartixa de Carbonell	VU	-	-	III
16	*Psammodromus algirus*	Lagartixa-do-mato	LC	-	-	III
17	*Psammodromus hispanicus*	Lagartixa-do-mato-ibérica	NT	-	-	III
18	*Tarentola mauritanica*	Osga	LC	-	-	III
19	*Vipera latastei*	Vibora-cornuda	VU	-	-	II

Portuguese Red Data List for Vertebrates (PRDLV) - EX: "Extinct", EW: "Extinct in the Wild", RE: "Regionally Extinct", CR: "Critically endangered", EN: "Endangered", VU: "Vulnerable", NT: "Near Threatened", LC: "Least Concern", DD: "Data Deficient", NA: "Not Applicable" and NE: "Not Evaluated.

EU Habitats Directive (HD) - *: Priority Species; Annex II: species whose conservation requires the designation of special areas of conservation; Annex IV: species in need of strict protection; Annex V: species whose taking in the wild and exploitation may be subject to management measures.

Bonn Convention (Bonn) - Appendix I: migratory species whose immediate protection is required; Appendix II: migratory species whose conservation and management should be covered by means of transnational agreements.

Bern Convention (Bern) - Appendix II: strictly protected fauna species; Appendix III: protected fauna species.

1.4 Amphibian species selected for implementation in BIO-SAFE Sado

Amphibians						
	Nomenclature		**Legislation**			
Nr	Scientific name	Portuguese name	PRDLV	HD	Bonn	Bern
1	*Alytes cisternasii*	Sapo-parteiro-ibérico	NT	IV	-	II
2	*Bufo bufo*	Sapo-comum	LC	-	-	III
3	*Bufo calamita*	Sapo-corredor	LC	IV	-	II
4	*Discoglossus galganoi*	Rã-de-focinho-pontiagudo	NT	II, IV	-	II
5	*Hyla arborea*	Rela-comum	LC	IV	-	II
6	*Hyla meridionalis*	Rela-meridional	LC	IV	-	II
7	*Pelobates cultripes*	Sapo-de-unha-negra	LC	IV	-	II
8	*Pelodytes punctatus*	Sapinho-de-verrugas-verdes	NE	-	-	III
9	*Pleurodeles waltl*	Salamandra-de-costelas salientes	LC	-	-	III
10	*Rana perezi*	Rã-verde	LC	V	-	III
11	*Salamandra salamandra*	Salamandra-de-pintas-amarelas	LC	-	-	III
12	*Triturus boscai / Lissotriton boscai*	Tritão-de-ventre-laranja	LC	-	-	III
13	*Triturus marmoratus pygmeus*	Tritão-marmorado	LC	IV	-	III

Portuguese Red Data List for Vertebrates (PRDLV) - EX: “Extinct", EW: "Extinct in the Wild", RE: “Regionally Extinct”, CR: "Critically endangered", EN: “Endangered“, VU: “Vulnerable”, NT: "Near Threatened", LC: “Least Concern”, DD: “Data Deficient”, NA: “Not Applicable” and NE: “Not Evaluated.

EU Habitats Directive (HD) - *: Priority Species; Annex II: species whose conservation requires the designation of special areas of conservation; Annex IV: species in need of strict protection; Annex V: species whose taking in the wild and exploitation may be subject to management measures.

Bonn Convention (Bonn) - Appendix I: migratory species whose immediate protection is required; Appendix II: migratory species whose conservation and management should be covered by means of transnational agreements.

Bern Convention (Bern) - Appendix II: strictly protected fauna species; Appendix III: protected fauna species.

1.5 Mammal species selected for implementation in BIO-SAFE Sado

Mammals						
	Nomenclature		**Legislation**			
Nr	Scientific name	Portuguese name	PRDLV	HD	Bonn	Bern
1	*Barbastella barbastellus*	Morcego-negro	DD	II, IV	II	II
2	*Dama dama*	Gamo	NE	-	-	III
3	*Crocidura russula*	Musaranho-de-dentes-brancos	LC	-	-	III
4	*Eliomys quercinus*	Leirão	DD	-	-	III
5	*Eptesicus serotinus*	Morcego-hortelão	LC	IV	II	II
6	*Erinaceus europaeus*	Ouriço-cacheiro	LC	-	-	III
7	*Felis silvestris*	Gato-bravo	VU	IV	-	II
8	*Genetta genetta*	Geneta	LC	V	-	III
9	*Herpestes ichneumon*	Saca-rabos	LC	V	-	III
10	*Lepus granatensis*	Lebre	LC	-	-	III
11	*Lutra lutra*	Lontra	LC	II, IV	-	II
12	*Lynx pardina*	Lince-ibérico	CR	*II, IV	-	II
13	*Martes foina*	Fuinha	LC	-	-	III
14	*Meles meles*	Texugo	LC	-	-	III
15	*Microtus cabrerae*	Rato de Cabrera	VU	II, IV	-	II
16	*Miniopterus schreibersii*	Morcego-de-peluche	VU	II, IV	II	II
17	*Mustela nivalis*	Doninha	LC	-	-	III
18	*Mustela putorius*	Toirão	DD	V	-	III
19	*Myotis daubentonii*	Morcego-de-água	LC	IV	II	II
20	*Myotis myotis*	Morcego-rato-grande	VU	II, IV	II	II
21	*Nyctalus leisleri*	Morcego-arborícola-pequeno	DD	IV	II	II
22	*Oryctolagus cuniculus*	Coelho-bravo	NT	-	-	-
23	*Pipistrellus kuhlii*	Morcego de Kunl	LC	IV	II	II
24	*Pipistrellus pipistrellus*	Morcego-anão	LC	IV	II	III
25	*Plecotus austriacus*	Morcego-orelhudo-cinzento	LC	IV	II	II
26	*Rhinolophus hipposideros*	Morcego-de-ferradura-pequeno	VU	II, IV	II	II
27	*Rhinolophus mehelyi*	Morcego-de-ferradura-mourisco	CR	II, IV	II	II

Mammals						
	Nomenclature		**Legislation**			
Nr	Scientific name	Portuguese name	PRDLV	HD	Bonn	Bern
28	*Rhinolophus euryale*	Morcego-de-ferradura-mediterrânico	CR	II, IV	II	II
29	*Rhinolophus ferrumequinum*	Morcego-de-ferradura-grande	VU	II, IV	II	II
30	*Suncus etruscus*	Musaranho-anão	LC	-	-	III
31	*Tadarida teniotis*	Morcego-rabudo	DD	IV	II	II
32	*Tursiops truncatus*	Roaz	LC	II, IV	-	II

Portuguese Red Data List for Vertebrates (PRDLV) - EX: “Extinct", EW: "Extinct in the Wild", RE: “Regionally Extinct”, CR: "Critically endangered", EN: “Endangered“, VU: “Vulnerable”, NT: "Near Threatened", LC: “Least Concern”, DD: “Data Deficient”, NA: “Not Applicable” and NE: “Not Evaluated.

EU Habitats Directive (HD) - *: Priority Species; Annex II: species whose conservation requires the designation of special areas of conservation; Annex IV: species in need of strict protection; Annex V: species whose taking in the wild and exploitation may be subject to management measures.

Bonn Convention (Bonn) - Appendix I: migratory species whose immediate protection is required; Appendix II: migratory species whose conservation and management should be covered by means of transnational agreements.

Bern Convention (Bern) - Appendix II: strictly protected fauna species; Appendix III: protected fauna species.

1.6 Fish species selected for implementation in BIO-SAFE Sado

Fish						
	Nomenclature		**Legislation**			
Nr	Scientific name	Portuguese name	PRDLV	HD	Bonn	Bern
1	Acipenser sturio	Esturjão	EX	II, IV	II	III
2	Alosa fallax fallax	Savelha	VU	II, V	-	III
3	Anguilla anguilla	Enguia	EN	-	-	-
4	Barbus bocagei	Barbo-comum	LC	V	-	III
5	Chondrostoma lusitanicum	Boga-portuguesa	CR	II	-	III
6	Chondrostoma polylepis	Boga-comum	LC	II	-	III
7	Cobitis paludica	Vedermã	LC	-	-	III
8	Gasterosteus gymnurus	Esgana-gata	EN	-	-	-
9	Hippocampus hippocampus	Cavalo marinho	-	-	-	II
10	Hippocampus ramulosus	Cavalo marinho	-	-	-	II
11	Petromyzon marinus	Lampreia marinha	VU	II	-	III
12	Pomatoschistus microps	Caboz	-	-	-	III
13	Pomatoschistus minutus	Caboz da areia	-	-	-	III
14	Squalius alburnoides	Bordalo	VU	II	-	III
15	Squalius pyrenaicus	Escalo do sul	EN	-	-	III
16	Syngnathus abaster	Agulhinha marinha	-	-	-	III

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