Portugal Millennium Ecosystem Assessment

State of the Assessment Report

A contribution to the Millennium Ecosystem Assessment, prepared by the Portugal Sub-Global Assessment Team

This report is a contribution to the Millennium Ecosystem Assessment prepared by the Portugal Sub-Global Assessment Team. The report has been prepared and reviewed through a process approved by the MA Board but the report itself has not been accepted or approved by the Assessment Panel or the MA Board.

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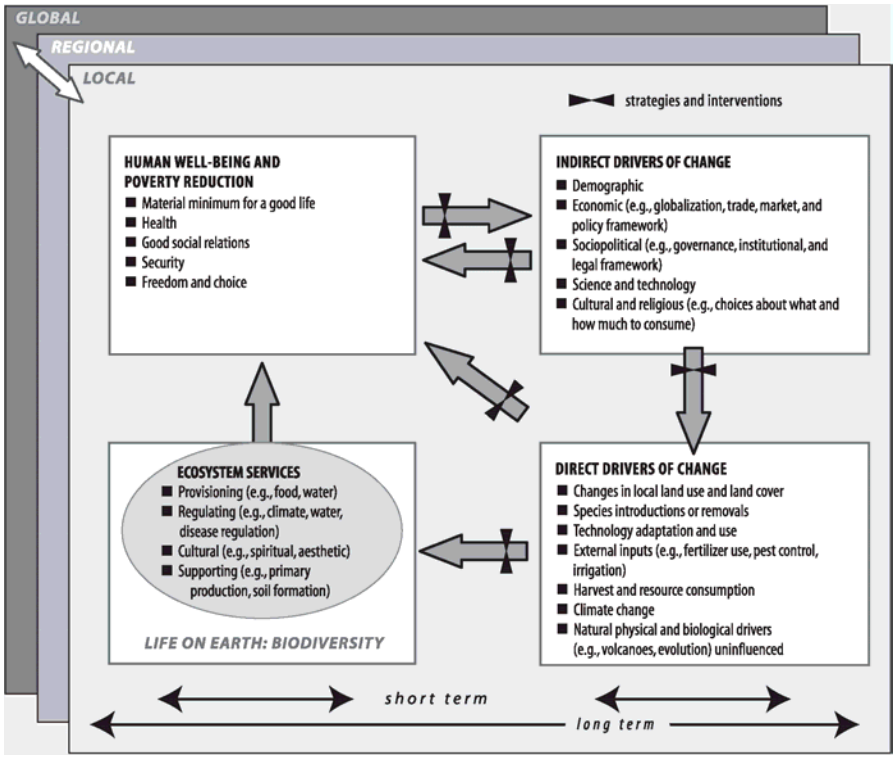
1 Introduction

The Millennium Ecosystem Assessment (MA) is an international assessment designed to meet the needs of decision makers for scientific information, concerning the consequences of ecosystem change for human well-being, and options for responding to those changes. The MA was launched by UN Secretary-General Kofi Annan, and was designed to meet some of the assessment needs of the Convention on Biological Diversity, Convention to Combat Desertification, and the Ramsar Convention on Wetlands. The Millennium Ecosystem Assessment is a multi-scale assessment, consisting of interconnected assessments at the global, sub-global and local levels.

There are 16 approved sub-global assessments, such as Sweden, Southern Africa, Philippines, and Western China. Portugal joined this group of sub-global assessments in May 2003, in an initiative led by the Centro de Biologia Ambiental of the University of Lisbon. The Portugal Assessment will continue till the end of 2005. The Portugal Sub-Global Assessment (ptMA, http://www.ecossistemas.org) is analyzing the condition of ecosystem services in Portugal, recent trends in those services, available policy responses, and scenarios for the next 50 years, following the conceptual framework of the MA (Figure 1). The MA assesses how factors that indirectly affect ecosystems (e.g. lifestyles) can lead to changes in factors that directly affect ecosystems (e.g. land use). The consequences of those changes for ecosystem services are identified, which in turn have impacts on human well-being. Both extractive services such as food production and non-extractive services, such as soil protection, are being analyzed in the ptMA.

Figure 1: Conceptual framework of the Millennium Ecosystem Assessment (MA 2003).



The Portugal Assessment is composed of a research team and a group of users. The research team has over thirty scientists from the natural and social sciences. The users are both the primary receivers of the information to be produced and stakeholders of the ecosystems to be assessed. They represent different sectors of society, including national and local government, non-governmental organizations, agriculture and industry.

1.1 A brief socio-ecological description of Portugal

Portugal covers an area of c. 92 000 km^2 with a population of about 10 million, and has an oceanic exclusive economic zone of c. 1 700 000 km^2 most of which associated with the Azores and Madeira archipelagos (Figure 2). The annual GDP per capita in 2002 was 12500€ (DPP 2003).

Portugal mainland has, from a climatic point of view, a clear Mediterranean influence, with dry and hot Summers and rainy Winters, but it is also influenced by the Temperate macroclimate. This situation leads to a notable climatic variation, that is confirmed by gradients of basic climatic data (Miranda 2002):

- Annual precipitation ranges from less than 400 mm in the Guadiana valleys (South of Portugal) to more than 3000 mm in the mountain range of Gerês (North of Portugal). The average number of rainy days ranges from 15 to more than 90.
- Mean annual temperature ranges from 6-8^o C in the mountains in the North and Center to 18-20^o C in the valleys of Algarve (South). Mean minimum temperatures ranges from -2^o C in the mountains in the North, to 8-10^o C in Algarve.
- Mean number of frost days ranges from less than 2 to 100. The number of days with tropical nights (nights with more than 20^o C) ranges from less than 2 to 20.

There is also a high diversity of lithological material including limestone, arenites, schists, serpentine, granite, and others (Silva 1982), which associated to the diversity of climatic situations, leads to a large diversity of soil types (Cardoso 1973) and ecosystems. The last glaciations only affected the mountain areas of Portugal (Zbyszewsky 1958), therefore many ecosystems and species were able to survive that period, which contributed to increased species and biota diversity. Some examples are the Tertiary relicts *Rhododendron pónticum* and *Asplenium cuneifolium* (Pinto da Silva 1967).

This diversity of ecosystems, confined to small spaces, result in many areas of ecosystem transition or ecotones, which are associated with high biodiversity. This is attested by the numerous endemisms and classified habitats, despite the insufficient number of studies for a complete assessment of this diversity. On the other hand, Mediterranean agriculture, thousands years old, has created a set of humanized habitats with high conservation value (Ministério Agricultura 1994), upon which the conservation of several species depends. Examples of such habitats are the "montado", the cereal steppe and the mountain "lameiros".

Portugal is one of the European Mediterranean countries where desertification has highest environmental risks (Sequeira 1998a, b, c), particularly risks associated with soil degradation caused by water erosion (Giordano 1992) and with the degradation of surface and underground waters (GCID 1998). Portugal ecosystems and agriculture are also particularly vulnerable to climate change (Santos *et al.* 2002), because of fire risk, water scarcity, and the number of species and habitats already threatened.

In conclusion, for its size Portugal is one of the European countries with highest diversity of organisms and farming systems, but at the same time is one of the countries more vulnerable to the loss of that diversity.

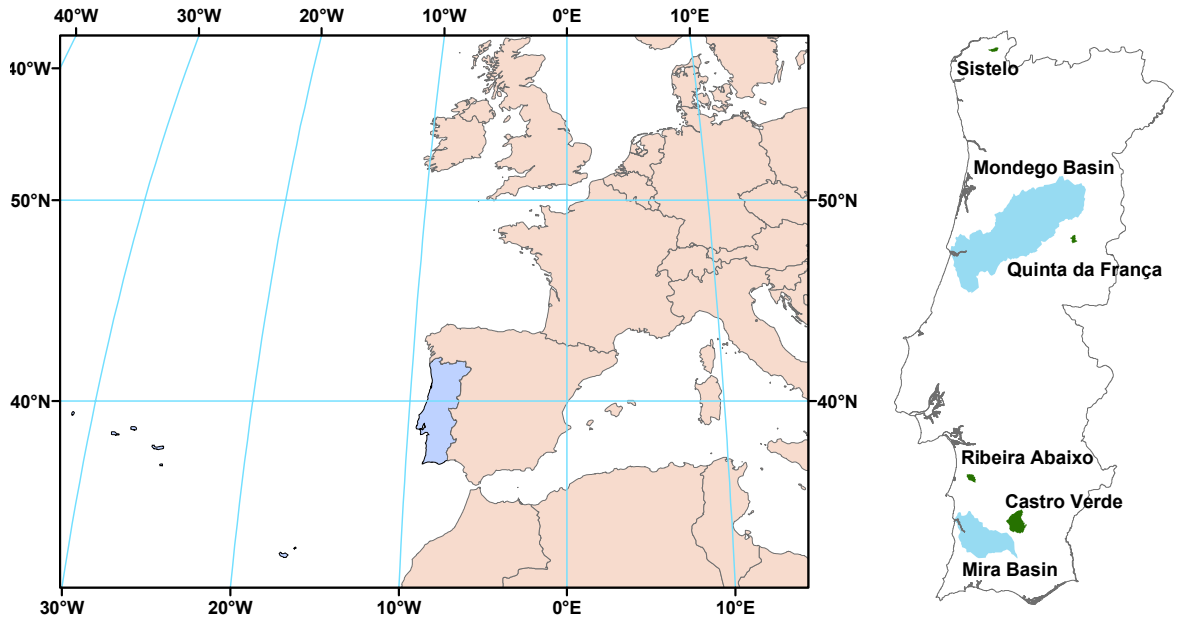
1.2 Scales and Systems

The ptMA was conceived from the outset as a multi-scale assessment. Scales and sites were chosen to balance relevance to users with availability of data. Users were engaged at different scales of the assessment. For instance, some of the study areas at local scales where chosen based on local user needs. Interestingly, national-scale users also contributed to choosing study areas at the basin and local scales. It is important to remark that study cases are not

fully representative of the country, but instead are designed to provide particular insights into ecosystem changes at each scale.

The Portugal Assessment is being undertaken at three scales: national, basin and local (Figure 2). Broadly speaking, and taking the national scale as the largest level that could be addressed, these were natural choices. However, it would have been interesting to address wider spatial scales. In particular, this would have meant the ability to address catchment basins not exclusively within Portugal, which is particularly important, given that these basins comprise a large proportion of the Portugal continental area. The basin scale is well suited for the ecosystem services approach, given that it integrates land ecosystems with freshwater ecosystems in a functional framework. One weakness of the basin scale is that it does not give any information about the basins in the rest of the country. The national scale is important for national government institutions to assess their policies, but has the weakness of being a much more difficult undertaking.

Figure 2: Geographic situation of Portugal (mainland and islands) and of the case studies of the Portugal Assessment.

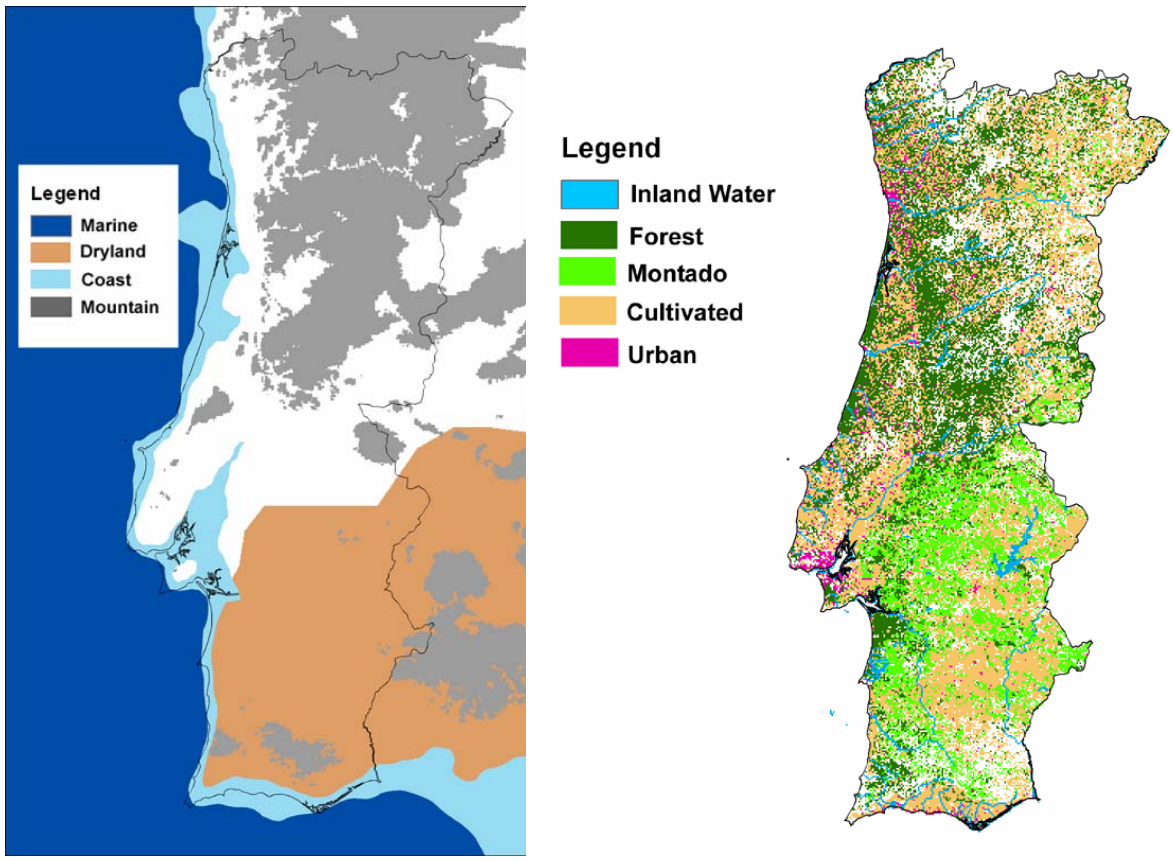


At the national scale the assessment is being organized into reporting units based on the global MA systems (MA 2003), but adapted to the needs of the Portugal users (Figure 2). The Marine system corresponds to marine areas where the sea is deeper than 50 m. The Coastal system is the interface between ocean and land, typically areas 50 m below sea level and 50 m above high tide level. The Inland Water system are the permanent water bodies inland from the coastal zone. The Montado system is an evergreen oak woodland, where the predominant tree species are the cork-oak (*Quercus suber*) and holm-oak (*Quercus ilex ssp. Rotundifolia*) Montado is an agroforestry system, where the main activities are cork, livestock and cereal crop production. Montado is an economically and ecologically important system and is characteristic of Portugal and Spain (where it is called *dehesa*), and therefore it is not a global MA system. However Montado corresponds to the overlap of the global Dryland and Forest systems in Portugal. Forest is land dominated by trees but excluding Montado. Cultivated are lands dominated by domesticated plant species. Mountain are steep and high lands. Islands correspond mainly to the Azores and Madeira archipelagos. Urban are human settlements with a population of 5000 or more.

For the basin scale, it was decided to choose basins for two rivers with contrasting situations: almost "natural" (Mira, in Alentejo[1], with 1576 km^2); heavy human influence (Mondego, in Beira Litoral, with 6670 km^2). The Mira is considered the best representative in Portugal of a pristine estuary and was also chosen due to a request from ICN to have an estuary in southern Portugal. The Mondego estuary was chosen because it has been intensively studied by a research group at the University of Coimbra.

At the local level, the sites were chosen based on users needs, the existence of past or ongoing research and/or demonstration activities, and as to cover different reporting units. This introduced a constraint, since none of these sites was within the two catchment basins studied. Sistelo is a municipality with 340 inhabitants and 27 km^2, adjacent to the National Park of Peneda-Gerês, in a mountainous area. Quinta da França is a farm with 5 km^2, in central Portugal, comprising several reporting units: inland water, forest and cultivated. Herdade da Ribeira Abaixo is a biological research station with 2.21 km^2, in an area of *montado*. Castro Verde is a farming area of cereal steppes.

Figure 3: Distribution of the mainland systems analyzed in the Portugal Assessment (Direcção erald as Florestas 2003; MA 2004).



1.3 Overview of the Report

This document presents the methods, the main results and the issues that arose in the Portugal Assessment during the first year of the assessment. It is organized to respond to questions posed by the MA Sub-Global Working Group, and mainly follows the chapter organization of the book that will summarize the results from the several sub-global assessments. The organization of the Portugal Assessment Book will be somewhat different.

[1] For a map of Portugal regions, please see Appendix B.

The report begins with the description of the assessment process, establishing the initial motivation for the assessment and its organization into users, research team, steering committee and advisory board. Particular attention is given to describing the process of user engagement, a crucial component in this type of exercise. Financial support, products, review process and timetable are then described. The major section in this chapter is the identification of user needs, which set the scene for the assessment effort. Chapter 3 does a brief analysis of ecosystem services and their relation to well-being. Chapter 4 establishes and analyzes the major drivers of ecosystem change in Portugal and their interactions. Drivers underlie the following three chapters: they are the ultimate determinants of the conditions and trends in ecosystem services, they are the focus of responses and their uncertainty with respect to their dynamics and effects establishes the different scenarios to be addressed. Chapter 5 consists of the analysis of conditions and trends. It is first carried out service-wise, for two services: water provisioning and biodiversity. It is then carried out system-wise, for three systems: marine/coastal; forest/montado; and cultivated. For these systems, the full set of services considered in this assessment is analyzed. The chapter concludes with a synthesis table, summarizing the conditions and trends for all the analyzed services and systems. Chapter 6 addresses responses to the major drivers affecting the priority systems of this assessment: cultivated and forest. Chapter 7 presents the preliminary scenario analysis. Chapter 8 presents the study cases of the Portugal Assessment, analyzing the services at the basin and local scales. This includes the community assessment in Sistelo, which is carrying out the complete conceptual framework (drivers, conditions and trends, responses, scenario) at a local scale. The concluding chapter analyses to what extent this report has addressed users' needs and integrates the findings at multiple scales.

2 Assessment Process

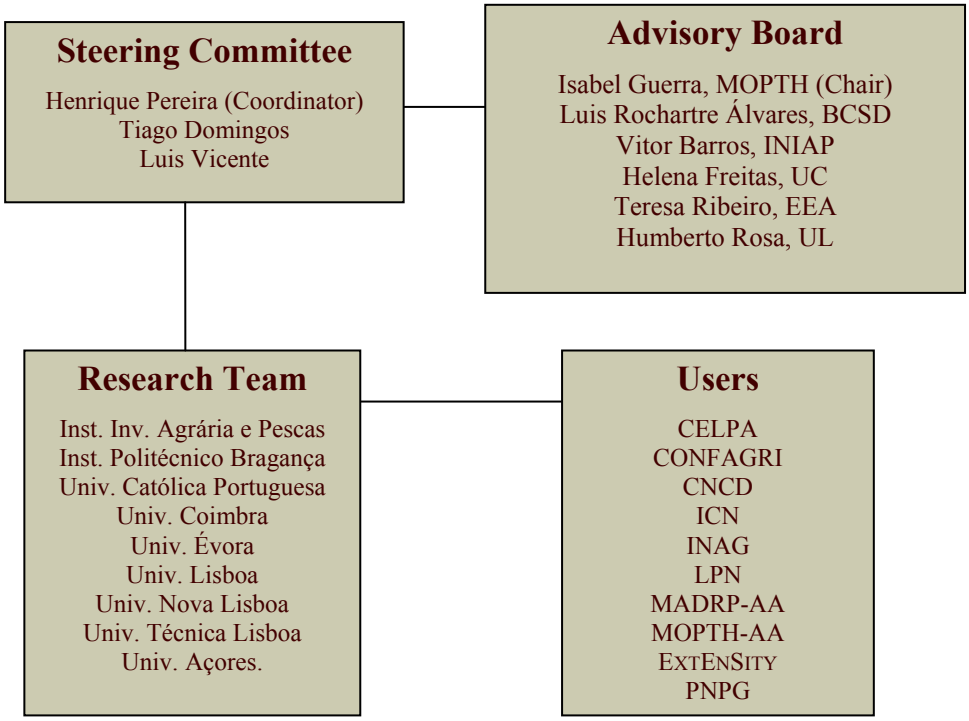
The Portugal Assessment started by the initiative of Henrique M. Pereira, Tiago Domingos, and Luis Vicente, who became the Steering Committee for the Assessment. They felt that the MA would be an opportunity to bring some of the new research being done in the ecosystem services arena into policy making in Portugal. Initial contacts with the MA Sub-Global Coordinator started in November 2002. Potential research team members and users were contacted by e-mail with a follow-up by phone, from November through December 2002, with the application for candidate assessment being submitted to the MA by January 2nd, 2003. Core financial support from the MA was received on April 16th, with the first meeting of the research team and users taking place on May 7th, 2003.

2.1 Organization

The Portugal Assessment is coordinated by the Centro de Biologia Ambiental (CBA) of the Faculdade de Ciências da Universidade de Lisboa. The CBA is a research center that integrates over 40 scientists working in environmental and conservation issues. The CBA manages dozens of scientific projects and has an annual budget for research of approximately one million dollars.

The Portugal Assessment is organized in four groups: the steering committee, the advisory board, the research team and the group of users (Figure 4).

Figure 4: Organizational chart of the Portugal Assessment.



2.1.1 *The users*

The users represent different sectors of society, including national and local government, non-governmental organizations, agriculture and industry (in parentheses we indicate the name of the representative):

National users

- Paper Industry Association, CELPA (Paulo Canaveira);
- National Confederation of Agricultural Cooperatives and Credit, CONFAGRI (Cátia Rosas);
- Portuguese Focal Point of the Convention to Combat Desertification, CNCD (Victor Louro)
- Institute for Nature Conservation, ICN (Henrique Carvalho);
- Institute of Water, INAG (Simone Pio);
- League for the Protection of Nature, LPN (Nuno Sarmento);
- Ministry of Agriculture, Rural Development and Fisheries – Environmental Auditor, MADRP-AA (Teresa Avelar);
- Ministry of Public Works, Transportation and Housing – Environmental Auditor, MOPTH-AA (Isabel Guerra);

Local users

- EXTENSITY Project (Tiago Domingos);
- National Park of Peneda-Gerês, PNPG (Henrique Carvalho).

Users have been engaged since the beginning of the assessment. They played a primary role in choosing scales, case studies at each scale, drivers and ecosystem services. Users expressed interest in following the progress of the scientific work very closely, so that they could provide feedback. This has been achieved by having users participating in the research team meetings. Users have been extremely active in scenario building and in the qualitative

assessment of conditions and trends of ecosystem services. In a few cases, users are providing the leading scientists for chapters of the assessment.

As the assessment work progressed, it became apparent that for the community assessment of Sistelo, both the National Park and the local community are users of the assessment. While no representatives of that community have been formally invited to the research team meetings, the community has been involved in the assessment through a set of participatory approaches (Section 8.2).

2.1.2 The research team

The assessment team has a wide range of expertise, covering multiple scientific disciplines and Portugal regions (Table 2.1 and Table 2.2).

Table 2.1: Lead Authors.

Name	Organization	Field of Expertise
Américo Mendes	Universidade Católica do Porto	Economics
Carlos Aguiar	Instituto Politécnico de Bragança	Agronomy
Carlos Carmona Belo	Inst. Nac. Inv. Agrária Pescas	Agronomy
Elvira Pereira	Universidade Técnica de Lisboa	Social Sciences
Eugénio Sequeira	Escola. Sup. Univ. Vasco da Gama	Soil Science
Fátima Borges	Inst. Nac. Inv. Agrária Pescas	Marine Ecology
Fernando Brito Soares	Universidade Nova de Lisboa	Economics
Francisco Andrade	Universidade de Lisboa	Marine Ecology
Fuensanta Salas Herrero	Universidade de Coimbra	Aquatic Ecology
Helena Adão	Universidade de Évora	Aquatic Ecology
Helena Freitas	Universidade de Coimbra	Terrestrial Ecology
Henrique Cabral	Universidade de Lisboa	Marine Ecology
Henrique Miguel Pereira	Universidade de Lisboa	Terrestrial Ecology
João Carlos Marques	Universidade de Coimbra	Aquatic Ecology
João Santos Pereira	Universidade Técnica de Lisboa	Forest Science
Luís Vicente	Universidade de Lisboa	Terrestrial Ecology
Maria Amélia Loução	Universidade de Lisboa	Terrestrial Ecology
Maria João Burnay	Universidade Técnica de Lisboa	Environmental Anthropology
Miguel Araújo	Universidade de Évora	Terrestrial Ecology
Paulo Borges	Universidade dos Açores	Terrestrial Ecology
Rui Rebelo	Universidade de Lisboa	Terrestrial Ecology
Rui Tomás Marques	Universidade de Lisboa	Ecology and Tourism
Simone Pio	Instituto da Água	Environmental Science
Tiago Domingos	Universidade Técnica de Lisboa	Ecological Economics

Table 2.2: Contributing Authors.

Name	Organization	Field of Expertise
Alexandra Correia	Universidade Técnica de Lisboa	Forest Science
Cibele Queiroz	Universidade de Lisboa	Terrestrial Ecology
Helena Carvalho	Universidade de Coimbra	Aquatic Ecology
Cristina Marta	Universidade de Coimbra	Ecological Economics

Humberto Martins	University of Manchester	Social Anthropology
Joaquim Marques Ferreira	EDIA	Economics
Francisco Fonseca	Universidade de Lisboa	Terrestrial Ecology
Margarida Santos-Reis	Universidade de Lisboa	Terrestrial Ecology
Margarida Ferreira	Universidade de Lisboa	Terrestrial Ecology
Maria João Martins	Universidade de Coimbra	Aquatic Ecology
Paulo Marques	Universidade de Lisboa	Terrestrial Ecology
Rute Pinto	Universidade de Coimbra	Aquatic Ecology
Vânia Proença	Universidade de Lisboa	Terrestrial Ecology

2.1.3 The steering committee

The steering committee coordinates all the technical work of the assessment, as well as all the logistic aspects, including preparation of the meetings, and the interaction with the users and the public at large. The steering committee also manages the assessment budget.

2.1.4 The advisory board

The advisory board's duties are: (1) to advise the steering committee on the conduction of the Portugal Assessment; (2) to coordinate the review process of the State of the Assessment Report and the Assessment Book. The board is composed by representatives from the research team, by scientists not involved in the research team, by representatives from the users group and by stakeholders not represented in the users group. The advisory board meets at least once each six months.

2.2 Financial Support

The major sources of financial support for the Portugal assessment were: core financial support from the MA ($32,500), outreach funds from the MA ($10,000), a grant from the Caixa Geral de Depósitos (2,500 €), and a grant from the University of Coimbra (750 €). There are also in-kind contributions from the home institutions of researchers (estimated as about $100,000, based on the time that researchers spend working on the assessment). The bulk of the MA core financial support (60%) is being used to support the costs of the meetings with the research team and the users. The rest of the MA core financial support is being used to support literature research, field work in the Sistelo assessment, and administrative costs. Extra financial and in-kind support for the research team meetings has been received from the Faculdade de Ciências da Universidade de Lisboa, Universidade Católica Portuguesa, Universidade Nova de Lisboa and Universidade Técnica de Lisboa, and from the Caminhos de Ferro, E.P.

2.3 Products

The three main products of the Portugal Assessment are: the User Needs and Response Options Report (available from http://www.ecossistemas.org), the State of the Assessment (this document), and the Portugal Assessment Book (to be published in 2005).

2.4 Review Process

The State of the Assessment Report (this document) was sent out for review by the users and by experts in early February 2004. The Advisory Board functioned as an editorial board, nominating the expert reviewers. Reviews were received during March, and the authors responded to these reviews over the next few months. The Advisory Board handled those responses and decided if they addressed the reviewers comments. In cases where no convergence between the authors and the reviewers was possible, the Advisory Board had three options: (1) note the divergence in the final document; (2) remove the contested part from the final document; (3) accept the reasons why the authors did not made the

modification suggested by the reviewer. A similar review process will happen for the Assessment Book in the first semester of 2005.

2.5 Timetable

The first months of the assessment were dedicated to assessing user needs and response options (Table 2.3). Next, work started on scenario development and on expert-based assessment of conditions and trends. At the same time, a zero-order draft of the Assessment Book to support the State of the Assessment Report was written. There was originally the intention of publishing this zero-order draft of the Assessment Book as a Pilot Assessment, but in late 2003 the decision was made of skipping the Pilot and expediting the publication of the Assessment Book. During 2004 work continued on the Assessment Book, and the field work for the study cases were finalized. The Assessment Book will be reviewed internally in the beginning of 2005, and there will be a Research Team and Users workshop dedicated to integrating the review comments into the document. The book will then sent out for an external round of review and will be published in late 2005.

Table 2.3: Timetable of the Portugal Assessment.

Date	Event
7 May 2003	Preparatory meeting
16-18 June 2003	Research Team and Users Workshop I: drafting of User Needs and Response Options Report, start of scenario development
August 2003	Publication of the User Needs and Response Options Report
9-10 October 2003	Research Team and Users Workshop II: continuation of scenario development, expert-based assessment of conditions and trends
December 2003	Preparation of the State of the Assessment Report for the MA
January 2004	Submission of the State of the Assessment to external review
11-12 March 2004	Research Team and Users Workshop III: response to reviewers, drafting of the Assessment Book, verification of assessment response to user needs.
December 2004	Publication of the State of the Assessment Report. Submission of the Assessment Book to internal review round
February 2005	Research Team and Users Workshop IV: integration of first round of reviews into the Assessment Book
April 2005	Submission of the Assessment Book to external review round
July 2005	Finalization of the Assessment Book chapters.
October 2005	Publication of the Portugal Assessment Book

2.6 User Needs

The next subsections summarize the User Needs and Response Options Report (available at http://ecossistemas.org). This report was the outcome of two one-day meetings with the users and was based on written contributions of each user describing their particular needs and response options. A word of caution should be said on the tables summarizing the user needs. If a user states that it needs information on a given ecosystem service and fails to mention others, it does not necessarily mean that the user places a smaller emphasis on those other services. It could just be that the user thinks it can get the information from sources other than ptMA, and therefore does not prioritize those services in the context of this assessment.

2.6.1 General user needs

All users stressed the need for tools for economic valuation of ecosystem services and for assessing the condition of ecosystem services (Table 2.4). Economic valuation of ecosystem services has received some attention over the last decade (Perman et al. 2003, Goulder and Kennedy 1997, Costanza 1997), but its application in decision-making in Portugal is still limited. Causes for this are multiple, but include lack of reliable data, lack of resources, and even some controversy associated to economic evaluation of nature. The benefits transfer approach (MA 2003), which allows to use estimates from other contexts in a new context, can avoid the need for data collection in some instances.

One problem discussed by the users in the context of assessing the condition of ecosystem services is how to define the reference condition. Another problem is how to use the condition of an indicator, such as the diversity of a taxon, to infer the condition of the services that an ecosystem provides.

A problem raised by some users is the equity of environmental benefits. For instance, if a farmer protects an ecosystem service that benefits people in a city several kilometers away, how can we ensure that the farmer is compensated? Another example would be an inhabitant of a Natural Park that is not allowed to build a certain infrastructure because of Park regulations protecting an ecosystem service that benefits the population at a national level.

The National Confederation of Agricultural Cooperatives and the League for the Protection of Nature raised questions on what will be the impact of European Union (EU) Directives on ecosystems and on the livelihood of the farmers. There were also questions about how to implement at the local level some of the measures in those directives.

Table 2.4: General information needs with high priority for each user.

	Economic Valuation of ES	Assessing Condition of ES	Equity of environmental benefits	CAP and Nitrate Directive	History of land-use	Natural Parks & Natura 2000	Agri-environmental measures
CONFAGRI	x		x	x	X	x	x
ICN	x					x	
MOPTH	x					x	
MADRP-AA	x	x			X		
LPN	x	x	x	x	X	x	x
CELPA		x					
INAG	x	x					
EXTENSITY	x	x	x				X
PNPG	x	x					

Information on the history of land-use change over the last century is limited. There are ongoing projects to systematize the available information for Alentejo (e.g Fundação da Ciência e Tecnologia, PCSH/C/HIS/709/93). Data at the national scale has been systematized for the last four decades, in the National Forest Inventory (DGF 2003a). However, digital maps are only available for the most recent inventory (1995-2001). More recently, the Corine Land Cover 2000 project has mapped changes for 1990-2000 for all EU member states. Users feel that it would be extremely important to systematize historical data on land-use change and to make that data available in digital formats.

Natura 2000 is a network designed to protect areas that represent unique ecosystems of the European Union, and is now starting to be implemented. The users raised questions on the socio-economic impacts of the implementation of these new protected areas, and on how

infrastructure and agricultural development can be made compatible with the goals of Natura 2000.

One component of the Common Agricultural Policy (CAP) of the EU is the implementation of agri-environmental measures, that is, subsidies for agricultural practices that are friendly to the environment. The National Confederation of Agricultural Cooperatives would like to know what is the economic value of the ecosystem services provided by small farmers, so that it could use those values as indicators in the negotiation of agri-environmental measures with the national government.

2.6.2 Systems and regions

Most users indicate Forest and Agriculture as priority systems for assessment (Table 2.5). Next in the scale of priorities are Oceans & Coast and Inland Waters (including wetlands). A few places and regions have also been suggested for assessment. All of these have been incorporated in the ptMA as study cases.

Table 2.5: Systems and regions with high priority for assessment.

	Forest	Agriculture	Oceans & Coast	Inland Waters	Other[2]
CONFAGRI	x	x			
ICN	x	x	x	x	River Basin in Alentejo
MOPTH	x		x		
MADRP-AA	x	x	x		
LPN		x	x	x	Farm in Castro Verde (Alentejo)
CELPA	x				
INAG			x	x	
EXTENSITY	x	x			Farm in Cova da Beira (Beira Interior)
PNPG	x	x			Sistelo region (Entre Douro e Minho)

2.6.3 Drivers and response options

Agricultural practices and land-use change (including habitat fragmentation and land-use planning) are the most important drivers to assess according to the users (Table 2.6). Furthermore, the users are now facing a few management options in agriculture and forestry including:

- choice between intensification of agriculture and forest plantations versus extensive land use practices;
- choice between conventional and organic farming;
- introduction or not of GMO's and exotic forest species.

Users would like to assess the impact of several pieces of legislation on ecosystem services, including the CAP, the Nitrate Directive and the Natura 2000 Protected Areas Network. Users are also concerned about the effects of erosion, pollution, and resource consumption on ecosystem services. The fragmentation of habitats and the direct impacts caused by infrastructure construction, particularly highways, railways, and urban development, also rank high in users' concerns. Finally, climate change, consumer behavior and species introductions are indicated as other drivers worth studying.

[2] For a map of Portugal regions please see Appendix B.

Both the Ministry of Public Works and the League for the Protection of Nature have raised questions on the best approach to comply with the Kyoto Protocol. At least two responses have been considered by the government:

- development of wind farms and other alternative energy sources;
- reduction of energy consumption.

Table 2.6: Drivers and response options with high priority for assessment.

	Consumer behavior	Legislation	Agricultural practices and land-use change	Resource and nutrient consumption	Erosion and pollution	Species introductions	Climate change	Infra-structure construction
CONFAGRI		x	x			x	x	
ICN		x	x	x				x
MOPTH			x		x		x	x
MADRP-AA			x					
LPN	x	x	x		x	x		x
CELPA	x		x	x	x			
INAG		x	x	x	x		x	
EXTENSITY			x					
PNPG		x	x					

2.6.4 Ecosystem services

All users suggest that biodiversity should be assessed by the ptMA (Table 2.7). The ecosystem services ranking next in users' priorities are: Recreation and Cultural; Soil and Flood Protection; Primary Productivity and Climate Regulation. An important component of the Recreation and Culture service mentioned by the users is the landscape value. Many people place a high value on the conservation of a given type of landscape, for instance the agricultural landscape "socalcos", where a mountain slope is divided in agricultural terraces at successive heights. The role of the Portugal forest and other ecosystems as carbon sinks, and the ways in which climate regulation services may be improved is important in order to Portugal fulfill its Kyoto Protocol requirements. The role of forests and of different agricultural practices in soil and flood protection has recently gained even more importance, after the largest wildfires in recent Portugal history affected in 2003 an area of over 420,000 ha (DGF 2003b). Among the provisioning services, users prioritize food and water.

Table 2.7: Ecosystem services with high priority for assessment.

	Food	**Water**	**Wood**	**Biodiversity**	**Primary Productivity & Climate Regulation**	**Soil and Flood Protection**	**Recreation & Cultural**
CONFAGRI	x	x		x	x	x	x
ICN	x	x	x	x	x	x	x
MOPTH	x	x	x	x	x	x	x
MADRP-AA				x			x
LPN	x	x		x	x	x	x
CELPA			x	x	x	x	
INAG		x		x	x	x	
EXTENSITY	x			x	x	x	x
PNPG				x			x

3 Ecosystem Services and Human Well-Being

The concept of ecosystem services is still new to many biologists and environmental scientists. This poses two major difficulties. First, it requires scientists to change their frame of mind to an anthropocentric perspective. Second, it requires scientists to familiarize themselves with tools for the valuation of ecosystem services, including economic tools. Establishing, as in this assessment, interdisciplinary teams, with social scientists, natural scientists and policy-makers, to analyse the relations between ecosystem services and human well-being, is crucial.

3.1 Choice of Ecosystem Services

The following services were selected by the ptMA to be assessed at the national scale:

- Biodiversity
- Provisioning services: water, food, and fiber
- Regulating services: climate regulation, soil protection & runoff regulation
- Cultural services: recreation.

Most of these services have also been analyzed at the basin and local levels, but in some instances other services have been added. For instance, landscape aesthetic value, sense of place and cultural heritage were identified as important services in the Sistelo case, and educational services were recognized in the Quinta da França and Herdade da Ribeira Abaixo cases.

The choice of the services analyzed at the national scale was done according to the following criteria:

- to guarantee that both extractive and non-extractive services were assessed;
- to guarantee that there was know-how on those services in the research team (although the research team was also iteratively adapted to fit the services which were going to be studied);
- to respond to the requirements of the users.

3.2 Relevant Components of Well-being

Well-being is a multidimensional, complex and context dependent concept. The Conceptual Framework of the MA considers five components of human well-being: material minimum for a good life, health, good social relations, security and freedoms and choice. Freedoms and choice is closely linked to the other four dimensions of well-being and reflects, in particular, the ability to achieve what a person values doing or being (MA, 2003). In the ptMA, well-being is being studied at two scales, the national scale and the local scale.

At the national scale measuring well-being poses particular challenges: different groups perceive and experience well-being differently and there are several different indicators and indices that can be considered for the assessment of human well-being. The ptMA is using indicators on income, comfort, health, literacy, education and participation, from the National Institute of Statistics, Eurostat and UNDP, to assess trends of well-being at the national level. Because averages conceal unequal distribution of well-being, issues of equity will be addressed using income poverty indicators and disaggregating some indicators by location (e.g. rural/urban) and gender.

Indicators more closely related to ecosystem services, covering the five components of human well-being, will also be used, linked for example to income and employment (e.g. primary sector and environment-related employment), fresh water and clean air (e.g. drinking water quality, air quality and related diseases), recreation and learning (e.g. nature and rural tourism, use of protected areas as places of environmental education and awareness,

environmental education projects), environmental hazards (e.g. contaminated soil, soil threatened by desertification, formal complaints for environmental reasons), and environmental governance (e.g. number of environmental NGOs, environmentally related public participation).

The determinants and constituents of well-being are context dependent and, at a local scale, are best assessed by the people experiencing it. A participatory approach was conducted in Sistelo (see section 8.2) to assess local criteria for well-being. This local perception of well-being will be complemented with objective indicators that can be compared with existing data at the national level.

3.3 Connection between Ecosystem Services and Human Well-being

Human well-being depends on ecosystem services; without them, human life on Earth, as we know it, would be impossible. But human well-being does not depend only on ecosystem services. Indeed, "the capacity of any society to meet the «requirements» of individual well-being depends on the level and quality of a range of assets – and on how society deploys them" (World Bank, 2003). These assets include not only natural assets but also human assets, human-made assets (physical and financial), knowledge assets and social assets.

The context dependent nature of well-being, the diversity of factors influencing well-being, and the need to consider spatial and temporal scales, complicate the establishment of links between ecosystem services and human well-being.

Portugal is nowadays considered a High Development Country. In 2002, Portugal had a Human Development Index (HDI) of 0.897 and ranked 26th among 177 countries (Table 3.1). HDI is a synthetic index combining four indicators – life expectancy at birth, adult literacy rate, combined gross enrollment ratio for primary, secondary and tertiary school levels and GDP per capita.

Table 3.1: Some Standard Indicators of Human Well-being. Sources: UNDP, 1993, 2000 and 2004; World Bank 2004.

Standard Indicators of Human Well-Being	1990 Portugal	2002 Portugal	2002 Developing Countries	2002 OECD countries
Human Development Index (value)	0.847	0.897	0.663	0.911
Human Development Index (rank)	41	26	-	-
Life expectancy at birth (years)	74.0	76.1	64.6	77.1
Under-five mortality rate (per 1,000 live births)	15[(a)]	6	89	14
Adult literacy rate (% ages 15 and above)	87.2	92.5	76.7	97,4[(b)]
GDP per capita (PPP US$)	8,770	18,280	4,054	24,904

(a) World Bank 2004; (b) Data refer to 1998.

Note that the averages in Table 3.1 conceal large disparities. For instance, in 2001 illiteracy rate of women was 11,5% while the illiteracy rate of men was 6,3%. Alentejo and the center inland region registered the highest illiteracy rates, in 2001, ascending to 19,8% in the Pinhal Interior Sul region, while in Great Lisbon the illiteracy rate was 5,3% (INE, 2001). At a local level the disparity is even more evident, e.g. in the Sistelo community the illiteracy rate was 36% in 2001.

Some of the standard indicators of Human Well-being have been improving in the last decades. Life expectancy at birth has increased 8.2 years from 1970-75 to 2000-2005, under-five mortality rate (per 1,000 live births) has decreased from 62 in 1970 to 6 in 2002 (UNDP, 2004) and literacy rate has increased from 66.6% in 1970 to 91% in 2001 (INE, 2001). This reflects improved access to health and education services, mainly provided by the state, and rising incomes.

These improvements in well-being have not been accompanied by an overall increase in the capacity of Portugal's ecosystems to provide services in a sustainable way (see section 5). Three explanations can be proposed for this.

First, and as already referred above, human well-being depends on a range of assets, some of them not directly linked to ecosystem services. The effects of the democratization of the country in 1974 and of joining the European Union in 1986 were key in the societal, industrial, educational and health developments in Portugal.

Second, there is a time-lag between the deterioration of the capacity of ecosystems to provide services and the impacts of that deterioration. Nevertheless, the increasing costs of environmental degradation are already apparent. For instance, public administration expenses on environmental management and protection have registered a per capita increase of 3% per year, from 1996 to 2001, representing in this last year 0.71% of GNP (INE, 2003a)[3]. These public administration expenses do not reflect, of course, the costs of environmental degradation affecting human well-being but they are an important signal. Costs will also be supported in the future, reducing well-being of future generations. Formal complaints for environmental reasons have also been increasing, more than three fold from 1996 to 2001 – the average annual increase was 26% (INE, 2003). This increase does not directly reflect a similar increase in environmental hazards, and may be a reflection of increasing environmental awareness and improved public participation.

A third issue is the increasing access to ecosystem services provided elsewhere, best exemplified by food production. Some improvement in the sustainability of agricultural practices has been observed but there has been a stagnation of the production. Therefore the daily calorie intake per capita increase of 4,8% from 1990 to 1997, was achieved mainly through imported food products (INE, 1999).

4 Drivers of ecosystem change

4.1 Definitions

The MA conceptual framework defines driver as any natural or human-induced factor that directly or indirectly causes a change in an ecosystem (MA, 2003). This definition has been successfully applied in the ptMA.

A direct driver unequivocally influences ecosystem processes and therefore can be identified and measured to differing degrees of accuracy. Indirect drivers operate more diffusely, from a distance, often by altering one or more direct drivers. The indirect drivers of change are primarily demographic, economic, sociopolitical, scientific and technological, and cultural and religious; the direct drivers are primarily physical, chemical and biological (MA, 2003). The distinction between direct and indirect drivers has been useful, but is being redefined to better reflect the dynamics and nature of the drivers in the ptMA.

[3] Although this represents a general tendency for increase, we should note that in 2002 these expenses decreased 3% (INE, 2004).

Endogenous drivers are those under the direct control of a decision-maker at a certain level, while exogenous drivers are not (MA, 2003).

The scale of a driver describes the typical extent (in space) or duration (in time) over which it has its impact. The grain of a driver is the spatio-temporal size of the smallest unit that is internally homogeneous. The speed of a driver is a measure of how fast it changes, so it is inversely related to its temporal grain.

4.2 Methods

To assess drivers, it is not only important to have input from the scientific team but also from users. Users can give significant input on what drivers are most important given that in some instances they control the policies that affect the drivers, or they are a major force behind those drivers.

Drivers were assessed through expert judgment exercises in workshops with the research team and the users and through a literature review by the scientific team.

Participants in the workshops were asked to identify drivers and give them a mark of importance, 1 for the most important and 5 for the least important.

4.3 List of Drivers

The results obtained with respect to drivers are presented in Table 4.1. This table presents only those drivers that were considered more important. The majority of drivers are indirect. The direct drivers are in general the endogenous ones. The only driver whose speed was considered fast is fire. Almost all drivers operate at the national scale.

The **fire regime** in Portugal has become worse along time. For example, in 2003, 5% of the area in Portugal burned.

Land tenure and farm structure is a problem in central and northern Portugal (to the north of the Tagus) associated to very small rural properties, with owners having little patches scattered over many areas. In spite of migration to urban areas, average property area has not increased sufficiently (in Portugal, it has increased from 6 ha to 9 ha, which is still far from 26 ha in France or 70 ha in the UK).

Economic growth has occurred at a fast but decreasing rate in the last 20 years. A main characteristic in Portugal is that construction has a disproportionate amount of GDP.

Land use changes are related to bad land planning mechanisms, excessive and badly planned urbanization, construction of infra-structure, abandonment of agricultural fields, conversion from agriculture to forestry, and changes in agricultural practices: from intensive to extensive, from small scale to large scale, from diversified to specialized.

Tourism has been increasing steadily in Portugal, essentially in coastal areas, in the Algarve and the coast of Lisbon and now in the coast of Alentejo, where it has very serious impacts. The pressure for tourism has an exogenous component, from international tourism markets, but is mostly endogenous, through internal demand for holiday houses and the economic interests of the construction sector.

The introduction and spread of **exotic species** (e.g Acacia) has created serious ecological problems, mainly due to competition with native species.

With respect to **population distribution and migration**, there is a large and increasing population concentrated in the coastal area. The coastline extension leads to a strong polarization between littoral and inland, with 93% of the population living within 100 km of the sea (WRI, 2003a) and 65% within 60 km. There is immigration of Africans, Eastern

Europeans, EU citizens and Brazilians. The vast majority of migrants come to work in Portugal (INE 2003b), but retired citizens play an important role in the immigration from some EU countries such as United Kingdom (about 10%).

Environmental legislation and attitudes currently originate mostly at the EU level (or international level, e.g. the Kyoto protocol), but the enforcement of legislation is carried out at the national level. Being originated at the EU level, environmental legislation is essentially the outcome of the environmental attitudes of EU citizens as a whole. Enforcement is extremely weak in Portugal and there is not enough national citizen pressure, due to insufficiently environmental awareness. Also, government policies are extremely permeable to organized interests, particularly associated to the construction sector. Attitudes change slowly, but legislation changes slightly faster. What is needed is a significant upgrading of the performance of public administration, interest groups and entrepreneurs. And this implies a very significant allocation of human and financial resources (by all, including government) to the implementation of framework-laws such as the Water Law, the Natura 2000 Network or the Network of National Protected areas.

The introduction of the **EU Common Agricultural Policy** in Portugal, in the 1980's, led to major changes in Portuguese agriculture (structural adjustment, modernisation, intensification). After this, the Common Agricultural Policy has itself seen major changes. On the one hand, the increasing importance of environmental issues, initially with the creation of agri-environmental measures (within the Rural Development Programme) and more recently with the implementation of cross-compliance (access to the single payment will require fulfillment of a series of environmental obligations). On the other hand, the shift from production support to income support, culminating recently in the creation of the single payment, based on average historic land use by the farmer and independent of current use. The single payment, usually called "decoupling", may lead to a significant increase in agricultural abandonment and as yet unforeseable impacts on the agri-environmental measures.

Also important have been the changes in **international trade agreements**, bringing the EU internal agricultural market closer to the international market, and hence decreasing prices for agricultural products.

4.4 Interactions Between Drivers

We now provide a description of the major network of interactions between drivers (Figure 5).

Economic growth, in the 60's and after the integration of Portugal in the EU, in the 80's and 90's, has created an increasing attractiveness for activities in the industrial and services sectors (which, as usual during the economic development process, grow much faster than the agricultural sector). Effectively, this means increased labor costs in agriculture, either hired labor costs, for agricultural companies, or opportunity costs, for farmers exploiting their farms directly. At the same time, entry into the Common Market and the reforms in world trade agreements has implied decreased agricultural prices, only partially compensated for by subsidies. Hence, maintaining economic viability requires an increase in labor productivity, through either (1) extensification, i.e., substituting labor by land or (2) intensification, i.e. substituting labor by machines and production inputs (water, fertilizers, improved seeds). The choice between the two is mostly based on the quality of the original production factors (labor and land comprising farm size, soil quality and water availability). If it is high, there will be intensification; if it is low, there will be extensification. This choice will also be influenced by the financial capacity of the landowners. Intensification leads to increased water consumption and pollution risk. Extensification can mean a transition from arable crops to livestock production, but also afforestation or simply abandonment.

A particular type of transition is related to fast growing forest plantations (eucalyptus or maybe pines): it is extensification in the sense of being a forest and decreasing labor input per unit area; it is intensification in the sense of increased economic productivity per unit area.

The abandonment of agriculture facilitates the establishment of shrubs corresponding to initial stages of the ecological succession, affecting, both positive and negatively, fauna and flora (this is particularly well known in the holm-oak *montado)*. Also, increased labour costs have made the cutting of shrubs for animal bedding uneconomic, eliminating one of the controlling factors of these. Additionally, abandonment of agriculture leads to having less people occupying and tending the landscape, and to decreased landscape compartmentalization. All these effects create the conditions for the development of frequent and severe fire cycles, especially when large continuous areas of shrubland are created.

On the other hand, abandonment of crop cultivation has led to conversion to extensive animal husbandry, leading in many interior regions to burning by shepherds to maintain the ecosystem in the early succession stage of grassland, which has been a major factor in increasing fire ignitions.

The transition from agriculture to forests leads to increased fire risk, that risk being much higher when the transition is due to abandonment than when it is due to an active decision by the farmer to install a forest . Fire intensity is increased by lack of management. Forest fires leads to abandonment, both in itself and through increased soil erosion, which reduces the productivity of forests in a given area (and produces water pollution).

Table 4.1: Most important drivers of ecosystem change in Portugal. Abbreviations: Ex – Exogenous; En – Endogenous; D – Direct; I – Indirect; N – national scale; EU – European Union scale; Imp. – Importance, from 1 (highest) to 3 (lowest).

Driver	Ex/ En	D/I	Spatial Scale	Speed	Imp.
Fire regime	Ex/En	D	N	Fast	1
Land tenure and farm structure	En	I	N	Slow	2
Land use changes	En	D	N	Medium	1
Tourism	Ex/En	I	N	Medium	2
Exotic species	En	D	N	Medium	3
Economic growth	Ex/En	I	N	Medium	1
Population distribution and migration	Ex/En	I	N	Medium	2
Environmental legislation and attitudes	Ex/En	I	N/EU	Medium-Slow	2
EU Common Agricultural Policy and global markets	Ex	I	EU	Medium	1

As rural populations decrease, it becomes less viable for public services (e.g. schools, higher education, hospitals) to be provided, inducing an increased attractiveness differential between the interior and the coastal urban areas.

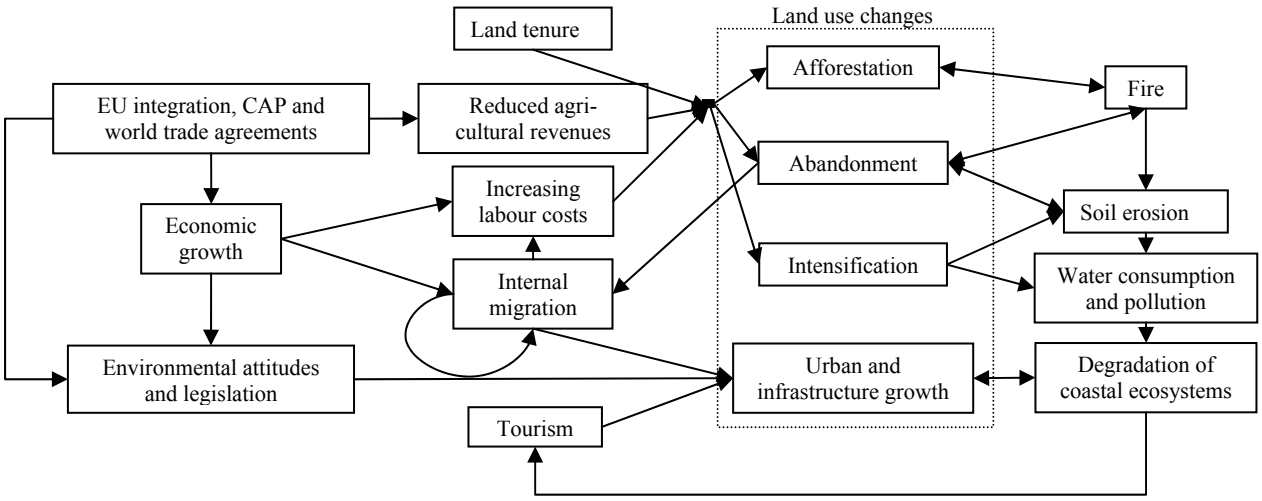
The slow increase in farm area hampers an additional crucial factor in the viability of agriculture: scale economies due to increasing farm size. Also, farmers have low qualifications and low innovation capacity.

The increase of importance of the industrial and services sectors also expands the attractive-ness of urban areas. The inexistence of adequate land planning mechanisms in Portugal does

not create an adequate control on this pressure. Additionally, in Portugal, the construction sector plays a disproportionate role in economic activity. For example, within the EU, Portugal is second only to Luxembourg in *per capita* consumption of cement, with this value being double the EU average and 2.5 times the value for the USA (Vieira 2003). This gives the sector disproportionate political power, allowing it to influence legislation on land planning and to lead the government to invest heavily in infrastructure. This adds up to fast urban and infrastructure growth (e.g highways). The former, taking place in coastal areas, places strong pressures on important ecosystems such as estuaries and coastal areas. The latter, affects important terrestrial ecosystems. The importance of the construction sector carries over to a construction-based approach to tourism, based on intensive exploitation of coastal areas, with the destruction of the attractiveness of the areas, itself the basis for tourist activity. This leads to a downward spiral, with decreasing value added per tourist leading to increasing number of tourists, and to the "colonization" of new tourist areas, in what might be called "slash and burn tourism".

It is frequently argued that economic growth, leading to increasing economic affluence, leads to increasingly favorable attitudes towards the environment. It is not clear that this is generally true, and in any case, these more favorable attitudes may be offset by the increased environmental pressure of a larger economy. For Portugal itself, the jury is still out on these effects. However, for the EU as a whole, it has been the case that economic affluence has in general bred environmental awareness. This is reflected in increasingly demanding environmental legislation, which must be adopted by Portugal (in some cases, based on average EU situations, and hence inadequate for the specific situations in Portugal). This legislation then creates the possibility of controlling the negative environmental effects mentioned above, but its real effectiveness is established by government budgeting, environmental monitoring and control, and environmental citizenship.

Figure 5: Illustration of interactions and feedbacks between drivers.



5 Conditions and Trends

The Portugal Assessment places an emphasis on evaluating the condition and trends of ecosystem services at the three scales of the assessment. This has been done through workshops with users and the research team, but also through the writing of review papers by the research team members. This section if based on the drafts of those papers and on the workshops.

5.1 Defining condition and trend

In a workshop dedicated to building a table of condition and trends for the ecosystem services of the Portugal systems by expert judgment, the definition of condition and trend was discussed at great length. It was apparent that it is very difficult to use a single definition across services. Furthermore, a definition that can be useful for an assessment by expert judgment may differ from the definition that is convenient for a technical paper. It was found that an important component of assessing condition is sustainability. For instance, in the MA framework for assessment (MA, 2003) it is suggested that for provisioning services both the flow and the stock of goods are relevant for the condition.

The ptMA settled on the following definition of the condition of an ecosystem service: *it is the current level of the service relatively to the level at which the service could be maximized in a sustainable way*. This definition places an emphasis on the status of the "stock" of the service. The trend of the condition was defined as the overall change in the condition over the last 40 years and looking into the next 10 years. If the condition was better 40 years ago than is likely to be 10 years into the future the trend was considered negative, and the trend was classified as positive if the reverse situation occurred. For provisioning services and recreation we also analyzed the trend of the production ("flow") of the service.

It was decided that the condition of a service in an area should be measured in relation to the current land-use of that area and not the potential land-use of that area.

5.2 Methods

For most ecosystem services there is little systematic information on the actual condition, and even less on trends. This has been identified as one area that needs more attention from the national government and public institutions.

Methods used in the Portugal Assessment include: geographic information systems, statistical modeling, compilation of published information, economic valuation, field work and expert opinion.

5.3 Services assessed nationally

In the ptMA, biodiversity and water provisioning are being assessed at a national scale across ecosystems. This section presents the preliminary results of this assessment.

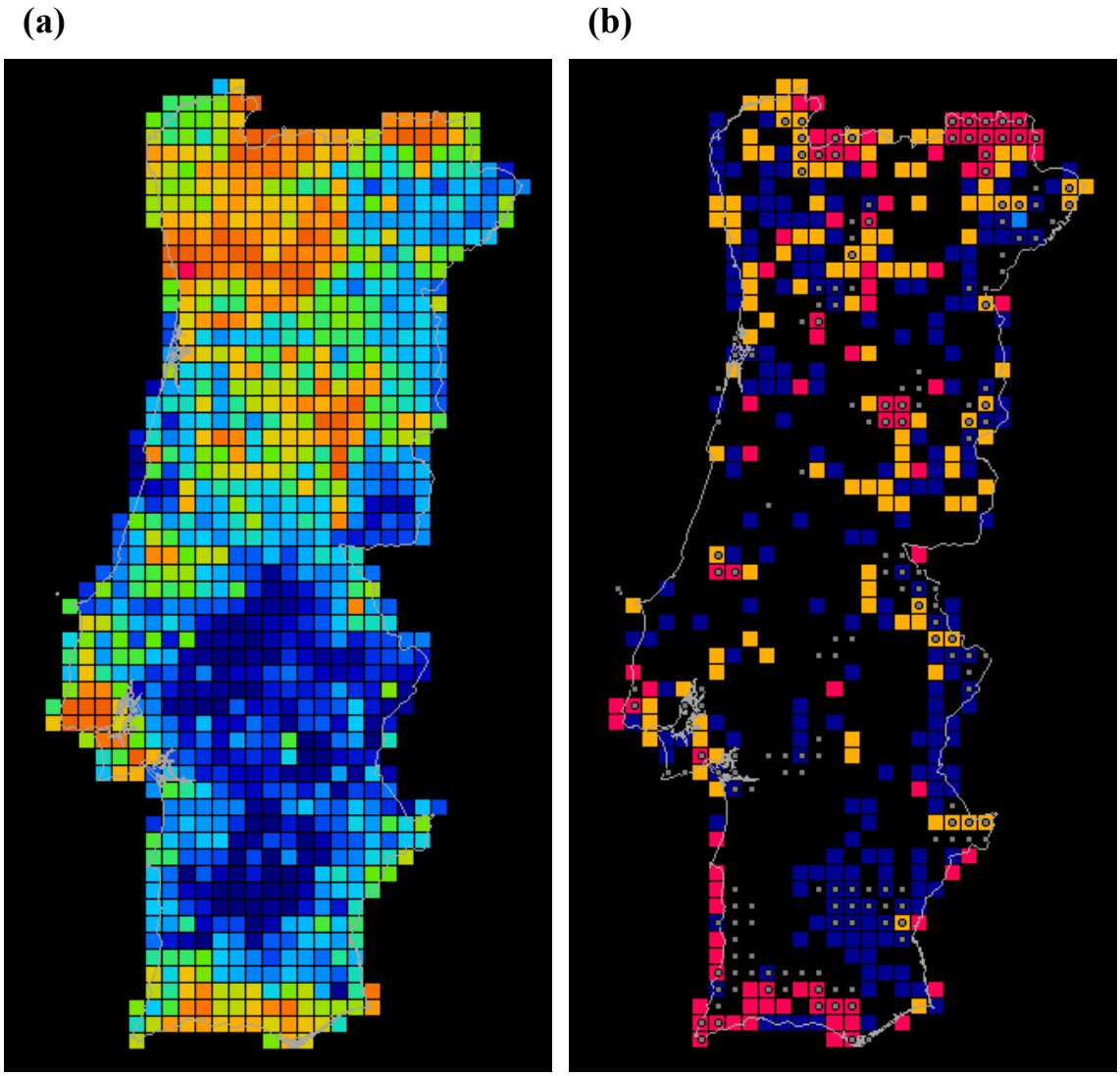
5.3.1 Biodiversity

Portugal has a very diverse fauna and flora for its size, and is part of one of the 25 world hotspots for biodiversity (Myers et al., 2000). Portugal has 67 mammal species (SNPRCN 1993), 207 breeding birds (Rufino 1989), 27 reptiles (Godinho et al. 1999), 17 amphibians (Godinho et al. 1999) and an estimated 3000 vascular plants species, of which 86 are endemic (Pereira et al. 2002). The wide variety of soil substracts, ranging from sand to ultrabasic rocks also support a high soil biodiversity.

There is still little data on the spatial distribution of the different species and even less on the historical trends of abundances and distribution. In the Portugal Assessment we aim to produce a biodiversity atlas at the resolution of the 10x10km UTM cell, using data for the best studied groups. Figure 6 is a first draft of such atlas, built in two stages. First, empirical data was compiled on the distribution of gymnosperms (Franco 1983), pteridophytes (Franco 1983), amphibians (Godinho et al. 1999), reptiles (Godinho et al. 1999), and butterflies (Maravalhas 2003). The spatial coverage of these datasets is in general far from complete. Therefore, to correct for sampling biases, we estimated for each species a distributional range based on one of the following models (Thuiller et al. 2003): General Linear Model, General Additive Model, Neural Networks and Classification Trees. The variables that were used in

the models as potential predictors were: run-off, soil pH, evapotranspiration, humidity, number of sun hours, precipitation, radiation, temperature, human population density, and percentage land cover of different ecosystems. For each species, each type of model was calibrated with 70% of the grid cells and tested in the remaining 30%. The model output is a probability of occurrence in each cell. For each species, the model with best fit was selected. Then, local richness for each grid cell was calculated by summing the predicted occurrences of all the species.

Figure 6: Spatial distribution of biodiversity in Portugal. (a) Species richness of selected groups (gymnosperms, pteridophytes, amphibians, reptiles, mammals and butterflies). Warm colors correspond to high species richness and cool colors to low species richness. (b) Irreplaceability of each UTM cell, measured as the number of range restricted species per cell. Decreasing levels of irreplaceability: red, yellow, blue, black. Dots denote cells protected in the Natura 2000 network.



The atlas suggests that local species richness is higher in the northwest of the country, around Lisbon and in the south coast. Interestingly, these correspond to some of the regions under highest pressure for development, and already have dense human populations. This overlap between biodiversity and human population has been observed in other studies (Araujo 2003, Cincotta 2002). However we should be aware that we would expected a sampling bias in areas of denser human population, and this bias is only partially removed by models. Perhaps a more useful measure than species richness is the degree of irreplaceability of each

cell. Irreplaceability was estimated as the effective maximum rarity (EMR) among taxa in each area (Pressey et al. 1994, Humphries et al. 1999). This is calculated from the inverse of range size (in number of grid cells) of the most restricted taxon in each grid cell that is not already represented in a grid cell with a more restricted taxon. When the ranking of irreplaceability is compared with the spatial distribution of the Natura 2000 Network it becomes apparent that in general cells with higher irreplaceability are protected by the network (Figure 6; see also Araujo and Sérgio 1999). However there are also cells with high irreplaceability that are not protected. It is important to note that it is likely that many more such cells exist given than much of the field data sampling was done in protected areas, and despite the correction with the distribution modeling, there will be more species outside protected areas than what is shown in Figure 6.

5.3.2 Water Provisioning

The socio-economic development of Portugal is characterized by a concentration of the population and economic activities near the coast, which causes unbalances that have to be taken into account when managing water resources. In the last few years there have been developments in the management of water resources, through the development of River Basin Management Plans for the 15 Portugal basins, the National Water Plan and the National Plan for Efficient Water Use. The development of these instruments coincided with the adoption of the European Water Directive (2000), and with the signing of the Convention for the Co-operation on Protection and Sustainable Use of the Portugal-Spanish Water Basins (1998). The latter convention is particularly important, given that Portugal depends on the run-off originating from Spain. One concern with the Portugal-Spanish convention is that it does not impose values for water quality parameters important for irrigation such as the sodium absorption ratio and the electrical conductivity.

In Portugal, as in other countries of Southern Europe, run-off is extremely variable, which is (partly) caused by the intra-annual and inter-annual variations in precipitation. Examples of Portugal basins with highly variable run-off are the Guadiana, Mira, Sado rivers and the small rivers in the Algarve (all in Southern Portugal). The highest run-off occurs during the winter months and there are long periods of low run-off. Mean annual rainfall is 922 mm, with 577 mm going to evapo-transpiration and 385 mm to run-off (INAG, 2001). Total annual water consumption in Portugal is 8 754 hm^3, with about 45% coming from surface run-off and the remainder from underground sources (INAG, 2001). About 74% of water consumption is associated with agricultural activity.

According to the National Water Plan, the available water resources are sufficient to satisfy current and future needs of Portugal consumers. Nevertheless, there is a need for a sustainable management of water resources in an ecosystem approach.

The main pressures on water resources are not restricted to the quantity of water available, but also to the quality and morphology of the water domain (Table 5.1). The lack of groundwater quality monitoring networks makes it difficult to identify contamination by pesticides from agricultural activities or heavy metals from industry. However, it is known that a large portion of the aquifers from the Algarve coastal region are exposed to nitrate pollution and saline intrusion (INAG, 2001). Exposition to nitrate pollution also occurs in the Tejo-Sado river basins, in Aveiro, Mondego, Beja, Caldas da Rainha, Escusa and Campo Maior (INAG, 2001).

Table 5.1: Main problems associated with the management of water resources (adapted from INAG, 2001).

Theme	Main Problems
Water quality	Water quality condition, including biological, physical, chemical and hydro-morphologic quality. Dependence on run-off and water uses from Spain. Alteration in the system of transport and deposition of sediments. Insufficient and precarious systems of wastewater collection and treatment
Nature conservation	Deterioration of surface inland, transitional and coastal waters. Alteration in the native biological communities. Deficit on prevention and knowledge of ecosystem conservation.
Supply and demand	Insufficient and precarious systems of water supply. Low water use efficiency. Conflict situations between different uses and between uses and environmental requirements.
Water domain and planning	Insufficient integration of the water protection component in the sectorial land-use plans. Lack of integrated management of surface waters and groundwaters. Insufficient valorization of wetlands.
Irrigation	Risks of soil salinization and sodication due to low quality of irrigation water. Increase of water consumption due to low quality of irrigation water
Information and knowledge	Insufficient interest, dialog and capacity building relative to the problematic of integrated water management. Gaps in the knowledge of the water cycle. Gaps in the knowledge of ecosystem service values.
Economic and financial regime	Low water prices do not promote water use efficiency and are insufficient to cover the costs of water supply systems. Low water prices do not internalize environmental costs

5.4 Services assessed by ecosystems

This section presents the analysis of condition and trends for the services for three groups of reporting systems of the Portugal Assessment: Marine/Coastal, Forest/Montado, and Cultivated. Other systems (Mountain, Islands, Inland Waters, and Urban) will be treated only in the Assessment Book.

5.4.1 Marine and coastal

The Portugal 200 NM Economic Exclusive Zone (EEZ) covers an overall area of 1 700 000 km^2, making it the second largest European EEZ. This is largely due to the Azores and Madeira islands, whose individual EEZ´s largely outnumber the mainland EEZ area of 326 362 km^2.

Interface with the sea takes place along a 1793 km long coastline, 976 km of which in mainland Portugal. Due to their volcanic origin, both Azores and Madeira do not have a defined continental shelf, in contrast to mainland Portugal, with a platform area of 47 202 km^2, for which an average production of 520 gC m^{-2} y^{-1} has been estimated.

The key coastal features in mainland Portugal are sand beaches and cliffs with or without beach, which account respectively for 60.3 and 35.9% of the total coast extension. To this may be added 3.4% of hardened coast and 0.4% of wetlands directly facing the ocean (Andrade et al. 2002). At the same time, c. 25% of the Portugal mainland coast shows a tendency to erosion or is undergoing active erosion processes, a trend that climate and sea level changes over the next century will undoubtedly accelerate (Andrade et al. 2002).

The five major threats to the services provided by the marine and coastal systems are: overfishing, contamination, destruction of ecosystems, territory loss, and climate change (Antunes and Santos, 1998). Some of these threats are associated with tourism and recreation

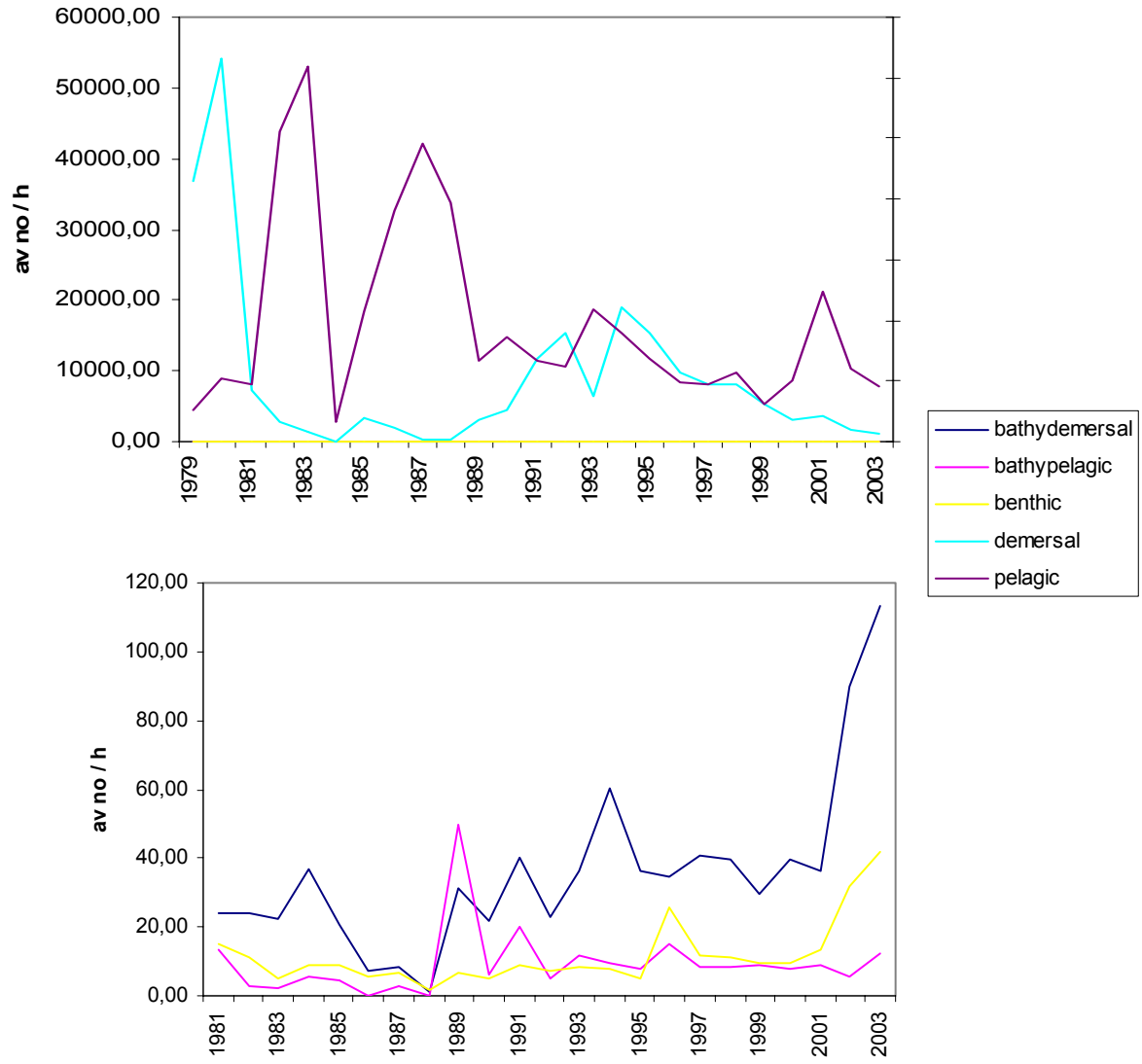
activities. In estuaries major drivers of ecosystem change are urbanization, increased input of nutrients and pollutants, and decreased input of sediments due to upstream dams.

5.4.1.1 Food production

Although Portugal has a wide EEZ, the richness and abundance of fisheries resources is not particularly high, mainly due to a narrow continental shelf (IIF 2001).

The Portugal fishing fleet can by divided in two groups: one that operates along the coast and on the continental shelf, and another that harvests in international waters or in EEZ's of other countries. From 1990 to 1998, a decrease of 30% in the number of fishing vessels occurred. In 1998 the fishing fleet had 11,189 vessels, corresponding to 114 643 TAB and 394 048 kW. About 50% of the fishing vessels are registered in Lisbon and Algarve harbors. The fleet is composed mainly by small vessels (c. 90% of the vessels have less than 12 m), with the fishing effort being more intense in coastal areas (IIF 2001).

Figure 7. Fish abundance (average number per hour of fishing) according to ecological guilds in the Portuguese coast, based on regular sampling surveys performed by IPIMAR from 1981 to 2003.



The estimated fish landings in 2000 were 156 348 ton, of which 152 370 ton were from within the Portugal EEZ. During the last decade, fish landings have declined more than

60 000 ton. Nonetheless, the estimates of the value of landings have been approximately constant in recent years at ca. 268 million € per year, due to an increase of the average price per kg (IIF 2001). The landings have been dominated by sardine, horse mackerel, tuna, mackerel, black scabbardfish, octopus and silver scabbardfish. Sardine landings attained ca. 80 000 ton, which represents 40% of the total of the landings (IIF 2001).

In the Portugal continental area sardine biomass is recovering since 2001 due to the extremely high recruitment of juveniles which entered the fishery in the beginning of the year 2000, and to the decreasing fishing effort forced by national regulation, which has been implemented following a dramatic sardine recruitment failure during the late nineties. According to Borges et al. (2003) the high variability of the recruitment is mainly due to climate change, explained by the phases of the Winter North Atlantic Oscillation (NAO) as the global driver. There is evidence that the mechanism for the recruitment variability is linked to the cyclical increase of Northern winds in the Northern spawning grounds during the extremely positive NAO phase of the late 90s, which was unfavorable to larval survival (Santos et al. 2001, Stradoudakis et al. 2003).

Pelagic species abundance, estimated based on IPIMAR research surveys, was highly variable over the last 25 years, showing low values in the late seventies, high abundance during the eighties and moderate values in recent years (Figure 7). Opposite trends to the pelagic group were indicated by the demersal fish abundance, which peaked in the late seventies, dipped in the eighties, recovered to moderate levels in the nineties, but showed a marked decrease in 2000-2003. The abundance of bathypelagic and bathydemersal fish seems to have been increasing during nineties and continues to show an increasing trend in the most recent years on record.

The impact of fishing on the size composition and diversity of fish communities of the Portugal coast was studied by Bianchi et al. (2000), who found a clear decrease in size range for the shallow fish assemblage and no clear trend for the deep fish assemblage. Possible changes in diversity were also looked for by Bianchi et al. (2000), in terms of species composition and dominance, but overall there was no evidence that fishing has changed community structure in the direction of a lower diversity.

5.4.1.2 Recreation

Direct occupation of the littoral fringe is somewhat constrained in Portugal, namely by the Maritime Public Domain legislation, which forbids permanent construction on the 50 m fringe adjacent to the highest high-water level. Yet, as we move from this fringe, housing – residential or tourism – occupies almost 24% of the Portugal coast (Andrade et al. 2002), with 1755 tourist facilities legally operating in 2000. In 2000, the total income from tourism represented about 8% of the national Gross Domestic Product, corresponding to 9.2 billion € (WTTC 2001). The vast majority of this tourism is associated with the coastal areas.

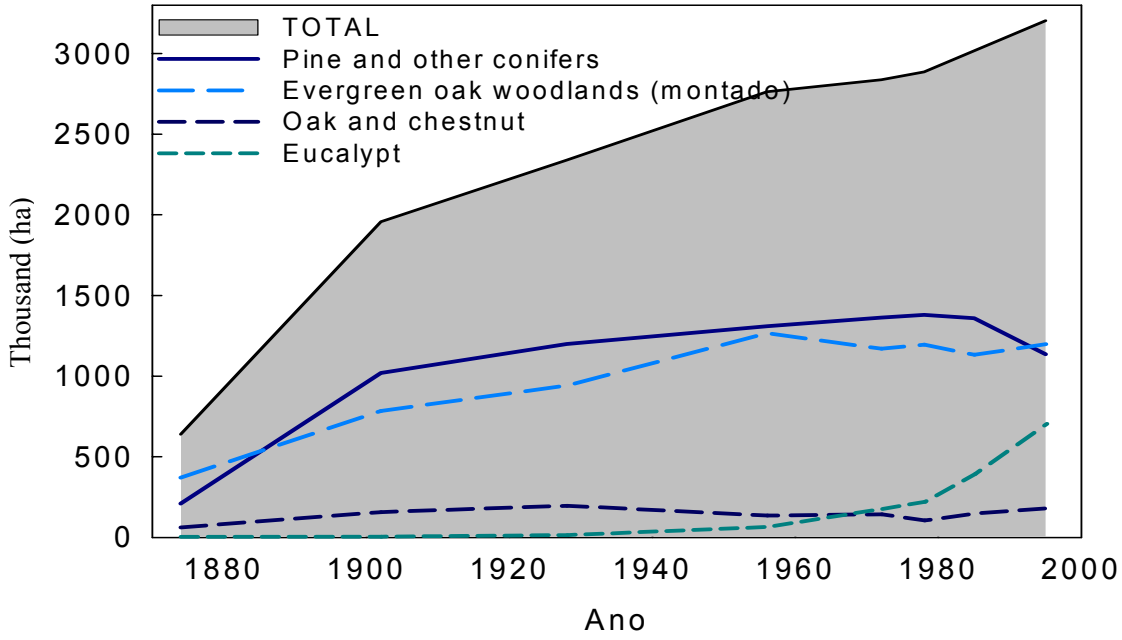
This occupation pattern and the corresponding value, directly reflect the environmental services available (or at stake) on the coast, where climate amenity, productivity, transportation/accessibility and landscape lead to the highest land costs in Portugal.

Tourism and recreation have negative impacts on coastal ecosystems. Tourism contribute to an overload of the costal territory resources due the extension and concentration of infrastructure and buildings.

5.4.2 Forest and Montado

In this section, we group together the analysis of the forest and *montado* reporting units. Forest in Portugal covers an area of 3.2 million ha (DGF, 2003a), occupying approximately 36% of the land surface. A proportion of 88% of this area is dominated by maritime pine (*Pinus pinaster*), eucalyptus (*Eucalyptus globulus*), cork-oak (*Quercus suber*) and holm-oak (*Quercus ilex*).

Figure 8: Area of main forest types (by dominating tree species) through time (Radich and Alves, 2000; DGF, 2003a).



Human occupation of the Iberian Peninsula has over 30 000 years. Forest loss started in the beginning of the Neolithic, due to conversion of forest to agriculture and pastures, often through fire. Native forest became progressively confined to mountain areas and, by the late 19th century, even mountain ranges had lost significant areas of forest. At the turn of the 19th to the 20th century, a transition from deforestation to reforestation occurred with government organized afforestation, creating a trend that would change the country's landscape till the end of the 20th century (Figure 8). The main tree species used for afforestation was the maritime pine, due to its pioneer characteristics in ecological succession. Eucalyptus started to be used in the 50s and rapidly expanded through the private sector, due to its economic importance, particularly for paper pulp production, and fast growth. By the 1990's, the afforestation rate with eucalyptus had reached more than 30 000 ha/year (Radich and Alves, 2000). However, industry now considers that the most adequate soils for this species have been occupied, and further expansion is not expected.

In 1998 the forest sector represented about 3% of the GNP (INE 2001b; MADRP 2000) and 11% of Portugal exports (MADRP 2000); in the EU, only Finland and Sweden have a forest sector with higher relative importance. An assessment of the value of the environmental services (Table 5.2), suggests that they would increase the economic value of the forest by at least 20%. Furthermore, the forest sector (considering both primary forest activities and processing of forest products) employs over 228 000 people (Mendes 2004), about 5.14% of the total employment.

Wildfires are an increasingly serious problem for Portugal forests. From 1975 to 2003, the five-year moving averages of burnt area have risen from 40,000 ha/year to 160,000 ha/year. The year 2003 was particularly bad, with fires in an area in excess of 420,000 ha (DGF, 2003b), approximately 5% of the area of the country. Of this, it is estimated that 280 000 ha were forest.

Table 5.2: Economic value of non-processed forest services and goods in 1998 (Mendes 2004).

Service/Commodity	Value (million €)
Wood	257.6
Cork	221.9
Total of timber goods	**479.5**
Resins	13.1
Honey	5.6
Fruits	41.2
Wild mushrooms	32.5
Aromatic and medicinal plants	1.9
Game	58.7
Fodder	125.2
Acorn	6.7
Woodland production	17.8
Total of non timber goods	**302.7**
Recreational use	5.9
Carbon sequestration	26.5
Agricultural land protection	75
Water resources protection	29
Environmental protection	20.1
Total of regulating and cultural services	**156.5**
TOTAL	**938.7**

Another major pressure on forests in Portugal is the ownership structure, particularly in the North and Center. Forest property is divided among a large quantity of smallholders, with no incentive to invest in a resource that is at high risk, due to fires, and without the possibility of benefiting from returns to scale in forest management.

Cork-oak montados are agro-silvo-pastoral systems and they represent one of the examples of sustainable, traditional systems of land use in Europe. They cover an area of 719×10^3 ha, mostly in Alentejo, Southern Portugal. These man-made ecosystems have a high economic value due to the cork oak production and a special cultural value relating to their importance for biodiversity conservation, as they harbour a high biological diversity and their historical interest as records of past social and agricultural systems. For a long time, montados used to combine two important goals of land management: production and conservation. However, decline of montados occurred in the sixties due to the increase of wheat production. In recent years these ecosystems have been subjected to strong land use changes, as a result of rapid technological and economic changes, and common agricultural policies. The density of trees was greatly reduced and oaks were severely affected by the mechanized work reaching their roots, by the increase of fertilization, and by high cattle density in relation to the carrying capacity of the system. These procedures affected soil microbiota and increased oaks susceptibility to abiotic and biotic stresses, namely, insects and parasitic fungi. At the same time, and due to the fragility and low quality of the soil, the referred intensive cultural practices lead to soil erosion and desertification, destruction of habitats and loss of biodiversity.

5.4.2.1 Biodiversity

About 45% of the Portugal species of mammals, birds, amphibians, reptiles and butterflies are associated with forest, particularly with deciduous and evergreen oak forests[4]. Several endangered species (e.g. the Iberian Lynx), are associated to oak forest habitats. In contrast, non-native forests such as eucalyptus plantations have low biodiversity. For instance, up to 13 species of birds breed regularly in eucaliptus plantations, as compared to 30-35 species recorded in oak forests nearby (Blondel and Aronson, 1999). Unfortunately, deciduous oak forests, the predominant habitat cover in the North before conversion to agriculture, account only for 4% of today's forest. Furthermore, most of the remaining deciduous forest is very fragmented.

5.4.2.2 Food production

Silvo-pastoral production is the most important food production activity of the Portugal forest, and is mostly associated with *montado* of holm-oak and cork-oak, including bovine, swine, caprine and ovine production. Silvo-pastoral production is an extensive system of livestock production but generally depends on the existence of active rural communities. Therefore it has been declining in areas where rural exodus occurred.

The most important fruits harvested are chestnuts, carob, and pinenuts. The production of these fruits has been increasing in recent years. Wild-mushrooms are also an important food product (6400 ton/yr, Mendes 2004) However, the sustainability of this production is threatened by the free access to this resource and by the, in general, low skills of the collectors.

5.4.2.3 Wood and cork production

The 11 341 000 m^3 o.b. of annual fallings for wood and pulp supply are smaller than the 15 195 000 m^3 o.b. of net annual increment in the forests with the same main function (DGF, 1999). Still, net annual increment per hectare in forests for wood supply (4.6 m^3/ha/year for *Pinus pinaster* and 9.0 m^3/ha/year for *Eucalyptus globulus*) could be increased by 20% or more with better management. Portugal is a net exporter of wood (ratio of 1.18) and pulp (ratio of 6.2) but the economic value of the imports of wood is greater than of exports (ratio of 0.75, DGF 2001).

Cork is the major non-timber forest product in Portugal. Portugal has a share of more than 50% of the world production, a leading position attained since the Spanish Civil War, in 1936.

Table 5.3: Cork production in ton (Mendes 2004).

Years	Total	Virgin cork	Reproduction cork
Average 43/51	170 666	44 222	126 444
Average 52/60	188 334	57 778	130 556
Average 61/69	221 555	78 444	143 111
Average 70/78	185 966	47 033	138 933
Average 79/87	149 422	33 700	115 722
Average 88/96	170 444	30 000	140 444
Average 97/00	165 500	30 000	135 500

[4] This estimate is based on the habitat preference of each species (excluding habitats that have only marginal use) as described in the following literature: MacDonald & Barret (1993), Mathias et al. (1999), Barbadillo et al. (1999), Pargana et al. (1996), Almeida et al. (1991), Rufino (1989), Saéz-Royuela (1990), Maravalhas (2003).

Portugal also had in a recent past a leading position in the production and processing of pine resin. However, the lower labor costs in China in the extraction of this product led to a quick decline of this activity, the annual production falling from 108 000 ton in 1986 to 15 000 ton in 1995.

5.4.2.4 Carbon sequestration

The standing stock of carbon on the Portugal forest ranges from up to 50 t/ha for Maritime Pine to around 17 t/ha for oak forests. For carbon in the soil the values range from 2.1 t/ha to 230 t/ha. Our current knowledge of the role of the Portugal forest in carbon sequestration is limited. We used research being currently done on *Montado* and Eucalpytus forest, as well other data on Maritime Pine forest to estimate the carbon sequestration capacity of the national forest. This estimate is the Net Biome Productivity (NBP), which discounts the losses dues to fires and logging. For the area covered by the forest types referred above (about 85% of the forest in mainland Portugal), the NBP is 1.52 Mt C/year. This is certainly an underestimate, but still accounts for 7% of the carbon emissions in 2000. The 2003 wildfires are likely to have affected the carbon sequestration capacity of the national forest, but more studies are needed to quantify the effects.

5.4.2.5 Soil protection and run-off regulation

Forest has an important soil protection role. Tree canopies absorb the kinetic energy of rainfall, the deposition of leaf matter increases the organic content of the soil, and trees transport nutrients from deep underground that later become available in the soil. As the Mediterranean type of climate prevails throughout the country, with heavy rains in winter and a dry summer, there is the tendency for soil erosion in unprotected land. Several historical interventions (e.g. logging during the discoveries and the mid 20th century wheat campaign) have degraded the capacity of Portugal forest to protect the soil. The fire-resistant native oak forests (Nunez-Regueira et al. 1999, 2000) were replaced by fire-prone pine and eucalyptus forests, and by agricultural land. Agricultural land has in turn been progressively abandoned in the past few decades, being replaced by fire-prone scrubland, which can evolve to the more fire-resistant native oak forests only if fire frequency is kept a low levels. The increase in pine and eucalyptus forest area and the depopulation of the interior of the country, together with lack of forest management associated with the small average holding size, has increased wildfire frequency, which causes large soil losses during rainfall and the deterioration of water quality downstream. It is important to note that, even in this situation, soil protection by forests may be greater than that by inadequate agricultural practices. If current frequencies of wildfires persist or increase there will be major consequences for the soil and for run-off. Physical and chemical soil erosion increase with decreasing soil thickness, which in turn decreases soil fertility and carbon sequestration. Surface run-off will increase with increasing likelihood of floods.

5.4.2.6 Recreation

Land-use planning of Portugal forest is essentially reduced to food and timber production and to nature conservation, with insufficient planning for recreation. The majority of forestland has a private ownership, which limits the development of activities with low consumer demand or low economic profitability. Currently, the main recreation activity in the forest is hunting, but nature sports and outdoor activities are starting to gain popularity.

For many years, in large parts of the country, hunting was in the so called “general regime” which is not very far from an open access regime. The only really enforced limits to hunting are the holding of a hunting license and some legal rules on the calendar for the hunting season and the species allowed for hunting. Hunters have no obligations to pay for game management and land owners have no right to “no hunting”. This situation changed

substantially with the creation of "associative hunting zones" and "tourist hunting zones". These are areas where a group of hunters have exclusive rights for hunting in exchange for paying the costs of proper game management. The area occupied with these management regimes has been increasing. In general, this has improved the condition of this service, since the managing organizations invest in improving conditions for game species. There are cases, however, of elimination of high trophic level consumers such as protected prey birds, as a way to maximize game productivity. Also, Northern Portugal is somewhat an exception to the improving trend, due to the heavy incidence of poaching.

There are also several campgrounds and spa resorts associated to the Portugal forest. The number of recreation visits (excluding hunting) to forest areas is estimated to be about 2 million visiting days per year (Mendes 2004). Some of the areas receiving more visitors are Serra de Sintra, Serra do Buçaco and Serra do Gerês. In the future, forests surrounding urban centers may acquire importance for weekend hikes, but this is not a tradition in Portugal yet.

5.4.3 Cultivated

Mainland Portugal has about 3.7 million ha of utilized agricultural area (UUA), about 42% of continental Portugal surface (MADRP 2003), of which 930 thousand ha are under forest cover (mostly in "Montado" which was analyzed in the "Forest" section). Farm structure is dualistic: large scale farms in Alentejo (see Appendix B for a map of the agricultural regions), and mostly small scale farms in the other regions. Overall, 78.8% of the utilized agricultural area (UUA) corresponds to farms with less than 5 ha UUA (EC 2002). Comparatively, only 57.5% of the cultivated land in Spain correspond to farms of that size. Furthermore, 37% of the farm owners are more than 65 years old, and 34% are illiterate (RGA 1999). The average disposable income of farm families as a percentage of average disposable income of families was about 40%, much lower than the EU average.

The coastal regions are densely populated, their local economies are relatively developed, and farming, mostly in small scale holdings, is still active and intensive, the main activities being corn, fodder, horticulture, vineyards, orchards, and dairying. The interior regions have low population densities, their local economies are lagging, and farming is mostly extensive and associated with livestock production, the main crops in terms of area being olive trees (in the interior Northern and Central regions) and wheat (in Alentejo). In some demarcated areas of the interior regions (Douro Valley, Dão and Alentejo) vineyards for quality wine are an important land use.

In the beginning of the 20th century, agricultural and social areas occupied c. 35% of the national territory. Until the mid fifties agricultural land use increased (reaching 50%), together with forests, and uncultivated land decreased. Since then forest land continued to increase, but agricultural land decreased (reaching c. 40% in the 1990's). However, forest land only partially substituted for agricultural land uses, the result being an increase in uncultivated land (Mendes, 2004). The first period (until the mid fifties) reflects the increasing use of marginal lands for wheat cultivation; the second period (from the mid fifties onwards) reflects agricultural abandonment due to migration abroad, in the 50's and 60's (with an unchanging agricultural technology being unable to cope with a decreased amount of available labour), and internal migration, to the cities, in the 80's and 90's. The latter is reflected in the average annual population growth rate in rural areas for the period 1980-2000 of –3.4% (WRI 2003b).

Farm and rural emigration have been occurring since the mid fifties. In the interior regions, in many places agriculture is no longer economically viable due to the increase in labor costs. Former agricultural uses are in some of these places replaced by permanent pastures and extensive cattle rearing whilst in others they are replaced by forest and shrubs. Left without

regular management due to the lack of rural labor, these lands have a high risk of forest fires. In the costal regions farm emigration also occurs. Here the greater pressures on agricultural lands come urban expansion. On the other hand, farmland use and farm employment have declined less in the Tagus valley, the coastal dairy production areas, and the Alentejo (in the wine basins of the Alentejo, farm employment has actually increased in the last 10 years), suggesting that the capacity of agriculture to maintain its resources (land and labour) is mostly determined by the scale and profitability of the farming system (Lima Santos, *pers. comm.*).

The adoption of new technologies such as improved seeds, higher inputs of fertilizers and pesticides and new mechanical means took off later than in other countries, having mainly occurred after the entry of Portugal into the European Economic Community. Therefore the productivity per unit area of the main crops is one half or one third of what happens in other Mediterranean countries of the EU. This had both negative and positive environmental impacts. On the one hand, the low use of fertilizers and pesticides partially avoided the negative impact in terms of soil and underground water contamination that took place in many European countries. Also, Portugal agriculture has been characterized by non-specialization, non-concentration and the maintenance of the traditional landscape mosaic. Therefore, Portugal agro-ecosystems supported an important agriculture biodiversity (crop varieties and livestock breeds) and wild biodiversity (non-domesticated animals and plants), in an rich landscape. On the other hand, the maintenance of the traditional pattern of land allocation to crops had negative impacts in some regions. For instance, the soil erosion that occurred in the basin of the Guadiana river had its roots in the use of marginal land (with low quality soils and excessive slopes for tillage) for the production of wheat under the "Campanha do Trigo" (Wheat Campaign) of the 30's (this campaign had the aim of ensuring the country's self-sufficiency in wheat production).

Currently, although the overall average fertiliser consumption is still one of the lowest in the EU (in the mid 90's it was one third of the EU average, EC 2003), there are some situations of aquifer pollution, e.g. the Beja aquifer in Alentejo, with nitrate concentration of 60 mg/l, and in some instances fertilizer use is as high as 1000 N units/ha/year (Dias & Sequeira 1992).

5.4.3.1 Biodiversity

About 43% of the Portugal species of mammals, birds, amphibians, reptiles and butterflies are associated with agriculture. Some of the most important agricultural land uses for biodiversity are: hay meadows ("lameiros"), high-plateau grazings (such as Nardetea) and other extensive grazings such as limestone or ultra-basic pastureland, rice fields, cereal pseudo-steppes, terrace vineyards and olive tree plantations. It is interesting to note that both field abandonment and intensification lead to homogenization of the landscape, each in its own way. Field abandonment causes the establishment of an early successional shrub layer and an increase of fire frequency (which can cause soil loss in areas with steep slopes). However, if fire frequency could be controlled, natural succession could take place with gains for the conservation of forest biodiversity and ecosystem services. Intensification leads to the loss of small scale habitats such as field margins and permanent pastures.

5.4.3.2 Food production

During the second half of the 20th century, the agricultural sector in Portugal essentially stagnated, growing at an average annual rate of 0.3% (Table 5.4). However, the demand for agricultural products grew dramatically, and the agricultural trade balance went from a situation of equilibrium in the 50's to a 500% deficit (ratio of imports to exports) for agricultural crops and livestock in 2000 (MADRP 2003). This increase of internal demand was one order of magnitude greater than the population growth of 20%. Notwithstanding the

degree of food self-reliance of the country (proportion of the national food consumption that could be satisfied with the national output), which was close to 90% in 2000 (MADRP 2003). Note that this is a value for food production as a whole, and in some particular sub-sectors (cereals, beef), the self-reliance indicator is much lower than 90%.

Over the next 10 years the internal demand for agricultural products is predicted to grow at a much slower rate of 0.6% per year (Mendes and Carvalho 2000), only slightly above the rate of increase in national agricultural production since Portugal joined the EU of 0.52% per year. However, the market for "quality products", such as fruit and vegetable, animal, organic farming and "traditional" products, may grow at a faster pace. Competitiveness gains for Portugal agriculture may come from exploring these market niches, from international price increases of the exported goods in those markets, or from the increase in silvo-pastoral productions in soils with low value for agriculture.

Table 5.4: Average annual growth rate (%) of GDP and some sectors, at market prices. Source: Soares (in press).

	1959-95	1959-65	1966-73	1974-79	1980-92	1993-95
GDP	4.3	6.0	6.3	3.1	3.7	0.4
Crop + Livestock + Forest + Hunting	0.3	-0.4	1.7	2.1	-1.6	3.3
Fisheries	0.3	3.5	1.3	3.7	-1.4	-8.5
Rest of the Economy	4.9	7.6	7.0	3.3	4.1	0.3

The main food products are: quality wine (mainly Port), vegetables, fruits, cereals and livestock (cattle, pigs, poultry, sheep and goats). Of all these, in the period 1990-2001, quality wine was the one presenting greatest growth in terms of economic importance, and cattle production the greatest decline (MADRP 2003).

5.4.3.3 Soil protection and run-off regulation

High quality land, defined as a combination of the suitability for agriculture of a series of factors including soil, topography and hidrology, is a scarce resource in Portugal (Giordano, 1992). Only 8% of the country surface is high-quality land, lower than the 14% that is observed overall in Southern Europe. Furthermore, very fertile soil occurs only in about half of high-quality land (SROA, 1972). High-quality land is precisely the land type that has been more affected by urban expansion and infrastructure development. At current urban expansion rates, all the vertisols in Lisbon will disappear by 2015 (Azevedo 1997) with similar situations for several other cities in Portugal.

In spite of agricultural intensification having occurred only in certain regions (mainly in Algarve, Ribatejo e Oeste, coastal Alentejo and coastal Beira Litoral), it has led to some situations of the disruption of the water cycle with overexploitation of underground water (e.g. Campina de Faro), the pollution of underground water with leaches from pesticides and fertilizers (INAG, 1997) and the pollution of surface water with farm run-off, particularly phosphorus. Furthermore, the change from extensive cattle breeding in silvo-pastoral systems to intensive cattle breeding in factory farms, the decreasing use of crop rotation and temporary pastures, and the excess of tilling can cause erosion and degradation of soil organic matter with the consequent loss of fertility. In parts of the South of Portugal the climate is semi-arid and the recovery of degraded soil is very difficult and long (Sequeira 2001). The use of water of poor quality in irrigation in some areas of the South (e.g. Roxo basin, Guadiana basin, Campilhas and Vale do Gaio dams) is causing the accumulation of salts in the soils, which will in turn increase the pollution of underground water and may be aggravated by global warming (Sequeira 2000). Pollution of the soil with heavy metals is a

problem in some focal points, such as areas close to mine exploration, copper pollution around vineyards (Magalhães et al. 1985) and pig factories (Sepulveda 1998).

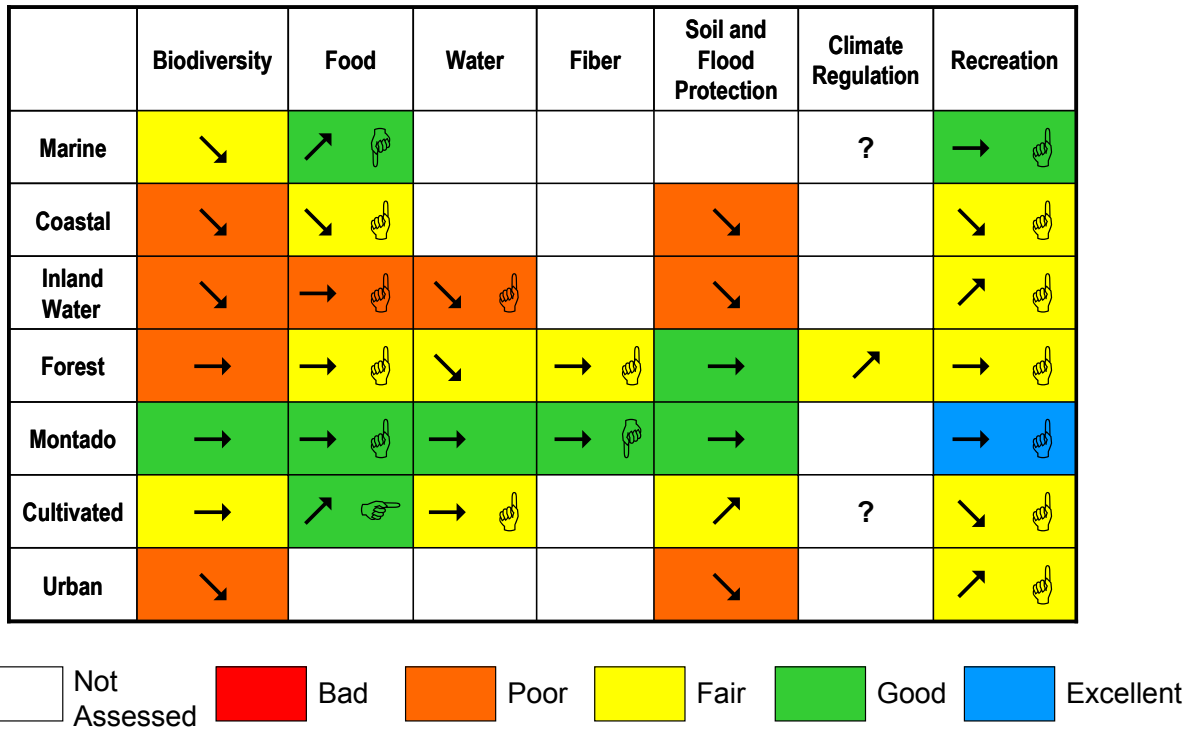
5.4.3.4 Recreation

The rural landscape has currently some demand for activities associated with rural and nature tourism, this demand not being separable between forest and agriculture systems. This demand is higher in areas where there is built heritage and that have particular gastronomic or cultural traditions. Rural and nature tourism is associated with the nostalgia for rural life of the urban population. It is also important to note that hunting is another activity that occurs both in the forest and the cultivated systems, and is difficult to analyze separately (see section 5.4.2.6 for an analysis of recreation in forest).

5.5 Overall expert assessment

Two of the workshops joining the research team and the users was dedicated to a qualitative assessment of conditions and trends of ecosystem services in Portugal (Figure 9). Naturally, such an exercise cannot be interpreted as an objective assessment of condition and trends, but more as the perception of the experts of such trends and conditions.

Figure 9: Condition and trend for the services of each Portugal ecosystem. The condition of the service is given by a color code. Two types of trend are shown: arrows give the trend of the condition (or "stock"); hands give the trend of the production (or "flow") for provisioning services and recreation. In some cases services were not assessed because they do not occur or they have a marginal importance. Question marks indicate services that would have been assessed if data were available.



The overall picture emerging from this exercise is of a high heterogeneity of the conditions and trends between services and ecosystems. For instance, while the Montado appears to have all the services in good or excellent condition, Inland Water displays a poor condition of most services. Biodiversity is in good condition in the Montado systems, fair or poor in the remaining systems.

For services that are marketed, it is interesting to note that in some instances the condition of the service is improving but the production is decreasing. For instance, while the condition

of fisheries in the marine system has improved over the last few decades, fish landings are declining.

6 Responses

There are many options for responding to the need to protect and restore ecosystems and the services they provide and to ensure the equitable distribution of the benefits of those services (MA, 2003). Fundamentally, these options can be characterized as interventions that stimulate or suppress certain human activities and those that create knowledge or investment (MA, 2003).

In this report, we have considered a restricted set of inter-related responses to some of the major drivers and trends considered previously.

During the 80's, the nexus of drivers presented in the section of drivers led to the decreasing economic viability of wheat cultivation in marginal lands. A large proportion of these lands would probably have been abandoned, but were instead forested with eucalyptus. The expansion of eucalyptus areas led to environmental concerns. These concerns were addressed by industry in the already forested areas by improving their management (see section 6.1). Environmental concerns with eucalyptus plantations were also addressed by local government and NGO's, by avoiding afforestation itself (see section 6.4). The major support for this response were the agri-environmental measures, which had been created by the EU, in response to the environmental damage which resulted from the original Common Agricultural Policy (see 6.3). However, this response was only focused on biodiversity conservation, with no (or almost no) regard for other ecosystem services and for social and economic aspects. The response to these situations requires an integrated approach, based on certification systems, which is addressed by project EXTENSITY (see 6.5). A significant component of this project is the proposal (based on substantiated calculations) of new agri-environmental measures for Portugal.

Abandonment and the creation of large continuous areas of forest have led to an increasing trend of wildfires, culminating in the devastating fires of 2003, which triggered a major governmental response (see 6.2)

The choice of responses also had the aim of considering responses at multiple scales, ranging from scales above that of the assessment (agri-environmental measures in the EU's Common Agricultural Policy), through the national scale (the response of the Portugal government to the 2003 wildfires) to local scale responses (acquisition of farms by LPN for biodiversity protection).

Several of these responses have multi-scale and multi-user components. For example, in the cereal pseudo-steppe, the threat to conservation at the regional scale (the Castro Verde municipality in Alentejo) of important animal species (which provide a global scale biodiversity service) led to the acquisition at a local scale of a certain number of farms by a national scale environmental NGO (LPN), using funds at the EU scale (Life program) and the national scale (corporate and individual donors).

Three of the responses involves the users of the ptMA: for forest plantations, CELPA; for the cereal pseudo-steppe, LPN: for certification of extensive agriculture, EXTENSITY, LPN, MADRP-AA.

6.1 Forest Plantations

In the 80's, when the area of eucalyptus was already very significant (about half of the current area), there was a large controversy (promoted by environmental NGO's and

environmental scientists) in Portugal surrounding the possible negative effects of eucalyptus plantations on soil erosion, loss of regulation of the hydrological cycle, excessive nutrient extraction and low diversity and abundance of animal and plant species. This led to the implementation of legislation establishing limits on continuous areas of eucalyptus plantations and mostly forbidding the conversion of *montados* into eucalyptus plantations.

However, criticism by environmental NGO's and environmental scientists (at universities and at government agencies) and mostly by media, influencing public opinion, continued. At the same time, there has been increasing pressures from international markets for environmental certification of forests. In response to these two pressures, the Portugal pulp and paper industry has been making an effort to improve the management of eucalyptus forests. However, most fiber production takes place in forests which are not owned by the industry. In these forests, management is generally bad (both environmentally and economically), frequently with excessive fertilization (e.g. twice the correct amount), excessive soil tillage, and low quality plant genetic material. So, the response of the Portugal pulp and paper industry was different according to whether it was addressing its own plantations or the plantations of other owners:

- Own forests. Improvement in criteria for selection of areas to afforest and improvement in forestry practices. The latter has been attained through experimentation and development of less aggressive production techniques, by an attempt at reducing the intensity of the multiple cultural practices, and by the permanent training of staff and service providers. Transition of part of the area to natural forestry – e.g. regeneration areas and waterlines.
- Other forests. Investment by industry in training and providing support to the providers of forestry services and associations of forestry owners.

6.2 Forest Fires

In 2003, in response to public pressure after the summer fires, the Portugal government began a reform of forestry management, including components such as mandatory forest management (with the Government being given the legal capacity to manage forests which are not managed by their owners) and the creation of an investment fund for forests. Increased forest management units will be achieved through aggregation of existing properties, and through joint management of several plots. This will be financed by the investment fund and by fiscal supports. A simplified land register system will also be introduced. The forest investment fund will be financed by an additional tax on fossil fuels (reflecting the contribution of forests to the fixation of the carbon dioxide released in the combustion of these) and by the income generated by the Government managed forests.

6.3 Agri-environmental Measures in the Common Agricultural Policy

The main factor influencing agriculture in Portugal in the recent past has been the EU's Common Agricultural Policy (CAP). This was implemented initially in 1986, when Portugal joined the EU. During the period 1986-1992, the emphasis of the CAP was on increased productivity, with large support for arable crops and cattle. This was essentially the continuation of the CAP as implemented in the EU in the 50's, with the aim of guaranteeing food security for the member states. By the 80's, this policy had fully attained its original aim, in fact with excessive success, leading to enormous surpluses in cereals, meat and dairy products, together with strong environmental impacts, namely with respect to nitrate and phosphate leaching in the northern countries and soil erosion and water consumption in the southern countries.

For Portugal, being within the scope of the CAP had a very large impact in 1986-1994. Agricultural prices decreased by 28% and direct subsidies increased by 480.4%[5]. The combined effect of these two was a 24% decrease (Avillez *et al*., 2004). In this period, the CAP led to intensification of production.

Answering these problems (but more concerned with the surpluses than with environmental problems), there was a first CAP reform in 1992, with subsidies no longer being calculated based on production, and instead based on area or number of animals. At the same time, three accompanying measures were created. The most relevant here was the afforestation of agricultural land and the agri-environmental measures. The latter provided support for environmentally friendly agriculture, e.g., conservation tillage, maintenance of traditional systems and agricultural landscapes, biodiversity conservation, reduced nutrient input farming and organic farming. In 1998, these measures covered 20% of the agricultural area of the EU15 and 16.8% of the agricultural area in Portugal (EEA, 2001).

In Portugal, the CAP reform of 1992 mostly stopped the intensification that occurred in 1986-1994. In 2000-2003, agri-environmental measures were particularly successful in promoting organic farming, integrated production and integrated protection (Carvalho *et al*., 2003). Although its aims are formally environmental, the agri-environmental measures have few standards for environmental effectiveness (Carvalho *et al*., 2003). In 2003, agri-environmental measures covered 318 018 ha (Carvalho *et al*., 2003, p. 142).

The 1992 reform still promoted excessive production. In 2003, a new reform has been carried out, almost completely "decoupling" subsidies from production: subsidies will now be paid based on past subsidies received by the farmers, essentially independently of their current activity. Again, environmental problems were a significant motivation, but more significant were international pressures for reduced subsidies and demands from EU consumers for safer food.

In the application of this reform there is a wide flexibility for the Member States to define the level of decoupling, so that the options being taken at the country level still maintain a very significant coupling. In Portugal, only cereal subsidies will be completely decoupled; support for animal production will only be partially or not at all decoupled, to avoid abandonment in the more fragile areas, dependent on extensive animal husbandry.

The concession of subsidies will be subject to the respect for EU Directive on the environment, food safety, plant and animal health and animal welfare, and to maintaining agricultural land in good agronomical and environmental conditions.

In Portugal, it is expected that the implementation of this reform will lead to a significant decrease in the area of dryland cereal cultivation, replaced by pastures (grazed by sheep and an increasing number of cattle) or forest an increase in ecologically sustainable land use systems and agricultural technologies (Avillez *et al*., 2004).

The current CAP reform will be valid until 2013. After that, it is generally expected that its funding will be directed at only two components (Avillez *et al*., 2004). First, measures aimed at stabilizing agricultural prices and incomes. Second, rural development measures, aimed at: (1) improvements in competitiveness based on the economic productivity of agricultural production factors; (2) payment of agri-environmental and social and economic cohesion services rendered by farmers.

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[5] Proportionally this is a very high number because, before integration in the EU, direct subsidies were very low (Avillez *et al*., 2004).

6.4 Cereal Pseudo-Steppe

The cereal pseudo-steppe is an agro-ecosystem constituted by arable crops in rotation with fallow land, occurring in Alentejo. Its widespread distribution is a consequence of the "Wheat Campaign", mentioned above in section 5.4.3. It is environmentally problematic with respect to soil erosion and desertification, but very important for nature conservation, supporting important threatened species such as *Otis tarda*, *Falco naumanni*, *Grus grus*, *Tetrax tetrax*, *Pterocles orientalis*, *Circus pygargus* and *Melanocorypha calandra*. A significant proportion of this habitat is within the municipality of Castro Verde. In the 80's, this area started being threatened by afforestation with eucalyptus.

In response to this, by the end of the 80's, the municipality of Castro Verde forbade the plantation of forests with rapid growth trees in about 85% of its area, to avoid agricultural abandonment and to maintain control of the land within the inhabitants of the municipality. The strategy was then to obtain public funds to grant subsidies to farmers adopting practices compatible with nature conservation. This was first proposed by LPN (Sequeira, 1994) and then taken up by ERENA, a consulting company, and the local farmers' association, leading to the creation of the Castro Verde Zonal Plan, financed by the agri-environmental measures of the CAP. This was the first, and still the only, plan of its kind in Portugal. Only in 2003 were Zonal Plans for seven other important conservation areas approved by the European Commission. These will be implemented in 2005.

LPN continued its intervention, by contributing to improvements in the Zonal Plan (e.g. by changing the dates of plowing, which were inadequate for bird nesting). This intervention was based on the integration by LPN of information obtained by scientists working in this area. The Castro Verde Zonal Plan has had very significant effects on the conservation of the bird species aimed at (Borralho *et al*., 1999).

In parallel, from 1994 to 1997, LPN also acquired farms, in Castro Verde, in risk of afforestation with eucalyptus. This acquisition was financed in 75% by the Life Program of the European Commission and in 25% by donations by individuals and by the pulp and paper companies that originally owned the farms. The farms have been rented to local farmers, on the condition of their compliance with strict regulations related to the protection of animal species.

Since 2000, farmers have been progressively abandoning the Castro Verde Zonal Plan, due to a significant reduction in subsidies for areas larger than 100 ha, precisely those that provide the most significant service of habitats for birds (Lampreia, 2003).

The Castro Verde Zonal Plan was ineffective in preventing soil erosion and desertification. In response to this, demonstration projects were started by LPN at its farms, with the aim of increasing effective soil and rooting depth through subsoiling and injection of wastewater sludge and with the use of direct seeding techniques. Preliminary results suggest that these practices lead to a reduction in erosion of up to 90% (Sequeira *et al*., 2003).

6.5 Sustainability Certification of Extensive Agriculture

There is a need and an opportunity for certification and management systems which can be viable, if they integrate the following components: reduced implementation costs (due to applicability at multiple farmers); ensured regulatory compliance; reduced operational costs (through reduced resource use and improved technical management); better prices at the consumer (through dissemination to consumers); improved agri-environmental subsidies; profits from other activities at the farm (namely tourism). This has led to the creation of project EXTENSITY – Environmental and Sustainability Management Systems in Extensive

Agriculture. This is a demonstration project, led by a university, Instituto Superior Técnico, and financed by the Life Program of the European Commission.

EXTENSITY involves multiple types of organizations, at different societal levels:

- Research organizations (in the environmental, agronomical and biotechnological areas).
- NGO's, comprising a national farmer's association (CAP), a local farmer's association (ANCOSE, itself an affiliate of CAP), an environmental NGO (LPN), and a consumer association (DECO).
- Private companies, comprising a certification and control company (SGS), a pasture and forage seeds commercialization company (Fertiprado), and a consulting company that support environmentally friendly shops (DECOECO).
- Government agencies from the Ministry of Agriculture, comprising the Environmental Auditor (in charge of environmental aspects in the ministry) and the Institute for Rural Development and Agricultural Hydraulics (in charge of the agri-environmental measures).

EXTENSITY has a strong multi-scale, multi-user, multi-knowledge system approach. Several of the partners of the project are involved in some way with the management of some of the pilot farms involved in the project (Fertiprado, IST and LPN). This is a way of ensuring a smooth flow of knowledge from the local to the national level. Also, two different approaches are being taken in the interaction with farmers: direct interaction; interaction through a local farmer's association (ANCOSE).

EXTENSITY acknowledges multiple forms of knowledge, through its integration of scientific and "civil society" actors. However, integration of local knowledge is hampered at farms with a hierarchical organization of personnel, e.g. a foreman or owner and salaried workers under his command. In this case, the former will tend to have a negative view of the knowledge of the latter, and will try to impose his worldview. Traditional knowledge is mostly integrated for a single region, through ANCOSE, which has a large number of older farmers. The younger farmers, associated to the larger farms with which EXTENSITY works, do not have this type of traditional knowledge (although they have a large amount of local knowledge).

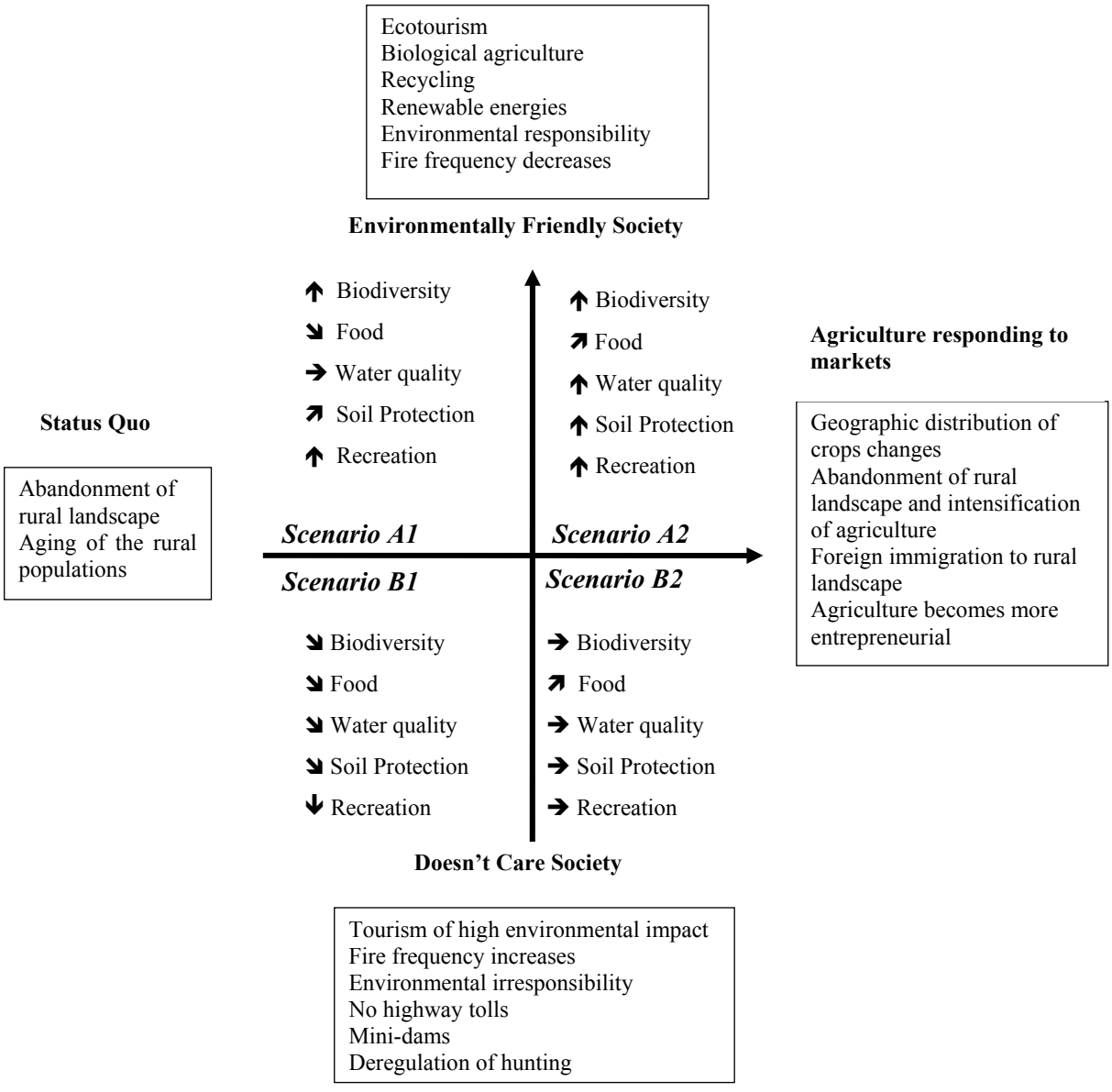
EXTENSITY addresses in the first place the farm scale, building on this to influence large scales, through policy intervention. This is done through the three national level NGO's, which belong to "umbrella" organizations at the EU level. In the initial definition of the project, these NGO's will bring information from their umbrella organizations. At the dissemination and policy influencing stage of the project, they will transmit to the EU level the results of the project. The participation in the project of two government agencies also enhances this wider policy influence.

7 Scenarios

To address the question of what will be the future of biodiversity and ecosystems in Portugal in the next 50 years, we developed draft scenarios in two workshops of the research team and the users. First, the research team and the users were asked to rank drivers of ecosystem change by degree of impact on ecosystems and by unpredictability. The drivers that ranked higher on unpredictability and on impact were used to build two axes for draft scenarios (Figure 10). One axis is related to society's attitudes towards the environment, and it has at one extreme a society that is well informed and that cares about the environment, and at the

other extreme a society that believes that everything can be solved by technology and that is only focused in increasing the standard of living. The other axis is related with the agricultural practices in Portugal, and at one extreme has the continuation of the current status quo, and at the other extreme an agriculture that is influenced positively by the CAP, with farmers responding to the markets.

Figure 10: Scenarios for Portugal drafted in the first workshop of the assessment. The boxes at the end of the axis summarize the main developments of the drivers in those quadrants. In each quadrant the trends of the different ecosystem services are denoted by arrows, with an upright arrow denoting a faster increase than an upwards oblique arrow.



Box 1: Adaptation of two MA global scenarios to Portugal

Order from Strength

At the beginning of the 21th century rising concerns with security in Europe lead to a reinforcement of border control and to protectionist trade policies. Portuguese governments promotes a policy of food auto-sufficiency with an increase of agricultural area, and the expansion of community gardens. The agricultural pressure in marginal soil increases with an increase in soil erosion, reduction of the percolation capacity of the soil, and the increase of diffuse pollution, with water quality being affected in several river basins. The intensification and extensification of agriculture accelerates biodiversity loss, with several top predators becoming extinct by 2025. Associated with the rise of nationalism, a renaissance of the Portugal culture develops, with the re-flourishing of fado and folk dance. Several cultural traditions and ancient agricultural practices are recovered. The recreational value of the semi-natural landscapes decreases, affected by the agricultural development and the development of mega-tourist resorts in the coast By mid century, much of the agricultural soil has become impoverished and food production has started to suffer significantly. Rural abandonment that had declined earlier in the century due to national subsidies to agriculture, is now on the rise again. Game has disappeared almost completely due to decades of deregulation.

Technogarden

Early in the 21th century the importance of ecosystem services became increasingly recognized and global markets were established to trade carbon and biodiversity credits. The creation of these markets and the problems associated with oil dependence lead to an increase in the environmental awareness of European citizens. The European Union increases the use of renewable energies and invests in the development of new technologies for renewable energy production. Legislation is enacted reducing taxes on labour income and increasing energy use taxes. The Portugal government invests in the education of scientists and engineers, with a focus on environmental fields, and the European mobility of qualified workers increases. The market of green technologies flourishes in Europe, with an economic boom happening. By 2025, unemployment is very low and the standard of living has increased, both in economic terms and in the access of people to clean air and water. People start associating the economic boom with the expansion of green technology, which slowly causes a revolution of mentalities in Portugal, with a vast majority of individuals becoming environmentally conscious. Marginal agricultural areas are abandoned and are converted to forest plantations and multiple use forest, managed for ecosystem services. By 2050, many of the species that were endangered in the beginning of the century have started to recovery, but some areas of the country where agriculture was intensified are now biological deserts.

The society attitude axis of the scenarios in Figure 10 is also one of the axes of the Global MA Scenarios. Because there was this similarity, and there was some interest from the MA Scenarios Working Group in scaling down the Global Scenarios to the national and local scales, we later decided to adopt the Global Scenarios as boundary conditions for the Portugal scenarios. This also has the advantage that the quantitative modeling done by the MA Scenarios Working Group can be used as a starting point for our work.

Storylines for each MA scenario are now being adapted to Portugal at the national, basin and local level (Box 1). Several trade-offs are becoming explicit in the scenario narratives. For instance, in the Order from Strength Scenario, despite a deterioration of ecosystem services, some cultural traditions are recovered and revitalized. On the other hand, it is also apparent that time lags are important. This is the case in the Order from Strength scenario, where the

trends in food production and rural exodus start to change at the end of the scenario due to decades of soil erosion and pollution.

During the development of scenarios there was some lively discussion between researchers and users, and it was apparent that scenarios are a tool that facilitates communication between people with different backgrounds. However, it seemed that users were not sure what to do with the result of the scenarios exercise.

8 Study cases

This section presents the results of the study cases at the basin and local level, with the exception of Castro Verde, which was not ready at the time of writing and will be included only in the final report.

8.1 Mondego and Mira Basins

The Mondego River drains a hydrological basin of approximately 6 670 km^2 and crosses the urbanised area of Coimbra (Beira Litoral). Its estuary is the location of a mercantile harbor (Figueira da Foz), consisting of two arms, north and south, which become separated by an island at approximately 7 km from the sea, joining again close to the mouth of the river. The two arms of the estuary exhibit very different hydrographical characteristics. The north arm is deeper (5 to 10 m during high tide, tidal range about 2 to 3 m), while the south arm (2 to 4 m deep, during high tide) is almost silted up in the upstream areas, which causes the freshwater discharge of the river to flow essentially through the north arm.

One of the most important economic activities in the Mondego River basin is the wood extraction for pulp production, using for such purpose *Eucalyptus globulus*, an introduced species from Australia. Additionally, the lower Mondego river valley consists of 15 000 ha of farming fields, mainly used for rice production, which contribute with an important input of nutrients into estuarine waters (Marques et al., 1993a; 2003; Pardal et al., 2000; Martins et al., 2001). The estuary, besides the harbor facilities, supports industrial activities, salt-works, and aquaculture farms.

The hydrological basin of the Mira River has a total area of approximately 1576 km^2, in southern Alentejo. The Mira estuary is 32 km long, extending between Vila Nova de Milfontes, located close to the mouth, and Odemira, at its upper limit, two small towns but nevertheless the most important in the whole basin region. The estuary is globally narrow and entrenched, with approximately 150 m in width in its lower part and only 30 m wide in the upper reaches, with a mean depth of about 6 m (Costa et al., 1994).

This estuary and the surrounding area are included in the Natural Park of Sudoeste Alentejano and Costa Vicentina. The landscape is characterized by irrigated fields, well-preserved eucalyptus and cork-oak woods and undergrowth (Raposo, 1996). The prevailing conditions allow, to a certain extent, to consider the Mira estuary as representative of a pristine system.

8.1.1 Biodiversity

Biodiversity has been assessed from benthic macrofauna data. The study of freshwaters macroinvertebrates in the Mondego River basin carried out by Feio (2004) indicates that Mondego river catchment is a high diverse area. On the other hand, the introduction of some species like the crayfish *Procambarus clarkii* had a negative significant effect on economic activities. Rice fields in the lower Mondego river basin are also habitats for new fish species like the mosquito fish *Gambusia affinis* that can attain large numbers and high production. When abandoned, such rice fields constitute ideal habitats for amphibians.

In the Mondego estuary, the biological diversity of subtidal benthic communities measured by the Shannon-Wiener diversity index is in a range of 1 to 3 bits/individual, although most of the sampling stations show low values. In 1998 and in 2002, respectively 51 and 38 species were identified, which suggests a significant decrease in species richness.

Eutrophication symptoms largely increased in this estuary since the 1980s, presumably as a result of excessive nutrients released into coastal waters. The most visible feature of this eutrophication is the occurrence of seasonal green macroalgae blooms (mainly of Enteromorpha spp.), which have been reported in the south arm for several years (Marques et al., 1993 a; 1993 b; 1997; Flindt et al., 1997). The *Zostera noltii* beds, which represent the richest habitat with regard to productivity and biodiversity (Marques et al., 1993 b; 1997), have been drastically reduced in the south arm, most likely as a function of competition with Enteromorpha, resulting from the different strategies of macroalgae and macrophytes to uptake nutrients, and also from the shading effects of macroalgae on macrophytes (Hardy et al., 1993; Hartog, 1994). In fact, in the beginning of the 1980s, the *Zostera noltii* beds covered a large fraction of the intertidal area, extending to the upstream section of the south arm, along the Murraceira Island, while by the end of the 1990s this species distribution was restricted to its downstream section.

The Mira estuary represents a transition area between the estuaries from the North and Centre of Portugal and those from the South, being considered the northern limit for the distribution of many Tropical African and Mediterranean species. The study carried out by Andrade (1986) along side 99 stations demonstrates that some of the sampling sites have a high diversity according to the Shannon-Wiener index, reaching values over 4 bits/individual, while in others diversity is quite low, with values next to 1, although none of them present species indicators of pollution.

8.1.2 Water provisioning

The water quality of streams and rivers draining the Mondego basin ranges from very clean to heavily polluted, as assessed by the use of physical, chemical and biological environmental criteria (Graça et al., 2002). New water treatment plants were built in recent years to decrease organic pollution, which might lead us to presume that water quality in the Mondego basin might be getting better. Nevertheless, different analyses performed at several functional points indicate a deficient functioning, which do not allow the treatment plants to be effective in reducing the quantity of pollutants discharged. In 2001, the regional environmental agency DRAOT estimated an annual loading of approximately 2031 ton of nitrogen and 281 ton of phosphorus, proceeding from industrial, agricultural, farming and domestic activities, leading to the occurrence of eutrophication symptoms along the whole basin, although part of such symptoms (e. g. the occurrence of algal blooms) appear to be related with water circulation problems, and not only with nutrients loading, namely in the estuary.

In the Mira basin, a wastewater treatment plant is operating since 1988. The main source of pollution consists of domestic effluents, agricultural activities and pig farming. Industrial loads are non-existent. Ferreira et al. (2002) estimated in the Mira estuary a low nutrient load (28.7 Ton/year and 4 Ton/year of nitrogen and phosphorus respectively), considering therefore that the impact of the nutrient inputs in this area is minimal.

8.1.3 Food Production

The main foodstuffs that can be obtained in the Mondego area are essentially those proceeding from fishing and agriculture activities. In the Mira area, farming industry and agricultural activities are the most important.

The main agricultural crops grown in the Mondego area are rice (6500 ha) and maize (36 000 ha). In 2001, maize productivity was 4123 kg/ha and rice productivity was 4913 kg/ha. Other less important crops can be found in the area such as potato, oat, rye and wheat. There is also an important area dedicated to vineyards, olive trees and apple trees, but with little national relevance.

Fisheries in the Mondego estuary and its surroundings are focused on high market value species, such as eel and lamprey. Illegal fishing tackles, like trawling, are used to capture some of those species, resulting in a deterioration of the system. The harbor of Figueira da Foz had a population of 523 fishermen in 2001, mainly devoted to sardine fisheries, trawling, and tuna. The number of fishermen has been decreasing since 1985 (Barreiros & Sobral, 1999).

Another activity taking place in this area is salt production. Nevertheless, the high costs of production resulting from the traditional way of extraction coupled with a great offer of product in better conditions from other areas of Portugal and abroad, have led to a progressive decline and abandonment of salt-works. Since the 1980s, some of the abandoned saltpans have been reoriented into fish farming factories, mainly of intensive production, where local species are grown.

The main agricultural products in the Mira area are wheat, maize, oat and barley (INE, 2001). Other products include rice, potato, industrial tomato, peach and apple. In 1997, 25% of the national production of oil was obtained in the Mira area. With regard to livestock, sheep had a remarkable increase of approximately 30% since 1994, while goats and cattle breeding increased respectively only 10% and 6%.

8.1.4 Recreation

In the Mondego river catchment area basin there are navigable courses located close to the Raiva Bridge, as well as in different inner lagoons. Nautical activities, both sporting and simply recreational, take place very frequently at such areas. Besides, spa activity in the Mondego area is very intense, with 54 places identified for that objective (DRAOT, 2001).

Tourism in the Mira area has increased in the past years and this trend is likely to continue. The Mira estuary has an important beach for summer activities, and recreation boats can be used in its downstream area.

8.2 The Community Assessment of Sistelo

Sistelo is a community with 341 persons of which 132 (39%) are more than 65 years old (INE, 2001). The community is spread over 5 small localities isolated from each other considering the mean distance and the absence of public transportation between them.

Sistelo was proposed by one of the users of ptMA, the National Park of Peneda-Gerês, as a study case of the mountain system for the analysis of condition of ecosystem services and biodiversity (Pereira et al. 2003). Sistelo borders the National Park, and it was recently included in the protected site of the Natura 2000 network which spans the National Park.

The climate in this region is considered Maritime Mediterranean, with mean annual temperature of 13º C, and high risk of frost, except from June to October (Rey, 2000). Mean annual rainfall in Sistelo is 2093 mm (SNIRG, 2004), unevenly distributed around the year, \with minimums in July and August. Different streams and rivers, including Vez River – the main tributary of Lima River, cross this area. A diversity of landscapes, habitats, flora and fauna with recognized ecological value can be found in this area.

Covering an area of 26.2 Km^2, Sistelo has a low population density – 13 hab/Km^2, comparing to the national average of 112 hab/Km^2 (INE, 2001). 84.5% of the labor force (61% of the

resident population) is employed in the primary sector – mainly agriculture and animal husbandry (INE, 2001). In 2001, half (50.5%) of the resident population with more than 15 years had as the main mean of living pensions (INE, 2001).

8.2.1 Methodology

In order to study well-being and the complex links between well-being and ecosystem condition as perceived by Sistelo's community, a participatory approach was used. The choice of this kind of approach was based on the recognition that the relationship between human well-being and ecosystem services are scale and context (cultural and socio-economic) dependent and that local people are the main actors and valuable information holders with specific needs, often not heard by policy makers.

The participatory approach was based on behavioural and epistemological principles shared by the Rapid Rural Appraisal (RRA) and/or the Participatory Rural Appraisal (PRA) (Chambers, 1992). The field methods and tools employed in this research were chosen and adapted from different sources including Narayan (1996), Rietbergen-McCracken and Narayan (1998) and SEAGA (2001). The methods and tools included direct observation, semi-structured interviews conducted with individuals, key informants and groups, trend lines, well-being ranking, criteria for well-being ranking, ecosystem resources scoring and ranking, landscape scoring and species list. Besides these methods and tools, familiarization with the community and participation in the community daily activities was considered important to learn more about the community and to establish a relaxed rapport and some measure of trust with the local people.

Participants in the study were selected using a non-probability sample of residents in the community. Eighty-six individuals participated in this study, including 80 residents (about 24% of resident population) and 6 non-residents key informants. From the total of participants 61% were women (women represent 62% of the resident population).

A review of secondary information was made before starting the fieldwork and meetings with representatives of local organizations were conducted in the beginning of the fieldwork. Triangulation of information sources, methods and people, and community validation of findings are used to ensure the trustworthiness of the findings.

8.2.2 Drivers of ecosystem change

The community identified several direct drivers: *baldio* afforestation during the 40's, abandonment of agricultural fields, decreasing of livestock, fire regime and introduction of new crop varieties.

The indirect drivers of change identified were: depopulation and aging linked to emigration, access to new sources of income, economic growth and improvement in infrastructure, improved access to goods and services, introduction of subsidies, in particular agri-environmental measures and compensatory allowances, and change of values.

Of those drivers, the main driving forces affecting ecosystem services are depopulation due to the lack of opportunities in a rural community like Sistelo, with the consequent abandonment of agricultural practices and changes in land use.

8.2.3 Interactions between drivers

The livelihood of the local population was traditionally based on agro-pastoralism with a diversified use of the territory in what can be considered an adaptative strategy to the heterogeneity of the mountain (Rey, 2000). Agriculture for instance was made in terraces at

successive heights in the mountain slope called "socalcos" and livestock husbandry was mainly based on the use of *baldio (common property*[6]*)* and the use of mobility strategies (Medeiros, 1984). People moved with their livestock from the valleys in the winter to the high zones with better pastures in the summer (Graça, 1996). Forest was also important because it was a source of wood for heating and of leaves and branches for cattle "beds" and food (Rey, 2000).

As a consequence of the forest policy in the 40's, the management and property of *baldio* was transferred to the State. The area of *baldio* in Sistelo accounted for 83% of total area in 1941, and 94,5% of this area was considered apt for afforestation (Medeiros, 1984). According to the people we interviewed the systematic forestation of this area and interdiction of use for the pastoral practice had profound negative consequences on the livelihoods of the community. Nevertheless according to our interviewees, some benefits were felt, as the afforestation process created employment opportunities.

After the 50's many local people gradually emigrated to countries like France or America looking for better life conditions (Graça, 1996) and the money sent back by the emigrants became a new source of income. Emigration, in particular of men, became a livelihood strategy for families in Sistelo. Between 1960 and 2001, the population in Sistelo was reduced by 57% (INE, 1964; INE, 2001).

With the exit of the young, the resident population became old, the traditional family exploration system, where the agricultural hard work was supported by the youngest members of the family gradually start to disappear, and agricultural practices progressively loose their strength (Caldas, 1982). Traditional agro-pastoralism practices that were based on abundant labor availability were gradually abandoned.

According to the people we have interviewed the more recent abandonment of agro-pastoralism practices is linked not only to emigration and aging of resident population, but also to existence of other sources of income, agriculture low productivity, and lack of "incentive" to produce.

For those employed in agriculture several problems affect nowadays the enhancement of agro-pastoralism practices. One of the main problems stated is that the use of machines in order to increase productivity, decrease labor needs and improve work conditions is very difficult, because agriculture in this zone is done in small terraces of difficult access. Also the very low proportion of literacy makes the modernization of agriculture more difficult (ARDAL, 2002). The illiteracy rate for ages > 10 was 35.9% in 2001, and the female illiteracy rate was 44.8% (INE, 2001).

Besides the problems to enhance agro-pastoralism practices, people interviewed stated lack of "incentives" to produce because, due to the market globalization, people have access to products coming from other countries and other regions of Portugal, and the high production

[6] *Baldio* is land that was historically given by a King to a specific community (Castro, 1992). This *baldio* land had a fundamental role in farmer's subsistence providing pasture for cattle, fuel for cooking and heating, and wood for construction. The original area of *baldio* suffered considerable reductions from the XVII century until the beginning of XX century, in particular due to individualized appropriation (Castro, 1992). The New State regime (1933) placed the existent, and quite reduced, area of *baldio* (about 5% of the land surface of Portugal) under its management and only in 1976 this land was returned to the original user communities (Brouwer, 1995). Note that most of *baldio* is uncultivated land but not all uncultivated land is *baldio;* it is only considered *baldio* the land that is the common property of residents in a particular location, owned and managed by local communities.

costs associated with transportation difficulties prevent local products from obtaining a competitive position and establishing themselves in the market.

Subsidies, in particular those linked to agri-environmental measures and compensatory allowances, do not seem to be enough to boost agricultural activities and keep people in rural areas. Nevertheless, these subsidies represented, in 2001, 63,4% of the income gained from animal sales according to a rough estimate by ARDAL (2002).

According to our interviewees, most of the young people that still live in Sistelo work in the nearest village, employed in industry or services sectors. For them agriculture represents very hard work that does not pay off.

Since agriculture was the main economic activity of this community for a long time, the abandonment of agricultural practices will have large effects on ecosystem services. Also this can have large effects on biodiversity in the way that a change of the species that are present in the terraces can occur.

One of the main problems associated with the absence of human activity is that terraces are now subjected to the invasion of shrubs and wood increasing the risk of fire. In what concerns the forest area, local people point to intense fires as the cause of a significant forest cover reduction. With the abandonment of agricultural practices the entire system is threatened (CONFAGRI, 2002) including the agricultural terraces as patrimony of the humanized landscape.

8.2.4 Local Criteria for Human Well-being

Near forty different criteria for human well-being were identified. We organized the most referred criteria (Table 8.1) according to the components of well-being considered in the Millennium Ecosystem Assessment Conceptual Framework (MA 2003).

Table 8.1. Human well-being criteria most referred by the participants (Pereira et. al, 2004)

Material Well-Being	**Bodily Well-Being**	**Social Well-being**	**Security**
Money income	Health	Not being alone; living with family	Security from retirement pensions
Access to goods and services	Leisure	Mutual Help	Safe environment: air and water quality
Assets: house, cattle and fields	Age	Conviviality	Tranquility
Food: quantity and quality	Capacity to work	Joy	-
Freedom of Choice and Action			

For the great majority of participants well-being has been improving in the community for the last 30 years, in particular, because of improvements in criteria related to material well-being and the enhancement of choices. But people also reported a deteriorating situation in some criteria related to bodily and social well-being. The reasons stated for the decline in social well-being criteria, such as joy, conviviality and mutual help, were the decrease and the aging of the population but also the disappearance of some traditional practices related to agriculture. These traditional practices consisted in regular gatherings of people to work on the fields of each other and to accomplish some production activities, such as “fiadas”

(spinning wool) and "desfolhadas" (stripping off corn leaves). During "fiadas" and "desfolhadas" people usually sang and danced together.

8.2.5 Ecosystem Services Perceived by the Community

Locals recognize several important ecosystem services: provisioning of food, pasture, wood, fuel, water, medicinal plants and water, regulating services for air and water quality and cultural services, such as cultural values, recreational services, sense of place and aesthetical values.

Although the importance of agricultural activities has been diminishing as a source of livelihood, provisioning services are those most stressed by the community as important for well-being. There is also, for older people, a kind of "emotional dependence" on agriculture and an affective relation with agricultural practices and cattle.

8.2.6 Human Well-being and Ecosystem Services

Sistelo is a good example of the complexity and diversity of links between human well-being and ecosystem services. Products obtained from ecosystems like food and fuel wood are still important in the community (e.g. fuel wood is still used for heating and cooking). However, the importance of these services at the local level is diminishing as people are aging, the number of persons living at Sistelo is decreasing, fields are being abandoned, people are earning income from other sources and, in the case of fuel wood, people are having access to other energy sources. Freedom of dependence of local provisioning ecosystem services is considered a major improvement for the well-being of the community. Cultural services are valued inside and outside the community, but the aesthetical value of Sistelo's *socalcos* landscape, although valued and recognized by outside people, is seen by local people as a constraint to well-being.

8.3 Quinta da França

Quinta da França (QF) is a 500 ha farm in Beira Interior, near the mountain range of "Serra da Estrela", managed by Terraprima, an agricultural company, since 1993. It has a great landscape diversity, with upland areas, irrigated pastures, terraces, olive groves, maritime pine, pyrenean oak and eucalyptus forests and shrub areas. One can also find alders, poplars, narrow-leafed ashes, planes, quinces, sweet chestnuts, figs, cherry trees, pear trees, apple trees, white mulberries e willows. Scattered over the farm there are several old walls and tree lines. QF is delimited by the rivers Zêzere and Caria, in a total of 13 km of river margins, covered with a dense riparian gallery. Along the River Zêzere it has three dams. It has a 2 hectare lake, over 20 km of traditional irrigation levees and several water-springs. It has 24 typical stone Portugal rural houses, covering a total area of 4 800 m^2. The houses are very diverse in size and are scattered over the farm. Other stone constructions like barns, pigsties, ovens and a traditional cheese-dairy are also present.

The farm has roughly equal-sized forest and agricultural areas. About 150 ha of the agri-cultural area is within the "Cova da Beira" irrigation project, due to be completed by 2009. A recent (2003-04) afforestation project is intervening on the whole forest area. This project is based on natural regeneration of *Quercus pyrenaica* (155 ha) and the plantation of a varied mixture dominated by pine, cypress and wild cherry (67 ha).

The climate in the surrounding region is moderately humid, mesothermal, with great water deficit and moderate summer thermal effectiveness. Average daily temperature varies between 7 ºC in December and 22.6 ºC in July, with extreme average values (in the same months) between 2.8 ºC and 30.2 ºC. Average annual precipitation is 995 mm, with 77% from October to February. There is a marked dry season from June to September, during which evaporation in free surface reaches 257 mm. There is frost from October to May. The

underlying geology is granitic, leading to acid soils, with pH in the range 4.5 to 6. Near the river, soils are alluvial, and, with greater distance, become colluvial.

8.3.1 Biodiversity

QF has no plant protected species. Of the vertebrate species known in Beira Interior, 6 out of 7 fishes, 11 out of 12 amphibians, 7 out of 15 reptiles, 100 out of 125 birds and 18 out of 38 mammals have been observed. Of these, one is classified as vulnerable by IUCN, and 12 others are in Annex II. The mixed forest, based on oak, created by the afforestation project will be beneficial for biodiversity.

8.3.2 Food production

Food production at Quinta da França is concentrated on animal husbandry with c. 600 sheep, c. 30 goats, c. 20 cows and 6 horses. This is supported by rain-fed cereals, oats and rye (c. 30 ha) and irrigated maize (c. 15 ha). Terraprima has its own registered trademark, which it used to commercialize in a shop in Lisbon its production of mutton. A project has been approved to install a small scale cheese production installation.

8.3.3 Timber and fuel production

Fiber production in the past has been mostly related to fuelwood production from the oak forest areas and also some timber production from the pine and eucalyptus forests. In the next decades, it will increase substantially, due to the ongoing afforestation project.

8.3.4 Regulating services

The landscape structure of the farm, namely the riparian gallery and the tree lines transversal to the main watercourses allow the dissipation of the kinetic energy of these watercourses during flooding, providing an excellent flood regulation service. Also, the existence of permanent soil cover on more than 90% of the farm (permanent pastures, forest and shrubs) ensures a high level of infiltration of pluvial waters, providing simultaneously soil protection and flood regulation services. This service will be strongly reinforced by the ongoing forestry project, which will replace shrubby areas. As a consequence, the number and intensity of fires will be reduced, increasing the average level and decreasing the variance of provision of flood regulation, soil protection and carbon sequestration services.

Carbon sequestration services will also increase due to the progressive replacement of natural pastures by permanent pastures sown with highly biodiverse and productive seed mixtures. This greater productivity leads to greater soil organic matter, not only directly but, more importantly, through increased animal stocking rates. Increased soil organic matter provides greater carbon sequestration and increases infiltration of pluvial water, again providing flood regulation services.

8.3.5 Cultural services

The farm is under a regulated game regime: it is a tourist game reserve. There has been no hunting of resident species since the creation of this reserve, in 1995. However, the populations of these species have not risen sufficiently to allow hunting to restart. Hunting activity is thus concentrated on migratory species (turtle dove and song thrush) and on “largadas”, where animals (ducks, pheasants, partridges) reared in captivity are released. The ongoing afforestation project will contribute to increase this service.

The farm has excellent conditions for tourism. Currently, a particular spot on the farm, near one of the irrigation dams in the river, is used by 25-100 people on each summer weekend. Camping on this spot by local scouts and youth associations is also allowed.

The managing partner of Terraprima lives near the farm and is very well integrated in the local social network. Hence, agricultural innovations at the farm are easily transmitted to the

surroundings. QF has a history of leading agricultural innovation in the region. In particular, in the 1950's, it introduced large scale orchards in the region, which is now one of the main productions in the region.

The farm has been in the same family for more than one century, representing a major connection between generations, and, for the current generation, the connection to the countryside and a major recreation spot. The farm has a very interesting and varied landscape, which has been maintained and improved along time.

The farm, mostly through the collaboration with Instituto Superior Técnico, is extremely involved in scientific research and demonstration activities. It has been the focus of two Life Environment projects, MISART – Integrated Modelling of an Environmental, Rural and Tourist System and LandSTATE – Sustainability of Tourism and Agriculture Through Consumer Involvement and is now one of the pilot farms in project EXTENSITY (see section 6.5). There is an ongoing project comparing natural to sown rain-fed permanent pastures, with respect to biomass and protein production and soil fertility, as a function of liming and micronutrient application. An "Open Day" for this project has taken place, with the participation of around 50 local farmers. The farm has been used as a case study in the course in Biophysical Planning in the Degree in Environmental Engineering at Instituto Superior Técnico. It has been the object of over 10 final undergraduate degree projects, 2 M.Sc. theses and an ongoing Ph.D. thesis. It has also held a professional training course in Aromatic and Medical Plants.

8.4 Herdade da Ribeira Abaixo

The Field Station of the Centro de Biologia Ambiental is located at the "Herdade da Ribeira Abaixo" (HRA), a 221 ha farm owned by the Ministry of Agriculture. The soils are skeletal, with a low amount of organic matter. The climate is markedly Mediterranean, with a mean annual precipitation of 500 mm, a mean annual temperature of 15.5ºC and a 3-4 months summer drought (CNA, 1983; data from the years 1967-80). There are several temporary streams crossing the HRA. The primitive forest has since long been transformed in cork-oak montado (woodland). The agricultural and livestock-raising practices have been progressively abandoned during the last 35 years, which allowed the development of a tall "maquis" shrub layer in the steepest slopes, as well as a partial regeneration of the primitive mixed cork-oak and Lusitanian-oak forest.

The first census of Santa Margarida da Serra County that includes most of the Grândola Hills and the HRA dates from 1513. By that time, there were more than 100 inhabitants (Silva 1997). During the following three centuries the population increased very slowly, stabilizing during the 19th century at around 500 persons. This low population density (around 10 inhabitants/km^2) is probably related with the poor soil quality and weak precipitation, which do not allow for intensive agriculture. For instance, all of the farms that were registered in 1819 were still unchanged in 1995, which may mean that a family could not be supported in smaller holdings. The largest changes in the resident population took place during the 20th century – a marked increase from 1900 to 1940 and a marked decrease from 1950 to the present. This population decrease, which also happened in other rural areas in Portugal, is due to the emigration of the younger generations to the main towns. Today, the population is mostly composed of elderly people.

8.4.1 Biodiversity

Cork-oak woodlands are included in the Habitats Directive (94/34/CEE; National Decree 140/99, 24th April), due to their importance for the conservation of several threatened species, namely birds of prey and mammalian carnivores. The first biological characterization of HRA (Santos-Reis and Correia, 1999) found:

- A total of 239 species of mushrooms (22% of the mushroom species occurring in mainland Portugal), out of which 30 were for the first time found in Portugal.
- 70 species of bryophytes (10% of the Portugal bryoflora). The vascular flora includes 304 species and subspecies, out of which 12 are Iberian endemisms.
- Up to 140 species of insects, 6 of fishes, 13 of amphibians, 15 of reptiles, 73 of birds and 23 of non-flying mammals.

8.4.2 Food production

The main activities of the inhabitants of Santa Margarida da Serra County have always been agricultural and pastoral. The first inhabitants were probably shepherds and raising livestock has been a permanent activity in the region (Silva, 1997). However, the composition of the grazing herds has changed. Apparently, goats were the most important livestock before being progressively replaced by pigs and sheep during the 19th century (Silva, 1997). Free-reared pigs and sheep are still the main livestock in the region; cattle were never significant.

Due to the lack of water, intensive agriculture was restricted to small areas close to the wells. Most of the land was used for the production of rain-fed cereal, following a 12 to 14-year cycle. Cork-oaks were kept, first because of their acorn production (and its role as fodder for cattle, sheep and pigs), and then because of the cork. Today, most of the land is dedicated to the production of cork, and acorns are still used as a food supplement for pigs and sheep. The shrub layer is regularly cut in a roughly 10-year cycle, and the regeneration of the herbaceous layer provides pasture for livestock, but some areas are still ploughed for the production of high-quality pasture. In the HRA, cork is extracted and the shrub layer removed every 9 years; a flock of about 200 sheep roams the HRA and the nearby holdings, grazing on the regenerating areas.

8.4.3 Cork production

Cork-oak is the most representative tree of the HRA, being present in practically the whole area. Adult tree densities vary according to slope orientation and soil depth, averaging 43 individuals/ha (Maria, 2003). It is therefore possible to estimate a total of about 9500 cork-oaks for the entire HRA. As the average production of cork per adult tree in this region is of 100 kg in each 9-year cycle (Silva, 1997), the production of cork in the HRA may amount to 9.5×10^5 kg per cycle, which means about 480 kg/ha/yr. At current prices (Duarte 2003) this corresponds to 768 €/ha/yr. The 1999 campaign, during which less than half of the cork-oaks were debarked, yielded a total of about 3×10^5 kg of cork, which corresponds at current prices to about 480 000 €.

Cork is a renewable resource and its extraction is a sustainable activity. Furthermore, debarking the trees is a labor-intensive activity that is highly dependent on skilled human labor, which is very well paid. This is one of the few well-paid seasonal jobs in this region, responsible for the annual maintenance of several households. This production system is highly dependent on the price of cork in the international markets. As long as the international markets continue to consider cork as the most efficient bottle-stopper, the future of cork-oak woodlands is apparently assured. However, future drops in the price of cork, its substitution by synthetic materials, or the general degradation of cork oaks in Portugal , may threaten the maintenance of vast tracts of cork-oak woodlands in these marginal lands, with no aptitude for agriculture or other types of forest.

8.4.4 Cultural services

The Field Station is currently used to support undergraduate field courses, undergraduate theses and PhD theses of national and foreign students. There are also several environmental education programs directed to a broad audience. In the latter, there was the participation of

55 persons in 2002 and 25 persons in 2003. In a questionnaire distributed to 95 participants of the "First Meeting on the Flora and Fauna of Cork-Oak Woodlands", the majority of the participants showed interest in hiking in the HRA (53%), for observing the fauna (20%) and the landscape (15%) (Maria, 2003). All these activities are enhanced by a growing trend of interest in ecotourism, nature observation and hiking, and are dependent on the maintenance of vast extensions of correctly managed cork-oak woodland, which is also one of the best ways to conserve the biodiversity of this region.

9 Conclusions

In this section, we integrate and summarize the findings of this report, namely establishing the relation between the findings at the national scale and the findings at the basin and local scales. We point to further work which should be carried out, both in the forthcoming Assessment Book and in further research. We start by carrying out an assessment of how this report has addressed the user needs initially identified, and how this could be improved in the final report.

9.1 User Needs

In this report, the major user needs (see Table 2.4 and Table 2.5) have been addressed in the following way:

- Economic valuation of ecosystem services has been provided comprehensively for the forest ecosystem. In other ecosystems, only market valued services have been economically valuated.
- The assessment of conditions and services has been quite comprehensive for the priority systems of agriculture and forest.
- The effects of the CAP have been comprehensively addressed, at multiple scales and through the analysis of its interaction with other drivers. The Nitrate Directive has only received a brief overview.
- The history of land use has been addressed qualitatively throughout the report, identifying and discussing its major drivers. It has been quantitatively addressed for aggregate categories at the national level.
- Natural Parks have been mostly addressed through the Sistelo study (adjacent to the National Park of Peneda-Geres) and the Mira basin study (which includes part of the Natural Park of Sudoeste Alentejano and Costa Vicentina). The Natura 2000 network has received scarce attention.
- The agri-environmental measures have been analysed as a response, at the EU and at the regional (Castro Verde) and local (farms) levels. Their integration with other responses, e.g. certification, has also been analyzed.

9.2 Drivers at Multiple Scales

At the local scale it is usually very clear what are the most important proximate drivers of ecosystem change, and how those drivers are going to evolve in the short-term. This assessment is more difficult at the national scale.

The most important drivers of ecosystem change at the national scale are: fire regime, land use changes (including abandonment of agricultural fields, afforestation, urban expansion and development of transportation infrastructures), EU common agricultural policy, global markets, and economic growth. Other important drivers include environmental legislation, social attitudes towards the environment, tourism, demography and exotic species. In some

instances these drivers interact synergistically. For instance, economic growth has led to increasing labor costs, which in association with reduced agricultural revenues, have led to the abandonment of agriculture, facilitating the establishment of shrubs, and hence increasing the frequency and intensity of fires.

The importance of each driver differs with the site at the local or basin scale (Table 9.1). Fire regime is clearly important at QF, having motivated the major response there: the forestation of about half the area of the farm. Land tenure and farm structure are not important at QF and HRA, because these are uncharacteristically large farms (especially QF). They are, however, a clear problem in Sistelo, where farms are small. Intensive farming is a problem in the Mondego basin, mainly with rice cultivation, leading to an important input of nutrients into estuarine waters. Tourism is important at both QF and HRA, but in the exactly opposite sense that it is important at the national scale. For the farms, it is low-intensity, environmentally friendly tourism, that constitutes a major economic opportunity for making landscape maintenance and biodiversity protection economically viable. At the national scale, it high-intensity, concentrated in the coastal regions, with strong environmental impacts. The major problem with exotic species is related to eucalyptus, and this is also the case in the Mondego basin. Economic growth and population migration has the significant effect both in QF and Sistelo of increasing labor costs, leading to reduced viability of many agricultural activities.

Environmental attitudes are clearly important for both QF and HRA. In the former, these have been transformed into a commercial opportunity to make viable sustainable agricultural practices, through the creation of a commercial brand strongly based on an environmental message (tightly coupled to a food safety message). In the latter, they represent the motivating factor for the interest in tourism at the farm.

The EU CAP has a major influence on QF and Sistelo, through the changes that subsidies produce in which agricultural activities are viable. Also, the influence of international markets is felt in Sistelo in agricultural activities which are no longer viable and in HRA as a threat to cork production.

Table 9.1 Drivers at multiple scales (QF-Quinta da França, HRA-Herdade da Ribeira Abaixo).

Driver	Mondego	Mira	QF	HRA	Sistelo
Fire regime			X		
Land tenure and farm structure					X
Land use changes					
Tourism		X		X	
Exotic species	X				
Economic growth			X		X
Population distribution and migration			X		X
Environmental legislation and attitudes			X	X	
EU Common Agricultural Policy and global markets			X	X	X

9.3 Conditions and trends

In a national scale assessment it is difficult to define how ecosystem services are going to be assessed. A choice between an ecosystem based approach or a geographic based approach has to be made. If the ecosystem approach is chosen, the ecosystems to be considered must be defined and mapped geographically. This categorization and mapping can be a difficult

process by itself. In our assessment we tried to do this categorization by consensus in the research team.

It is important to realized that ecosystem services are scale-dependent. For instance, a forest bordering a basin can play an important role in the water cycle, but that only becomes apparent at the basin scale, not at the local scale.

Condition of ecosystem services is very heterogeneous across systems, with inland waters presenting more problems than any other system. Curiously, the dryland "montado" appears to be doing relatively well. The size of some systems is changing with forest and shrub land expansion and the partial abandonment of cultivated fields. The estimated economic value of ecosystem services from the forest is at least 900 million Euros per year, with at least 20% of this value coming from non-marketed services such as soil and flood protection. Furthermore, about 5% of the total employment is associated with the forest sector.

During the second half of the 20th century, food production in the cultivated systems grew much slower than national food demand. Use of fertilizers and pesticides is generally low, when compared with other EU countries. However, there are some instances of contamination of underground water by nitrates. Other localized problems include soil erosion due to poor agricultural practices and loss of fertile soil to urban sprawl and other land uses. Fish landings from the ocean and the coast have decreased over the last decade, but at the same time oceanic fish stocks have improved and the majority of oceanic species are above the precautionary biomass threshold. Nevertheless, some oceanic species are overexploited and, in a few cases, even with strong regulation, recovery will be very difficult. Coastal fisheries are doing worse than oceanic fisheries, partially because of pollution and eutrophication. In inland waters there has been an increase in food production due to aquaculture but the sustainability of that production has been decreasing due to its impacts on water quality.

About 75% of water consumption is associated with agricultural activity and about half of the water comes from underground sources. Despite some localized problems (including highly variable intra- and inter-annual run-off in the South), there are no critical problems of supply and demand of water in Portugal. However there are serious problems with water quality. Some aquifers in the cultivated systems have problems with nitrate pollution and saline intrusion. Moreover, several rivers are heavily polluted from industrial, farming and domestic activities, with eutrophication occurring in some basins. Finally, despite the increase in total forest area over the last decades, the capacity of forests to provision freshwater has not improved significantly due to the increase in fire frequency and because the majority of the forest area increase is with eucalyptus plantations, which are worse than oak or pine forest for water provisioning.

Annual fellings for wood supply are small than the net annual increment in forests with the same main function. However, better management could both improve annual increments by more than 20% and the sustainability of the production in terms of fertilizer use, soil erosion, and nutrient depletion. The dryland "montado" produces more than 50% of world cork, a process that has high ecological sustainability.

Broadly speaking there is a spatial overlap between terrestrial biodiversity and human populations in Portugal: areas with more species are also under the highest pressure for development. However, most sites with high irreplaceability of biodiversity are protected under the Natura 2000 network. Still, biodiversity is declining in most systems, both in populations of indicator species such as top predators and in area of rare or vulnerable habitats. The worst situation is found in urban systems where biodiversity is much lower than

what it could be with better urban planning. Forest, inland water systems and coastal areas are not doing much better: with the exception of the “montado” woodland only a small proportion of forest is covered by native oaks, with monocultures of eucalyptus and pine dominating; inland water systems have suffered from dam construction, pollution and eutrophication; in coastal areas the pressure from urban development and tourism has led to the loss of wetlands and other habitats. Some marine species such as seabirds and mammals have decreased their range or population size, but surveys of ocean fish species do not show negative trends. Some cultivated systems such as cereal pseudo-steppes and slough fields are particularly important for biodiversity but their maintenance is threatened due to agricultural abandonment. On the other hand, agricultural intensification in some other areas has led to landscape homogenization and loss of biological diversity including loss of domestic races.

Critical ecological problems with soil protection and water cycle regulation services occur in the urban system (poor urban planning) and in the coastal areas (loss of wetlands and infrastructure development near cliffs). In some cultivated areas in the South, cultivation of cereals with excessive tillage in inadequate soils and the decreasing use of crop rotation has led to soil degradation, recovery being particularly difficult in that dryland. The forest system is affected by fire frequency, which causes soil loss during rainfall, deterioration of water quality downstream and increased rain-off.

Current knowledge of the role of Portuguese forest in carbon sequestration is limited. An (under)estimate of Net Biome Productivity is about 1.52 Mt C/year, which accounts for 7% of carbon emissions in 2000. While carbon sequestration capacity has been improving due to the increase in total forest area, this improvement is hampered by increases in fire frequency and intensity.

In 2000, total income from tourism represented about 8% of GDP. The vast majority is associated with mass tourism in coastal areas, where some signs of saturation and even deterioration of recreation quality are appearing. Hunting is one the most important recreational services in forest, cultivated and mountain systems, with an estimated annual economic value of 60 million euros. The recent creation of associative hunting zones and tourism hunting zones implementing a user-payer philosophy and the assurance of no-hunting rights to land owners may improve the condition of this service. But concerns have been raised about predator control in these zones. There are about 2 million non-hunting visiting days per year to forest and mountain areas. Furthermore, there is now an increase in demand for rural tourism in areas with traditional agricultural practices. Finally, dam construction in inland waters has provided new opportunities for recreation, including sailing and bathing areas.

9.4 Responses

One of the major responses analyzed was the acquisition of farms by a national scale environmental NGO in a specific "hot spot" area for hosting biodiversity, the cereal pseudo-steppe, responding to land use changes driven by the European Union’s Common Agricultural Policy and the pressure to create eucalyptus plantations. This multi-scale intervention of an environmental NGO has been very useful. The technical capacity and intervention influence of the NGO, owing to its national scale, has been applied at the local level. At the same time, this experience has had feedback on its intervention at the national scale. However, the strong focus of the NGO on biodiversity conservation has led to a low performance with respect to soil conservation. Managing this trade-off is still an open problem.

9.5 Scenarios

The ptMA started by trying to develop its own scenarios, but it turned out that these overlapped partially with the global MA scenarios. So a decision was made to adapt the global scenarios to Portugal. This process is ongoing but it is already clear that different scenarios have very different outcomes in terms of the evolution of ecosystem services and that the most important drivers at the Portugal scale may differ from the drivers at the global scale. Also, scenarios bring out trade-offs such as that between historical traditions and nature conservation.

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Appendix A: List of Abbreviations

ANCOSE	National Association of "Serra da Estrela" Sheep Breeders
BCSD	Business Council on Sustainable Development
CBA	Centre for Environmental Biology
CAP	Common Agricultural Policy
CELPA	Paper Industry Association
CONFAGRI	National Confederation of Agricultural Cooperatives and Credit
DRAOT	Regional Directorate for Environmental and Land Planning
EDIA	Corporation for the Development and Infrastructures of Alqueva
EEA	European Environment Agency
EEZ	Economic Exclusive Zone
EMR	Effective Maximum Rarity
EU	European Union
EXTENSITY	Environmental and Sustainability Management Systems in Extensive Agriculture
GDP	Gross Domestic Product
GMO	Genetically Modified Organism
GNP	Gross National Product
HRA	Herdade da Ribeira Abaixo
ICN	Institute for Nature Conservation
ICS	Institute of Social Sciences
INAG	Institute of Water

INIAP	National Institute of Agriculture and Fisheries Research
IPB	Polytechnic Institute of Bragança
LPN	League for the Protection of Nature
MA	Millennium Ecosystem Assessment
MADRP-AA	Ministry of Agriculture, Rural Development and Fisheries – Environmental Auditor
MOPTH	Ministry of Public Works, Transportation and Housing
NAO	North Atlantic Oscillation
NBP	Net Biome Productivity
NGO	Non-Governmental Organization
PNPG	National Park of Peneda-Gerês
PtMA	Portugal Sub-Global Assessment
RGA	General Census of Agriculture
UC	University of Coimbra
UCP	Portugal Catholic University
UE	University of Évora
UL	University of Lisbon
UM	University of Manchester
UNL	New University of Lisbon
USA	United States of America
UTL	Technical University of Lisbon
UTM	Universal Transverse Mercator
UAA	Utilizable Agricultural Area
QF	Quinta da França

Appendix B: Map of the agricultural regions of Portugal (MADRP 2002).