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LINKING BIODIVERSITY, ECOSYSTEM SERVICES AND ECONOMIC ACTIVITIES: AN INDICATOR-BASED ASSESSMENT

SETTORE SCIENTIFICO-DISCIPLINARE DI AFFERENZA:
SECS-P/06 ECONOMIA APPLICATA

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A mia madre

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Introduction

At the very basis of biodiversity conservation stands the need to be able to quantify status and trends of biodiversity. Since biodiversity is too complex to be fully quantified at scales that are policy relevant, its assessment can be done by means of indicators. There are three basic functions of indicators: simplification, quantification and communication. The first function refers to the identification of the main components of complex phenomena, while the second deals with making them quantifiable. Finally, indicators should be easily understandable so that the information they convey can be communicated (EEA, 2003).

Biodiversity indicators must supply significant and meaningful information to policymakers and other stakeholders. As far as policy makers are concerned, the indicators should describe the effectiveness of policy choices and must, therefore, be able to indicate cause-effect relationships and provide a reliable trigger for action. In addition, biodiversity is valuable for a vast array of stakeholders in many different ways. As a consequence, indicators should reflect these values and should be tailored on the requirements and degree of knowledge of the various audiences to which they are addressed.

The need for the development of biodiversity indicators has been acknowledged by international institutions as well as by national governments in the last two decades and the Convention on Biological Diversity of 1992 represents the starting point of this process. Subsequently several attempts have been made to define the most important components of biodiversity and the relevant indicators to measure their status (EEA, 2003; EEA, 2007). In addition, various studies have reviewed advantages and shortcomings, as well as data availability for the computation of those indicators (Ten Brink, 2000; EASAC, 2005).

The literature review showed that conservation biologists use biodiversity indicators in order to establish conservation priorities and monitoring needs. However, although biodiversity protection can be an objective in itself, it seems important to underline that biodiversity provides direct benefits to human well-being, even though this linkages still show a large uncertainty component.

This thesis aims at establishing a link between biodiversity, measured via indicators, and human well-being, through the impact exerted by biodiversity on different economic sectors. This analysis allows drawing some interesting conclusions on the potential for using biodiversity indicators in the definition of priorities in biodiversity conservation. This represents a step forward in the role of biodiversity indicators, from being measures of the status and trends of biodiversity to being adopted as policy and decision-making tools. This thesis is structured as follows.

Chapter 1 provides a description of the state of the art of the use of biodiversity indicators, through an extensive review of indicators already developed and used in literature, highlighting the main advantages and shortcomings of each of them. Subsequently, an indicator development process is described and applied to the information available from an existing database, the Natura 2000 Database.

In Chapter 2 indicators are used to define biodiversity and landscape profiles for 207 countries worldwide. The analysis then focuses on the differences between international and domestic tourism flows as far as their respective demand for biodiversity and landscape quality is concerned. A second stage of the analysis is centred specifically on tourism heading to coastal regions, in order to identify potential peculiarities of coastal tourism as far as the demand for biodiversity and landscape is concerned.

Chapter 3 provides an example of how biodiversity can be measured by means of the different indicators presented in Chapter 1, and how the latter can be used to assess the influence of the biodiversity profile of a destination on the tourism flows towards it. This analysis is implemented at the national level on domestic tourism flows, choosing Ireland as a case study.

In Chapter 4 landscape diversity indicators are constructed following a process analogous to the one implemented for biodiversity, using data retrieved from the CORINE Land Cover Database. These indicators are then included, together with climatic and socio-demographic variables, in a model aiming at describing tourist flow towards a destination. This analysis is implemented at the sub-national level, choosing the municipalities of Tuscany, Italy, as a case study.

Finally, Chapter 5 presents an alternative use of biodiversity indicators, evaluating the effectiveness of a network of protected areas in preserving species and habitat diversity from pressures arising from agricultural activities. The Italian Natura 2000 sites have been selected as a case study and the information contained in the Natura 2000 database has been used to develop two indices of pressures originating from agricultural activities. In addition to the impact of agriculture on biodiversity, a potential assessment of the impacts of biodiversity on tourism flows and of the indirect impact of agricultural pressures on tourism is provided.

1. Developing biodiversity indicators: An empirical approach

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Abstract

Biodiversity is an extremely complex concept, whose aspects and features are difficult to describe as such. There is a widespread consensus on the need to develop indicators suitable for describing the different aspects of biodiversity and identifying their status and trends. This paper analyses the progress made so far, both by the scientific community and international and European political institutions, in the development of biodiversity indicators. Against that background, an empirical approach to the construction of biodiversity indicators will be proposed, taking advantage of the Natura 2000 database, which incorporates information on species and habitats of European interest existing on the territory of the European Union Member States.

The process leading to the construction of biodiversity indicators will be presented in detail and their applicability will be discussed. Finally, some suggestion are put forward concerning the use of biodiversity indicators, not only as a means for assessing the progress towards policy objectives, but also as a useful tool to make policy decisions and evaluate their effectiveness.

Keywords: Biodiversity indicators, Natura 2000, Species diversity, Habitat diversity, Decision-making tool

1.1 Introduction

Providing a simple yet comprehensive definition of biodiversity is a challenging task. Noss (1990) suggests that, rather than looking for such a definition, the focus should be placed on the identification of the major components of biodiversity at several levels of organization. This would allow identifying a set of measurable indicators, assessing the overall status of biodiversity and monitoring its trends.

Three primary attributes which constitute the biodiversity of an area can be identified: composition, structure, and function. Composition concerns the variety of elements and includes species lists and measures of species diversity and genetic diversity. Structure refers to the physical organization of a system and it is mainly linked to habitat complexity and to the pattern of landscape patches. Finally, function involves ecological processes, including gene flow, disturbances, and nutrient cycling (Franklin et al., 1981).

Noss (1990) maintains that biodiversity can be monitored at multiple levels of organization, as well as at multiple spatial and temporal scales. According to the chosen scale and the objective of the analysis different levels of resolution appear to be appropriate. In addition, no single indicator can adequately account for all the relevant aspects of biodiversity and a set of different indicators is required to build a complete biodiversity profile of an area.

This paper reviews the main developments in the identification and construction of biodiversity indicators promoted by the scientific community and international political institutions. The need for further specification of several identified indicators is recognized and an empirical approach is proposed adopting an existing database, Natura 2000, as the starting point. A detailed description of the proposed indicator construction and computation process is provided, highlighting its consistency with the international and European action towards biodiversity conservation. Finally, several conclusions and recommendations on the use of the developed biodiversity indicators are formulated.

1.2 Biodiversity conservation in the international political context

In view of providing a suitable framework for analysing the issue of biodiversity indicators, it seems important to begin with a brief description of the milestones of the indicator development process, with a particular focus on instruments related to the European Union. The Convention on Biological Diversity was one of two major treaties opened for signature at the United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro in 1992 and it entered into force in 1993.

The treaty defines biodiversity as "the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems". The main objectives of the Convention are the conservation of biological diversity, the sustainable use of its components and an equitable sharing of the benefits arising from the utilisation of genetic resources.

The Convention acknowledges the role of indicators as information tools that summarise data on complex environmental issues and describe the overall status and trends of biodiversity. Moreover, it highlights seven focal areas in which the development of indicators seems to be necessary, namely the status and trends of the components of biological diversity, the threats to biodiversity, ecosystem integrity and ecosystem goods and services, sustainable use, status of access and benefit sharing, status of resource transfers and use and public opinion.

The European Community signed the convention in 1993 and in 1998 adopted a European Community Biodiversity Strategy, in order to provide a framework for the implementation of the convention. The strategy reflects the broad obligations the EC endorsed with respect to the convention, as well as a detailed description of the activities to be implemented[1]. The strategy explicitly calls for the development of a set of indicators corresponding to these focal areas, so as to be able to measure progress towards the objective of reducing biodiversity loss.

In April 2002, the Parties to the CBD committed themselves to achieve a significant reduction of the current rate of biodiversity loss at the global, regional and national level by 2010. A review of the implementation of the strategy was initiated in 2004 and it led to the EC Communication on halting the loss of biodiversity by 2010 (EEA, 2007). At the Pan-

[1] The Strategy identifies eight policy areas: conservation of natural resources, agriculture, fisheries, regional policy and spatial planning, forests, energy and transport, tourism and development and economic cooperation. In addition, concrete objectives and the way to achieve them are laid down in four Biodiversity Action Plans, published in 2001.

European level, an analogous objective of halting biodiversity loss by 2010 was agreed upon by pan-European environment ministers in the Kiev Resolution on Biodiversity signed in 2003. In addition, at national level, several countries have also included the 2010 target as part of their national biodiversity strategies. This widespread political agreement on the 2010 target has been accompanied by a growing consensus on the need for long-term, structured, global and European coordination of biodiversity monitoring and indicator development (EEA, 2007).

1.3 Biodiversity indicators

1.3.1 The rationale and functions of biodiversity indicators

At the very basis of biodiversity conservation stands the need to be able to quantify status and trends of biodiversity. Since biodiversity is too complex to be fully quantified at scales that are policy relevant, its assessment can be done by means of indicators. These can be considered as information tools, summarizing data on complex environmental issues to indicate the overall status and trends of biodiversity. They can be used to assess performance of policy choices and to signal key issues to be addressed. In addition, they are important tools for monitoring the status and trends of biological diversity and, in turn, feeding back information on ways to continually improve the effectiveness of biodiversity management programmes.

It must be acknowledged that, while research on environmental indicators has made significant progress in some sectors, such as forestry, far less has been made in developing indicators for biological diversity. This is due to scientific uncertainty, such as poor understanding of complex ecosystem processes and functions, and the limited availability of time series data.

There are three basic functions of indicators: simplification, quantification and communication. The first function refers to the identification of the main components of complex phenomena, while the second deals with making them quantifiable. Finally, indicators should be easily understandable so that the information they convey can be communicated (EEA, 2003). Biodiversity indicators must supply significant and meaningful information to policymakers and other stakeholders. As far as policy makers are concerned, the indicators should describe the effectiveness of policy choices and must, therefore, be able to indicate cause-effect relationships and provide a reliable trigger for action. For high-level policymakers, instead, indicators should provide a broad description of the overall biodiversity status. In addition, biodiversity is valuable for a vast array of stakeholders in many different ways. As a consequence, indicators should reflect these values and should be tailored on the requirements and degree of knowledge of the various audiences to which they are addressed. These considerations lead to the need to develop a set of different measures of biodiversity allowing highlighting the most relevant aspects, depending on the specific context and on the issues to be addressed.

A crucial consideration that needs to be taken into account when choosing the appropriate biodiversity indicators is the geographical scale of the analysis. Information on biodiversity is usually collected locally but biodiversity indicators report trends at different spatial scales and their level of detail and accuracy is inversely proportional to scale. Aggregation of data to wider geographical scales is useful in that it allows identifying trends at a policy-relevant level. However, this may mask significant changes in biodiversity occurring at the local scale.

1.3.2 Review of existing indicators on the status and trends of the components of biodiversity

The previous sections traced an overview of the international and European action and policy decisions towards the objective of reducing biodiversity loss and of developing appropriate indicators to monitor progress towards this target. The European Environmental Agency has elaborated fifteen headline indicators covering all the focal areas identified by the CBD. In addition, a set of 26 specific indicators have been developed to address the different aspects of each headline indicator (EEA, 2007).

Since the focus of this study is the identification of indicators for measuring status and trends of the different components of biodiversity, it seems interesting to describe in detail the specific indicators referring to this focal area. Table 1—1 displays the indicator hierarchy moving from the CBD focal area, to the European Union headline indicators and to the specific indicators proposed by the European Environmental Agency.

Insert Table 1—1 about here

The abundance and distribution of selected species is a state indicator, measuring the number of individuals of each species living in a particular area. This indicator appears to be policy relevant, since it contributes to the evaluation of conservation and land use policies, and biodiversity relevant, since viable populations indicate the presence of healthy habitats and ecosystems (EEA, 2007).

For most EU Member States, high-quality data are available for a large number of vertebrate species, mainly birds, mammals, amphibians and fishes, some invertebrate species, especially butterflies, and several groups of plants. However, long-term data series would be necessary in order to properly assess trends and evolutions. This indicator can be easily aggregated and is cost-effective, since most of the information is collected by amateurs and professionals.

When dealing with species diversity it seems worth mentioning species richness. This indicator refers to the number of different species recorded in a particular site and it can be expressed both as the number per unit of area and the number per habitat type. The main shortcoming of this indicator is that trends must be assessed for a large number of species and this process is costly. Moreover, species richness depends on the considered spatial scale, since the larger the scale, the greater the diversity. Finally, this indicator appears to be rather insensitive to changes, since, before observing a reduction in the number of species, a long process of species abundance degradation takes place, without being reflected by the indicator (Ten Brink, 2000). On the other hand, this appears to be the most intuitive and easy to compute species diversity indicator. It can be suitable for wider spatial scales of analysis, for which it would not be possible to achieve a deep level of detail and, for smaller scale studies, it can be coupled with the abundance indicator and complete the information provided by the latter.

Conservation biologists use richness and abundance of selected species as indicators in order to establish conservation priorities and monitoring needs. Indicator species prove to be useful in describing the magnitude of anthropogenic disturbance (Medellin et al., 2000; Hill et al, 1995; Nummellin, 1998), to monitor the deterioration and loss of specific ecosystems (Altieri, 1999), to account for population trends in other species (Block et al., 1987, Suter, 2002) and to define biodiversity hotspots. In addition the geographical range of some species can be used to identify area surfaces that should be protected. Finally, the abundance and richness of particular species can be employed as a tourist attraction factor (Caro and O'Doherty, 1999).

The second indicator mentioned by the EEA is the Red List Index for European species reflects the proportion of species expected to remain extant in the near future in the absence of additional conservation action. The methodology for the computation of this indicator has been developed by Butchard et al (2004) and it considers the number of different species recorded in each IUCN Red List category. There are three main categories for species at high risk of extinction, namely critically endangered, endangered and vulnerable.[2] Red List

[2] The World Conservation Union (IUCN) has published lists of species at risk of extinction since the 1950s, compiling these as Red Data Books since the 1960s and as Red Lists since the 1980s. Initially,

Indices are calculated from the number of species in each category in each assessment, and trends are assessed through the number of species changing categories as a result of genuine improvement or deterioration status (Butchard et al., 2004).

This indicator is highly relevant to the 2010 target, explicitly addressing species extinctions, a key component of biodiversity loss. It is also biodiversity relevant, since it relates to the rate at which species are slipping towards extinction, and to the proportion of species expected to remain extant in the near future, barring additional conservation actions (EEA, 2003). Another significant strength of the RLI is that it is highly representative, being based on assessments of a high proportion of species in a taxonomic group across the world (Butchard et al., 2004). However, this indicator presents a resolution problem, since the size, trend or distribution of populations may have to undergo quite substantial changes before qualifying for a higher or lower Red List category, and hence before changing the RLI value.

The indicator species of European interest covers the species which are considered to be of European interest, selected because they were perceived to be under some sort of threat at an EU scale and listed in Annexes II, IV and V of the Council Directive 92/43/EEC on the conservation of natural habitats and wild fauna and flora, known as the Habitat Directive[3]. The considered species cover various taxonomic groups, trophic levels and habitats. The indicator directly reflects success of the Habitats Directive, therefore it is highly relevant for Member States and EU nature conservation policy. The main disadvantage of this indicator is the limited trend information since the data will only be reported in a six-year cycle. In addition, the indicator is based on the EU Habitats Directive, implying that a transfer to the global level would not be possible.

Ecosystem coverage reflects the proportional and absolute change in the extent of different land cover categories in the period 1990 – 2000, as defined by the CORINE Land Cover Database[4]. The database takes into account thirteen ecosystem types, namely forests,

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species were assigned to qualitatively defined categories. To improve objectivity and consistency of application, the IUCN Species Survival Commission initiated the development of quantitative criteria in 1989. After several rounds of review and revision, a system was adopted in 1994 (IUCN 1994), with further revisions published in 2001 (IUCN 2001).

[3] The Habitats Directive, together with the Birds Directive, forms the cornerstone of Europe's nature conservation policy. It is built around two pillars: the Natura 2000 network of protected sites and the strict system of species protection. All in all the directive protects over 1.000 animals and plant species and over 200 so called "habitat types", e.g. special types of forests, meadows and wetlands, which are of European importance.

[4] The objective of the pan-European project CORINE Land Cover (CLC) is the provision of a unique and comparable data set of land cover for Europe. It is part of the European Union programme CORINE (Coordination of Information on the Environment). The mapping of the land cover and land use was performed on the basis of satellite remote sensing images on a scale of 1:100,000. The first CLC data base CLC1990, which was finalised in the 1990s, consistently provided land use information comprising 44 classes.

cropland, semi natural vegetation, wetlands, inland water systems, glaciers, permanent snow and urban, constructed, industrial and artificial areas. This indicator is based on the interpretation of satellite imagery.

Ecosystem coverage is highly relevant for the 2010 target, since it indicates the area of available habitats and ecosystems across Europe, in fact, a dramatic decrease in the area covered by a particular ecosystem will have a negative influence on the species dependent on it. The CORINE Land Cover methodology is well established and widely acknowledged; nonetheless, the use of remote sensing data implies that some degree of detail is lost. As a matter of fact, the minimal unit is fixed at 25 hectares, meaning that smaller areas of certain habitat types may not be adequately detected.

Indicators of land cover change have been used in literature in the assessment of the environmental impact of urban expansion and green space dynamics (Pauleit et al., 2005), to assess the diversity and abundance of specific land cover types and biodiversity (Firbank, 2003) and as land quality indicators (Dumanski and Pieri, 2000). Habitats of European interest, as already pointed out for species, refer to protected habitats identified by the Habitats Directive, for which Member States have monitoring and reporting obligations concerning their conservation status. This is a policy relevant indicator, directly indicating the implementation and success of the Habitats Directive. Results can be aggregated to the European level. However, the data will be reported on a six-year basis and an extension of this indicator to a wider geographical scale will not be possible.

Livestock genetic diversity refers to the share of breeding female population between introduced and native breed species, namely, cattle and sheep, per country, as a proxy for the genetic diversity of these species. This indicator addresses each Member State's responsibility to maintain native breeds, as a contribution to global genetic diversity, and the level of threat to which these native breeds are subject. In addition, it refers to genetic diversity, which is one of the three main components of biodiversity, and directly shows biodiversity loss. Livestock genetic diversity has been employed in the conservation policy literature in order to determine the optimal allocation of funding in order to minimize genetic diversity loss (Simianer et al., 2003) and to evaluate the loss of farm genetic diversity resources (Wollny, 2003).

The coverage of nationally designated protected areas, illustrates the rate of growth in the number and total area of nationally protected areas over time. There is international acceptance of the indicator at a global, regional and national scale and it provides information and can be used at different scales. Information on sites that have been designated for conservation purposes should be available in every country. However, this

does not describe the quality of management or whether the areas are protected from incompatible uses. The coverage and the effectiveness of protected areas has been employed as a measure of the progress towards biodiversity conservation targets (Chape et al., 2005).
The coverage of sites designated under the EU Habitats and Birds Directive shows trends in spatial coverage of proposed sites. As far as data collection and methodology are concerned, EU Member States have already put in place procedures for compilation of information on Natura 2000 sites at both national and regional levels. The main shortcoming of this indicator is that it only applies to EU Member States.
The analysis of the most widely acknowledged indicators of the status and trends of the components of biological diversity, shows that most of these indicators have already reached a good level of testing and they provide scientifically sound information. Moreover, most of them have already been employed in several studies aiming at assessing the effectiveness of conservation policies. The main obstacles to their further development seem to be data availability constraints and the limited comparability of data derived from different sources.
It is interesting to notice that an explicit reference is made by the European Environment agency to the Habitats and Birds Directives and the possibility to use the information collected by EU Member States to assess trends in the conservation of European biodiversity. Data collection has already started and the result of this process has been the creation of the Nautra 2000 database. However, both the analysis of official reports by EU institutions and the literature review concerning conservation policy choices highlight that no attempts have been made so far to use this database to compute indicators on the status of biodiversity. The remainder of this paper will provide a brief description of the structure of this database and propose an innovative indicator-building protocol employing this information.

1.4 The Natura 2000 database as a source of biodiversity information

The objective of this paper is to provide a further specification and an empirical application of the indicators proposed by the EEA, which are directly linked to the implementation of the Habitats and Birds Directives, namely species of European interest, habitats of European interest and coverage of sites designated under the EU Habitats and Birds Directives.
The Natura 2000 database can be considered as a sort of snapshot of the biodiversity profile of European countries. As highlighted by the literature review on indicators, in order to be able to evaluate the trends and changes in such profiles, data should be available over a long time span for all countries and all species and habitats. For the time being the database does not have such characteristics, nonetheless, it appears to be a remarkable source of

information and it can be used to construct biodiversity profiles at the national and sub-national level. This section will briefly describe the framework within which the European Natura 2000 network is included and the kind of information the Natura 2000 database can provide.

1.4.1 The Habitats and Birds Directive and the Natura 2000 database

The Directive 79/409/EC on the conservation of wild birds, commonly referred to as the Birds Directive aims at maintaining bird species at a level which guarantees the respect of ecological, scientific and cultural requirements, while, at the same time, taking into account economic and recreational needs (European Community, 1979). In order to achieve this result, the Directive formulates specific measures to be adopted by Member States, including the establishment of special protection areas (SPAs). Protected species are listed in Annexes I to V of the directive.

The Directive 92/43/EEC on the conservation of natural habitats and wild fauna and flora, commonly referred to as the Habitats Directive, aims at protecting biodiversity through the conservation of natural habitats and of wild fauna and flora in the territory of the EU Member States (European Community, 1992). In order to achieve its objective, the directive requires the establishment of a European ecological network, called Natura 2000, consisting of special areas for conservation (SACs), to be designated under the habitats directive, and the SPAs, designated under the Birds Directive. Habitats and species to be affected by the directive and special measures to be taken are listed in Annex I to VI of the Directive. In view of implementing the requirements of both directives, the European Commission has established a standard format for the collection of relevant information from member countries, in order to create an overall database.

The information each country must provide is related to site identification, location and description, ecological information on species and habitats, the level of institutional protection the site is granted and relation with CORINE biotope sites. In addition, information on activities implemented in and around the site must be provided, together with maps and other supporting material.

The ecological information concerning the sites appears to be the most relevant aspect, in view of developing biodiversity indicators. Member states must provide a detail description of all the habitat types, as listed in Annex I of the Habitats Directive, and all flora and fauna species, listed in Annex II, present in each site. An evaluation of each habitat according to different criteria is required. The criteria are representativity, relative surface, conservation status and global assessment and site managing authorities need to attach a ranking to each of them for each habitat. Rankings are based on an ordinal scale, ranging from A to D. It is important to remind that those rankings are associated to different meanings depending on the criterion under consideration.

Representativity gives a measure of “how typical a habitat is” and in this case the rankings mean excellent, good, significant and non-significant representativity. Relative surface represents the area of the site covered by a particular habitat in relation to the total area it covers at the national level. In this case, the rankings indicate a share ranging from 100% to 15%, from 15% to 2% and from 2% to 0% respectively.

Conservation status reflects the degree of conservation of the structure and functions of the habitat as well as its restoration possibilities. Finally, global assessment implies an overall valuation of the previous criteria, taking into account the different weights that each criterion can assume in different circumstances and for different habitat types. For these last two criteria, rankings mean excellent, good and average or reduced conservation status or global assessment.

As far as flora and fauna species are concerned six taxa, amphibians and reptiles, birds, fishes, invertebrates, mammals and plants, are assessed separately. Since, the site can be important for different stages of the life cycle of a species, for each species it must be stated if it is resident, breeding, staging or wintering in the considered site.

Site managing authorities need to evaluate each species according to four criteria: population size, isolation, conservation status and global assessment. The rankings that can be attached to each criterion are once more based on a scale ranging from A to D.

The first criterion reflects the size and density of the population present in a site in relation to the population of the same species living on the national territory. Rankings A, B and C identify a percentage ranging from 100% to 15%, from 15% to 2% and from 2% to 0%, respectively.

The second criterion deals with the degree of geographic isolation of each population in each site with respect to the natural range of the species to which it belongs. This criterion can be interpreted as a measure of the contribution of a given population to genetic diversity of its species. A signals an almost complete isolation, B suggests that the population is not isolated but lives on the margins of the distribution area, while C implies that the population lives in an extended distribution range.

The conservation status refers to the degree of conservation of the habitat characteristics that are crucial for the survival of each species, as well as the restoration possibilities of those characteristics. The global assessment gives a measure of the value of each site for the

conservation of the considered species. As pointed out for habitats, the rankings must be interpreted as excellent, good and an average or reduced conservation status or global assessment.
In addition to the ecological information, a general description of the main features of the site, including geological, morphological and landscape characteristics, is required. Finally, all human activities or natural processes occurring inside or around protected sites need to be specified. Member states are required to specify the influence and the intensity of each activity, as well as the share of the site affected.

1.4.2 A protocol for constructing biodiversity indicators using the Natura 2000 database

The indicators relating to species and habitats of European interest and the coverage of protected areas proposed by the EEA, appear to need further specification. This section provides an example of how the Natura 2000 database can be used to obtain more precise indicators at the site level. The information contained in the database appears to be extremely detailed, thus it has been necessary to select the most relevant aspects in view of constructing biodiversity indicators.

As far as the species of European interest are concerned, three specific indicators have been developed, namely species richness, species abundance and species isolation; each of them reflects a different aspect of species diversity. Species richness provides information on the ratio between the number of species present in each site and the number of species existing at the national level. This indicator has been calculated for each taxon and then an average was computed among the six taxa, so as to obtain a single value per site. The underlying assumption is the concept of "inter-species democracy", meaning that species are considered equally important, regardless for the taxon to which they belong.
Species abundance is constructed adopting the information provided by the population criterion specified by the database and reflecting the share of specimen present in a site out of the total species population living on the national territory. Species isolation represents the degree of isolation of a population living in one site with respect to the geographic range of the species to which it belongs. For the purpose of this study it has been used as a proxy to genetic diversity, since a population having limited contacts with other individuals of the same species is likely to preserve some peculiar genetic traits.
Habitat richness represents the ratio between the number of habitats recorded in each site and

the total number of habitats existing at the national level, while habitat abundance describes each habitat's relative surface in a site with respect to the total area it covers at the national level. Finally, site coverage delivers the percentage of land covered by Natura 2000 sites with respect to the total surface of the national territory. Table 1—2 highlights the link between the EEA proposed indicators and the ones developed in this study.

Insert Table 1—2 about here

As pointed out when describing the structure of the Natura 2000 database, each protected species and habitat is evaluated by site managing authorities according to a set of criteria and the rankings are based on an ordinal scale ranging from A to C. It appeared crucial to attach a numerical value to those rankings, so as to develop the biodiversity indicators. When species population and habitat relative surface are concerned, the Natura 2000 database defines the rankings as indicating a share of the total species population, or total habitat surface, at the country level. Bearing in mind that "A" represents a share ranging from 100% to 15%, "B" from 15% to 2% and "C" from 2% to 0%, it has been decided to associate ranking A to a value of 100, ranking B to a value of 15 and ranking C to a value of 2, choosing the upper limit of the interval defined by the database[5].

The species abundance, species isolation and habitat abundance indicators have been computed according to Equation (1.1):

$$Abundance_i\ (Isolation_i\ ) = \frac{(No.\ "A" \times 100 + No.\ "B" \times 15 + No.\ "C" \times 2\ )}{x_i} \qquad (1.1)$$

where x_i represents the number of species or habitats present in the site.

Since species richness and habitat richness have been defined as the number of different species and habitats recorded in a site with respect to the number of species and habitats existing on the national territory, these indicators have been computed according to Equation (1.2):

$$Richness = \frac{x_i}{x_j} \qquad (1.2)$$

[5] This is an arbitrary choice and alternatives are possible. For instance, it could have been decided to attach the mean value of each interval to those rankings. However, since these indicators are used to produce biodiversity profiles at the site level, with the objective of comparing different locations, the choice of the value exerts a limited influence on the results of the analysis.

where x_i represents the number of habitats or species present in the site and x_j stands for the number of protected species or habitats existing on the national territory.
Finally, the coverage of Natura 2000 sites depends on the unit of analysis, according to Equation (1.3):

$$Coverage\ of\ \Pr otected\ Areas = \frac{\sum_{i=1}^{n} A_i}{A_j} \tag{1.3}$$

where A_i represents the site area and A_j the total surface of the unit of analysis. The score of each indicator is normalised on an interval ranging from 0 to 1.
The result of this process has been the construction of a set of indicators addressing the most relevant aspects of species and habitat diversity. Furthermore, since they have been computed at the site level, they can be used for tracing biodiversity profiles of different areas of EU member states and can be aggregated at different spatial scales, from the national, to the regional and sub-regional level.

1.5 Biodiversity indicators as policy decision and evaluation tools

This paper has provided an overview of the policy scenario as well as of the progress achieved in the development of biodiversity indicators, with the aim of measuring status and trends of the different components of biodiversity. It must be highlighted that a remarkable effort, in terms of data collection, development and comparability of the indicators across different geographical scales has been done, both by the scientific community and international and European institutions. However, several gaps still need to be filled, with respect to both geographical coverage of the available datasets and the scientific understanding of anthropogenic and natural dynamics influencing biodiversity.
This analysis demonstrates that, on the one hand, the there is a need to further develop the indicators proposed so far, especially the ones relating to the species and habitats of European interest, and that, on the other hand, that the necessary information can be found in an existing database. The Natura 2000 database presents the advantage of establishing a common format for biodiversity data collection across European Member States and should guarantee a regular update of this information. In addition, since it provides information at the site level, the proposed indicators can be aggregated at any geographical scale.
The indicators proposed in this paper fulfil three different functions. Firstly, they measure the status of biodiversity in a particular area. Secondly, they can be employed in the

evaluation of conservation policies, since changes in their level score will reflect the effectiveness of the international and European action for biodiversity conservation. In addition, it could be possible to ascertain whether the level of protection granted to biodiversity manages to satisfactorily ensure its conservation, since a vast array of human activities, including agriculture, are implemented inside protected sites or in their surroundings and this could reduce the benefits of conservation policies.

However, the use of biodiversity indicators should not be limited to the description of status and trends and the evaluation of policy choices. Biodiversity plays a fundamental role in determining human wellbeing and, in many cases, this role is not fully understood and not thoroughly studied. It seems therefore important to remind that, although biodiversity conservation is certainly an end in itself, the benefits of conservation actions and policies can go well beyond the maintenance of the current levels of biodiversity.

Several economic sectors, in fact, can directly profit from high levels of biodiversity. Against this background, biodiversity indicators could be considered as explanatory variables in models describing the profitability of those sectors. A useful example is tourism, where natural amenities, including biodiversity, play a remarkable role in determining tourism demand. A set of different indicators can be used to trace biodiversity profiles at the national and sub-national level and this, jointly with other variables, can be used to model tourism flows and tourist behaviour concerning the destination choice.

It seems possible to conclude that the construction of biodiversity indicators described in this paper, besides leading to an empirical measurement of status and trends of biodiversity, provides a useful tool for decision-making which may allow establishing priorities in biodiversity conservation policy choices.

Tables

Table 1—1 -Biodiversity indicators identified by the European Union and the EEA within the CBD focal area "Status and Trends of the components of biological diversity"

CBD Focal area	EU headline indicators	EEA specific indicator
Status and Trends of the components of biological diversity	Trends in the abundance and distribution of selected species	Abundance and distribution of selected species
	Change in the status of threatened and/or protected species	Red List Index for European Species
		Species of European Interest
	Trends in the extent of selected biomes, ecosystems and habitats	Ecosystem coverage
		Habitats of European interest
		Livestock genetic diversity
	Coverage of protected areas	Nationally designated protected areas
		Sites designated under the EU Habitats and Birds Directives

Source: EEA, 2007

Table 1—2 -Development of biodiversity indicators from the Natura 2000 database

EEA specific indicator	Natura 2000 indicators	Information from the Natura 2000 database
Species of European Interest	Species richness	Number of different species in the site/ number of species in the country
	Species abundance	Species population
	Species genetic diversity	Species isolation
Habitats of European interest	Habitat richness	Number of different habitats in the site/ number of habitats in the country
	Habitat abundance	Habitat relative surface
Sites designated under the EU Habitats and Birds Directives	Site coverage	Site area

Source: EEA, 2007; own elaboration

References

Altieri M (1999), The ecological role of biodiversity in agro-ecosystems, *Agriculture, Ecosystems and Environment,* Vol. 74, pp.19–31

Block W.M., Brennan L.A., Gutiérrez R.J. (1987), Evaluation of guild-indicator species for use in resource management, *Environmental Management,* Vol. 11, Issue 2, pp.265-269

Butchart SHM, Stattersfield AJ, Bennun LA, Shutes SM, Akçakaya H.R. (2004) Measuring Global Trends in the Status of Biodiversity: Red List Indices for Birds. *PLoS Biol 2(12): e383*.

Caro, T. M.; O'Doherty G., (1999) On the Use of Surrogate Species in Conservation Biology*, Conservation Biology, 13(4):805-814.*

S Chape**,** Harrison J.**,** Spalding M. and Lysenko I. (XXX), Measuring the extent and effectiveness of protected areas as an indicator for meeting global biodiversity targets, *Phil. Trans. R. Soc. B*, Vol. 360, No. 1454, pp. 443 – 455

Dumanski J. and Pieri C. (2000), Land quality indicators: research plan, *Agriculture, Ecosystems & Environment*, Volume 81, Issue 2, pp. 93 – 102

Hill J. K., Hamer K. C., Lace L. A. and Banham W. M. T. (1995), Effects of Selective Logging on Tropical Forest Butterflies on Buru, Indonesia, *Journal of Applied Ecology*, Vol. 32, No. 4, pp. 754-760

Estrada A., Coates-Estrada R. and Meritt D. Jr. (1993), Bat Species Richness and Abundance in Tropical Rain Forest Fragments and in Agricultural Habitats at Los Tuxtlas, Mexico, *Ecography*, Vol. 16, No. 4, pp. 309-318

European Commission (1998), *Communication from the Commission to the Council and the European Parliament on a European Community Biodiversity Strategy*, COM (1998) 42, http://europa.eu/scadplus/leg/en/lvb/l28183.htm

European Environmental Agency (2003), *An inventory of biodiversity indicators in Europe, 2002*, Technical Report n. 92, Copenhagen, available on the website http://reports.eea.europa.eu/technical_report_2004_92/en/Technical92_for_web.pdf

Firbank L. G., Barr C. J., Bunce R. G. H., Furse M. T., Haines-Young R., Hornung M., Howard D. C., Sheail J., Sier A. and. Smart S. M (2003), Assessing stock and change in land cover and biodiversity in GB: an introduction to Countryside Survey 2000, *Journal of Environmental Management*, Volume 67, Issue 3, Pages 207-218

Franklin, J. F., K. Cromack, W. Denison (1981), *Ecological characteristics of old-growth Douglas-fir forests*, USDA Forest Service General Technical Report PNW- 1 18. Pacific Northwest Forest and Range Experiment Station, Portland, Oregon.

IUCN (1994), *IUCN Red List categories*, IUCN Species Survival Commission, Gland, Switzerland

IUCN (2001), *IUCN Red List categories and criteria: version 3.1*, IUCN Species Survival Commission; Gland, Switzerland

Medellin R. A., Equihua M., Amin M. A. (2000), Bat Diversity and Abundance as Indicators of Disturbance in Neotropical Rainforests, *Conservation Biology*, Volume 14, No. 6, pp. 1666-1675

Noss R. (1990), Indicators for monitoring biodiversity: A hierarchical approach, *Conservation Biology*, Volume 4, No. 4, pp.355 – 364

Nummelin M. (1998), Log-Normal Distribution of Species Abundances is not a Universal Indicator of Rain Forest Disturbance, *Journal of Applied Ecology*, Vol. 35, No. 3, pp. 454 – 457

Suter W. Graf R. F., Ruedi H. (2002), Capercaillie (Tetrao urogallus) and Avian Biodiversity: Testing the Umbrella-Species Concept. *Conservation Biology*, Vol. 16, No. 3, pp. 778 – 788

Pauleit S., Ennos R. and Golding Y. (2005), Modeling the environmental impacts of urban land use and land cover change—a study in Merseyside, UK, *Landscape and Urban Planning*, Vol. 71, Issues 2-4, pp. 295 – 310

Simianer H., Marti S.B., Gibson J., Hanotte O., Rege J.E.O. (2003), An approach to the optimal allocation of conservation funds to minimize loss of genetic diversity between livestock breeds, *Ecological Economics*, Vol. 45, pp. 377 – 392

Wollny C.B.A (2003), The need to conserve farm animal genetic resources in Africa: should policy makers be concerned?, *Ecological Economics*, Vol. 45, Issue 3, pp. 341 – 351

2. Tourism demand and biodiversity: A worldwide analysis

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Abstract

Tourism is the largest business sector of the world economy, accounting for 10% of global GDP and 35% of the world's export services. The tourism industry heavily depends on a healthy environment since visitors tend to look for beautiful places to spend their holidays, characterised by warm weather, sunshine, pristine nature and clean air and water. It can be argued that tourists seek the same conditions that tend to be associated to high levels of biodiversity.

Against this background, this paper aims at the study of the impacts of biodiversity on tourism flows at the worldwide level, testing whether species and habitat diversity can exert a significant influence on the tourist's destination choice. Tourist arrivals in 207 countries have been analysed and disentangled into an international and a domestic component.

International and domestic flows have been modelled as a function of the characteristics of the trip, the country's socio-economic conditions, natural and cultural attractions and species and habitat diversity. Results allow concluding that, on the one hand, species and habitat diversity can influence tourists' destination choice, and that, on the other hand, significant differences exist between international and domestic tourism demand. As a matter of fact, the former appears to be more heavily influenced by the number of different species and well-known natural and cultural attractions, while the latter seems to be more interested in the surface covered by specific habitats, especially forests, and in the conservation status, rather than in the number, of the species living in their country.

Keywords: International tourism, domestic tourism, species diversity, habitat diversity, biodiversity indicators

2.1 Introduction and scope of the analysis

Tourism is the largest business sector of the world economy, accounting for 10% of global GDP and 35% of the world's export services. Since 1985, tourism flows have been growing an average of 9% per year. In 2005, receipts from international tourism reached US$ 6.82 trillion, an increase of $49 billion over 2004 (Honey and Krantz, 2007). Tourism, shows a stronger dependency on a healthy environment than other industries and economic sectors. A recent study commissioned by the WWF highlighted that tourists seek beautiful places to spend their holidays and they tend to look for the same conditions that are generally associated to high biodiversity, namely warm weather, sunshine, pristine nature and clean air and water (Honey and Krantz, 2007).

This paper aims at analysing the impacts of biodiversity on tourism flows at the worldwide level. The underlying hypothesis to be tested is that species and habitat diversity can exert a significant influence on the tourist's destination choice. Furthermore, the demand for a country's tourism services can be disentangled into an international and a domestic component, which may follow distinct patterns and may be sensitive to different aspects of the biodiversity profile of the destination. Therefore we shall focus on both international and domestic tourism arrivals in 207 countries, adopting 1995 as a reference year, and explore the links between tourism flows and species and habitat diversity. In order to describe each country's biodiversity profile, a set of suitable species and habitat diversity indicators have been selected, using data published by the World Bank and the World Resource Institute.

In this context, the present paper builds upon the state of the art literature extending the current tourist destination choice models to include biodiversity variables in addition to the widely used socio-economic characteristics of the destination, climate factors as well as the proximity of natural and cultural heritage sites. Moreover, two sets of models will be proposed. The first will describe tourism flows at the national level, while the second will focus on each country's coastal regions, performing a separate analysis for international and domestic arrivals, as displayed in Table 2—1.

Insert Table 2—1 about here

The paper organized as follows. Section 2.2 highlights the features of the global tourism demand and its growth perspectives. Section 2.3 provides a review of the relevant literature on the determinants of tourism destination choice. Section 2.4 describes the data sources used for this analysis and Section 2.5 justifies the choice of the selected biodiversity indicators. The model specification and the estimation results are discussed in Section 2.6, while Section 2.7 uses those results to trace two distinct profiles for international and domestic tourist demand. Finally, Section 2.8 draws some conclusions, providing inputs for further research.

2.2 Motivation of the study

Since the Second World War, the growth of international tourism has been exponential. Annual tourist arrivals worldwide increased from 25 million in 1950 to 450 million in 1990. Between 1969 and 1979, the World Bank encouraged developing countries to invest in tourism as a strategy for attracting foreign investment, and the governments of developing countries began to see tourism as a means to redistribute resources from North to South.

The World Tourism Barometer (WTO, 2008) reports that, in the last few years, international tourism has registered a sharp increase in the number of arrivals, reaching 900 million in 2007. The Middle East has registered the highest growth rate, with an estimated 13% rise with respect to 2006. In second place stand Asia and the Pacific, with an increase of 10%, followed by Africa, registering an 8% rise to the figure of 44 million visitors in 2007. East Asia and the Pacific, Asia, the Middle East and Africa, on the other hand, are forecast to record growth rates of over 5% per year, compared to the world average of 4.1% (Honey and Krantz, 2007).

Although Europe and North America remain the top destinations in international travel, representing about 65% of all international tourist arrivals, these more mature regions are anticipated to show lower than average growth rates in the forthcoming decades. In addition, tourism has become increasingly important for developing countries, accounting for 70% of exports from the Least Developed Countries (LDCs). The United Nations Conference on Trade and Development (UNCTAD) qualifies tourism as one of the main contributors to GDP of 49 least-developed countries, as well as one of the main sectors in terms of employment (Christ *et al.*, 2003).

Furthermore, many of those countries host a significant share of worldwide biodiversity hotspots, including Mexico, Brazil, Thailand, Malaysia and Indonesia. However, tourism in developed countries can also have significant implications for biodiversity conservation, because biodiversity hotspots also occur in these northern destinations, such as the California Floristic Province, the northern part of Mesoamerica, the Mediterranean Basin, the Caucasus, and the mountains of south-central China.

Therefore it becomes important to assess the degree to which tourism is dependent on biodiversity, in particular, among biodiversity-rich countries. This way it would be possible to shed light on the proportion of tourism’s GDP contribution and its link with biodiversity, which may represent the principal tourism attraction factor.

2.3 Literature review on the determinants of tourism demand

Economic variables such as income, tourism prices, cost of transportation and exchange rates are widely used as explanatory variables to describe tourist arrivals (Dritsakis, 2004; Witt and Witt 1995). In addition to the tourist's available income, GDP of the country of destination may also be used as a driver of tourism flows, arguing that the growth of international tourism will tend to concentrate in those regions with the highest level of economic development (Hamilton, 2005 a; Eugenio-Martín *et al.*, 2004).

Secondly, population density also revealed to affect international tourism as a proportional increase in departures. Hamilton points out the ambiguous interpretation of the impact of population density on tourism flows, since tourists may be attracted towards densely populated countries, since this implies a larger number of towns and cities as well as of tourism facilities and infrastructure. On the other hand, if a high population density entails a lack of natural and wilderness areas, those areas may become unattractive to tourists (Hamilton, 2004; Hamilton et al., 2005a).

Thirdly, many studies have been carried out on the relationship between climate and tourism demand. Temperature is often considered as the only relevant climatic variable, since most climate parameters, such as humidity, cloudiness and weather extremes, are strongly correlated to temperature and the relevant data are generally available and reliable (Bigano *et al.*, 2007, Lise and Tol, 2002). Hamilton *et al*. (2005 a; b) found that climate change shifts international tourist towards higher altitudes and latitudes.

Fourthly, cultural and natural heritage are also deemed to be significant determinants of the tourist's destination choice. Heritage tourism is often analysed as a specific tourism segment, influenced by the tourist's personal characteristics, awareness and perception as well as by the site's attributes (Poria, 2003). Hamilton (2004) uses the number of UNESCO World Heritage sites as a proxy for a country cultural attractiveness and the total protected area at the national level as a proxy for the availability of undeveloped land. An important determinant of tourism destination choice is the presence of coastal areas and beaches. Previous studies have found that a country's coastline and beach length positively influence the number of tourist arrivals (Madison, 2001; Bigano *et al*., 2007).

Domestic tourism has often been overlooked with respect to international flows. The study by Bigano *et al*. (2007) represents one of the few exceptions to this trend since they consider the peculiarities of the impacts of climate change on international and domestic tourism flows. Some studies have been carried out at the national level, for instance for China (Wen, 1997), Australia (Faulkner, 1998) and Germany (Coles, 2003), but there seems to be a substantial lack of in-depth analyses of domestic tourism flows at the regional or global scale.

The biodiversity component of the natural and environmental amenities available in different countries has not been addressed in the reviewed literature. As a matter of fact, research has focused either on a broad measure of environmental amenities, such as the share of protected area out of the country surface, or on ecotourism, a specific segment in the tourism market (Wunder, 2000; Naidoo and Adamovicz, 2005). An integrated assessment of different components of biodiversity and their impact on tourism flows is lacking. This papers aims at filling this gap in the literature.

2.4 Description of the data sources

This paper aims at investigating the role of biodiversity in the choice of tourism destination, bearing in mind two distinct markets, domestic and international tourism. This way it will be possible to test whether the impacts of the components of biodiversity, and their significance, are different across the two markets. In order to create a comprehensive database, encompassing the relevant determinants of tourism demand highlighted by the literature review, data has been gathered from a broad set of different sources. Table 2—2 shows the full of variables used in this study, including the respective data sources and the unit of measurement.

Data on tourism arrivals, both at the national and sub-national level, as well as the data on GDP per capita have been retrieved from an extensive collection work, done by Bigano et al. (2004). They have created a worldwide database, encompassing cross-section data for 207 countries, adopting 1995 as a reference year. In addition, expenditures and length of stay have been retrieved from Bigano *et al.* (2004). Population density data for 1995 have been collected from the World Resource Database (2001) and the country surface was taken from CIA World Factbook (2001). Coastline and beach length have been retrieved from Reefbase (2000) and the Report of the IPCC Coastal Zone Management Subgroup (1999).

As far as habitat diversity is concerned, the surface covered by wetland and forests has been included in the database. The species component, in turn, refers to the number of birds and mammals species recorded in each country. The data for both habitats and species were retrieved from the World Bank (2007). In addition to the number of species, it has been decided to include the Biodiversity Index for birds and mammals. This indicator takes into account both the number of species per unit of area and the respective level of threat to which those species are subject. This index represents the number of threatened species living in a 10 square kilometre area[6] weighted by the level of risk to which they are prone, thus providing an indication of the effectiveness of the country's biodiversity conservation policies and an indirect measure of the degree of stress of species and ecosystems (Wendland *et.al.*, 2009)

Furthermore, the number of sites recorded in the World Heritage List for each country was retrieved from UNESCO (2003). Finally, data on average annual temperature and precipitation for the period 1961-1990 have been retrieved from Bigano et al. (2004).

Insert Table 2—2 about here

2.5 Selection of biodiversity indicators

According to the Convention on Biological Diversity, biodiversity is defined as *"the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems"* (CBD, 1992).

The convention foresees an obligation for each contracting party to develop national strategies and plans for the conservation of biodiversity. At the very basis of biodiversity conservation stands the need to be able to measure it and to quantify its status and trends. Since biodiversity, and the manipulation of the respective data, are rather complex to be mapped, their quantitative assessment is often done by means of indicators. In turn, there is a variety of potential biodiversity indicators and the choice of the most appropriate ones, as well as the level of detail of their measurement, depends on the objective and on the scope of the analysis under consideration.

Since the present paper aims at identifying the impact of biodiversity on tourism flows on a global scale, it has been chosen to focus on two types of indicators, habitat abundance and species richness. Habitat abundance is defined as the share of a country's surface covered by a particular habitat type. This indicator is considered important in the description of a country's biodiversity profile since spatial landscape patterns and habitat distribution are strongly linked to the overall condition of ecological resources (O'Neill et al., 1997). We shall give particular emphasis to wetlands and forests, on the grounds that those are well-studied ecosystems for which good quality data are available and their role in the hosting and conservation of biodiversity is widely acknowledged.

To begin with, forests are a biodiversity-rich ecosystem and they support a vast array of species from birds and mammals to soil microbes. As a consequence, forest logging and

[6] The resolution is 0.083333 degree, corresponding to ca. 10km at equator (Wendland *et al.*, 2009)

deforestation may cause substantial changes in tree species abundance and distribution as well as significant losses of critical habitat hindering the survival of those species (Lyndenmayer, 1999; Bawa and Seidler, 1998). Subsequently, the high biological productivity of wetlands and the strong selection pressure peculiar to the aquatic environment produce a rich biota associated only with wetlands. This ecosystem typically occurs in discrete patches, therefore populations tend to be isolated and more vulnerable to extinction. A minimal threshold of wetland density needs to be maintained in order to sustain the wetland biota (Gibbs, 2000).

Species richness is defined as the number of different species living in a particular area or country. This indicator is a fundamental measurement of community diversity and it underlies many ecological models and conservation strategies (Gotelli and Coldwell, 2001). It is the most intuitive measure of biodiversity and it is relatively easy to compute once the scale of the analysis has been determined. Previous studies suggest that the species richness of certain indicator taxa, namely birds, may reflect that of other, more poorly studied taxa, providing a guide to conservationists (Prendergast and Eversham, 1997). Chase et al. (2000) use birds and small mammal species as potential biodiversity indicators for the coastal sage scrub habitats of southern California. Noss (1990) suggests that flagship species and vulnerable species may be used as indicators of species diversity. Due to the geographical scale of the present analysis, it has been decided to focus on bird and mammal richness, testing whether these can be considered as flagship or charismatic species, potentially exerting a sensible effect on tourist preferences. Moreover, several studies use bird and mammal species richness as indicators of the overall species diversity.

In addition to species richness, it has been decided to include a synthetic indicator reflecting the level of threat to which each species is exposed. This can be interpreted as a response indicator, giving a measure of the effectiveness of protection policies. In particular, synthetic biodiversity indicators have been computed for bird and mammal species (Wendland, 2009). These indices are constructed using the most recent available global vector data on species ranges of birds (BirdLife International, 2006) and mammals (Baillie et al., 2004) weighted by their threat status as defined by the IUCN Red List (IUCN, 2007).

2.6 Model for national tourism flows

2.6.1 Econometric model specification and estimation results

Tourism demand has been modelled as a function of a set of explanatory variables reflecting the characteristics of a country that are most likely to influence the country’s tourism attraction potential. The functional form of the model is a log-log regression model, displayed in Equation (3.1):

$$\ln Y_i = \beta_0 + \beta_1 \ln X_{1i} + \beta_2 \ln X_{2i} + \beta_3 \ln X_{3i} + \beta_4 \ln X_{4i} + \beta_5 \ln X_{5i} + u_i \qquad (2.1)$$

Where the dependent variable is the number of tourist arrivals per country (Y_i) and the explanatory variables are the characteristics of the trip (x_1), country socio-economic and demographic situation (x_2), climate conditions (x_3), cultural and natural heritage (x_4) and the features of the country's biodiversity profile (x_5). The coefficients can be interpreted as the elasticities of the number of tourist arrivals with respect to the different dependent variables[7].
In order to analyse the differences in the structure of demand across international and domestic tourism flows, the number of international and domestic arrivals in each country have been regressed against the previously described explanatory variables, running two separate models. Estimation results are presented in Table 2—3.

As we can see, GDP of the destination country has a positive and significant impact on the number of both international and domestic tourist arrivals. This result steams two possible interpretations. As regards international tourism, a higher GDP per capita in the country of destination may be read as an indicator of the degree of development. A developed country will have more and/or higher quality, accommodations and infrastructure that make the destination attractive from the tourist point of view. As far as the domestic tourism flows are concerned, the positive impact of GDP per capita can be interpreted as an income effect, since residents in countries having achieved a higher income level will have higher ability to pay for travelling.

Secondly, population density is also found to exert a positive and significant impact on tourism flows, in both the international and domestic segment, even though its coefficient is significantly higher for domestic tourists. This may signal that the more densely populated a country, the more its nationals will tend to spend their holiday in their own country. The same reasoning holds for the country area. On the one hand, a larger country presents a variety of different landscapes and cultural sites, and therefore it attracts a higher proportion of both international and domestic tourists. On the other hand, larger countries supply *ceteris paribus* a larger amount of accommodation possibilities. As far as the climatic variables are

[7] The model has been run for the total number of tourists visiting each country. International and domestic tourists arrivals have been included among the explanatory variables. The difference of their respective coefficients has been found to be significant with a confidence level of 95%. Therefore, it has been decided to run the same model for international and domestic tourist arrivals. The results of those models are presented in the remainder of this paper.

concerned, the average annual temperature is negatively correlated to tourist arrivals in both models. However, this magnitude reveals to be statistically significant only in the domestic sub-sample. This result signals that this market segment is more sensitive to potential temperature increases.

As observed before, the habitat diversity component is represented by the share of country surface covered by forest and wetland habitats. Different econometric patterns emerge across the international and domestic segment. In fact, the number of international arrivals is not influenced by forest habitats, while the domestic segment is positively influenced. Once more, this result suggests that the structure of preferences among the two segments differ. As regards the species diversity component, the number of bird species has a negative influence on international tourist arrivals, while the number of mammal species is found to exert a positive effect. In turn these indicators do not show any impact on the domestic tourism flows. The Biodiversity Index for bird species is positively correlated to domestic tourism flows, which could signal a higher interest in the conservation status of bird species than in the number of different species. The share of country surface mapped as protected area and the number of UNESCO World Heritage sites have a positive impact on the number of international tourist arrivals. An interesting result concerns the impact of the presence of coastal areas. As a matter of fact, countries having access to the coast are found to attract a higher number of domestic tourists, signalling a higher sensitivity of domestic tourism demand, compared with international demand, to the possibility to access the coast.

Insert Table 2—3 about here

These results contain several insignificant variables; this suggests the presence of sample size and multicollinearity problems. Therefore a stepwise removal of insignificant variables has been performed and the results are displayed in Table 2—4 for international tourists and in Table 2—5 for domestic tourists. These results show that three variables, namely GDP per capita, population density and country surface are consistently significant across the two models. The number of bird and mammal species, the share of country surface mapped as protected area and the number of world heritage sites are significant when international tourist flows are considered. On the other hand, the extension of forests, the score of the biodiversity index for bird species and the country's average temperature are significant as regards domestic flows. The removal of insignificant variables does not substantially affect the explanatory power of the models.

Insert Table 2—4 andTable 2—5 about here

2.6.2 A model for coastal tourism flows

The subsequent step of this analysis involved the estimation of an econometric model focusing on a sub-sample of tourism flows, which only refers to coastal areas. It is generally intuitively understood what is meant by coastal zone, it is difficult to place precise boundaries around it, either landward or seaward. The coastal zone is generally defined as the part of the land affected by its proximity to the sea, and that part of the sea affected by its proximity to the land as the extent to which man's land-based activities have a measurable influence on water chemistry and marine ecology (Van den Bergh and Nijkamp, 1998).

In addition, the coastal zone may vary in territorial depth from one area to another depending on the issues to be considered. Despite the challenging task of defining it, the landward part of the coastal zone can play an important role for human settlement and tourism (EEA, 1995).

In order to proceed with the estimations, it has been chosen to disaggregate tourism data at the NUTS II level. Then we took into account domestic and international tourism flows going towards these NUTS II regions, in particular those having direct access to the coast. The model structure is analogous to the one presented section 2.6.1. Two additional explanatory variables were considered: the length of the coastline and the beach surface. These are interpreted as relevant characteristics of a country's coastal area. In addition to that, the number of NUTS II regions having access to the coast, out of the total number of regions of each country, has been considered as a proxy for the potential for seaside recreation and coastal tourism.

The estimation results, as shown in Table 2—6, reiterate some of the results obtained from the previous model. As a matter of fact, GDP per capita and population density in the country of destination prove to exert a positive and significant impact on international and domestic tourist arrivals. The length of the coastline appears to be positively correlated with the number of tourists choosing the country's coastal regions as their destination. However, the coefficient is remarkably higher for domestic tourists, thus confirming that domestic tourists seem to be more influenced by the possibility to access the coast, when making decisions regarding their destination.

The number of UNESCO World Heritage sites produces a positive impact on international tourist arrivals. On the other hand, species and habitat diversity indicators do not exert a significant influence on either of the two demand components. The only significant exception is the Biodiversity Index for bird species, which proves to be positively correlated to domestic arrivals, consistently with the findings of the previous model.

Insert Table 2—6 about here

As already noted in the previous paragraph, the results displayed in Table 2—6 contain several insignificant variables and multicollinearity appears to be an issue. A stepwise removal of the insignificant variables has been performed and the results are displayed in Table 2—7 for international tourists and in Table 2—8 for domestic tourists. These results show that GDP per capita, is significant across the two models. As far as international tourists are concerned, the extension of forested areas, the number of mammal species and the number of World Heritage sites are significant in the restricted model. When domestic tourists are considered, population density, the length of the coastline, the number of bird species, the biodiversity index for birds, the number of world heritage sites and the country's average yearly precipitation are significant in the restricted model. Again the removal of insignificant variables does not substantially alter the explanatory power of the models.

2.7 Synthesis

The previous analysis allows drawing some interesting conclusions on the difference between international and domestic tourism demand, as far as the choice of the destination is concerned. As a matter of fact, the two segments of the tourism market have shown a set of common demand determinants, such as the level of economic development, the population density and the surface of the country of destination. Nonetheless, significant differences emerge when the variables referring to the tourists' preferences are considered. As far as habitats are concerned, larger surfaces covered by forests and wetland areas are found to attract a higher number of domestic tourists. The presence of those habitats can be better known by the country residents and may be more valuable to them not only for recreational purposes but also for cultural and traditional reasons. The latter characteristic is not necessarily acknowledged or perceived by international tourists.

As regards species diversity, international tourists appear to be more strongly influenced by a higher richness of both birds and mammal species. The number of different species living in one country, especially for biodiversity-rich regions, may be thoroughly advertised by tour operators or travelling websites. This can exert a more significant influence on long-distance travellers, attracted by the possibility to see different animals, rather than on domestic ones who may be more familiar with the presence of particular species on their territory and may also have previously visited the sites.

However, it is interesting to notice that the number of bird species turns out to exert a negative impact on international tourist arrivals, while the number of mammals produces a positive impact. This can be explained by two considerations. On the one hand mammals can be perceived as charismatic species, which attract a specific typology of tourism. On the other hand, the presence of bird species is generally linked to particular habitats or ecosystems, especially forests and wetlands, which have been found to have a negative effect on international tourism demand. By contrast the synthetic biodiversity index for birds produces a positive impact on domestic tourism demand. A positive influence on domestic tourist arrivals reflects a higher sensitivity of a country's nationals to the conservation status and the level of threat to which bird species are subject.

Moreover, natural protected areas seem to exert a significantly different impact on international and domestic arrivals, since they both positively influence the number of international tourists but not on the domestic ones. Once more this could reflect a difference in the perceived importance of those attractions, since they may represent a pull factor for international visitors but may be less relevant for the domestic ones[8]. Finally, heritage sites appear to have a positive impact on both domestic and international flows. One plausible explanation for this is that tourism flows going to coastal areas are less interested in the biodiversity component of a country's or a region's attraction potential. There may be other drivers of tourism demand which may better describe tourist preferences.

2.8 Conclusions and inputs for further research

This study has assessed that a set of features of biodiversity can exert an influence on the number of tourists visiting a country. The chosen species and habitat diversity indicators, namely the number of bird and mammal species, the synthetic biodiversity index for those two taxa and the surface covered by forest and wetland ecosystems at the national level, proved to be useful in describing tourist demand patterns.

A second outcome of this analysis has been the identification of distinct demand patterns for international and domestic visitors. As a matter of fact, the former appear to be more heavily influenced by species richness and natural and cultural attractions, while the latter seem to be more interested in the surface covered by specific habitats, namely forest, and in the conservation status, rather than in the number, of different species living in their country.

In the first case, those seem to be the elements on which advertising and tourism promotion campaigns would focus, since they represent features of the destination that could be easily perceived by the tourist. Domestic visitors, instead, turn out to be influenced by habitats

[8] This finding is consistent with previous studies which found out that international visitors were more interested than domestic visitors in learning-based activities such as learning about native plants and animals, experiencing culture, or visiting museums, because of cultural and geographical proximity (Ryan, 2002)

having a peculiar importance for local residents but being irrelevant to international tourists. Moreover domestic tourists are attracted by a better species conservation status, which reflects the health conditions of the overall environment. This segment of the tourism market seems to be looking for less evident characteristics of species and habitat diversity.

As far as the model for coastal areas is concerned, results are less clear and therefore it is more difficult to draw conclusions from them. As a matter of fact, while the GDP, population density and length of the coastline show the same type of influence highlighted by the previous model, the species and habitat diversity variables do not exert any significant influence on neither international nor domestic tourism flows. The only exception is represented by the synthetic biodiversity index for birds, which is positively correlated with the number of domestic tourists and the number of World There seem to be ground for further research concentrating on the supply of tourism services specifically linked to coastal recreation. However it should be reminded that this data are not available with the same accuracy for all countries, therefore, it would seem reasonable to implement such an analysis on selected countries or regions rather than at the worldwide level.

Tables

Table 2—1 Modelling tourism flows according to origin and type of destination

	Origin	
Destination	Domestic All regions (model 1)	International All regions (model 1)
	Domestic Coastal regions (model 2)	International Coastal regions (model 2)

Table 2—2 Description of the data sources

Variables	Unit of measurement	Year	Source
International arrivals	000	1995	Bigano et al, 2004
Domestic arrivals	000	1995	Bigano et al, 2004
International arrivals NUTS II	000	1995	Bigano et al, 2004
Domestic arrivals NUTS II	000	1995	Bigano et al, 2004
Number of days	number	1995	Tol and Bigano, 2006
Expenditures	USD/person/day	1995	Tol and Bigano, 2006
Population	000	1995	CIA World Fact Book (2001)
Population/km2	000	1995	World Resources Database 2000-2001
Area km2 (land+water)	km2	1995	CIA World Fact Book (2001)
GDP per capita 1995 USD	USD	1995	Bigano et al, 2004
Landlocked	dummy		ReefBase
Lenght coastline	km	2000	World Vector Shoreline (2000)
Beach lenght	km	1990	IPCC (1990)
Area covered by wetlands	%	2000	World Bank (2007)
Area covered by forests	%	2000	World Bank (2007)
Number of bird species	number	2000	World Bank (2007)
Number of mammal species	number	2000	World Bank (2007)
Biodiversity index for birds	number of species*threat status	2007	Wendland et al. (2008)
No. world heritage sites	number	2003	UNESCO
Annual precipitation	mm	Average 1961-1990	Bigano et al, 2004
Annual temperature	°C	Average 1961-1990	Bigano et al, 2004

Table 2—3 Results of the worldwide model specification

	International tourists		Domestic tourists	
	Coefficient	**P>|t|**	**Coefficient**	**P>|t|**
Expenditure	-0.0705677	0.399	0.0414015	0.571
No. days	0.3792364	0.159	0.0837597	0.721
GDP per capita	1.324785	0.000***	1.218922	0.000***
Population density	0.5507417	0.000***	1.061621	0.000***
Country surface	0.3795171	0.000***	1.064997	0.000***
Landlocked	-0.0723657	0.788	-0.9795348	0.000***
Forests (% surface)	-0.008181	0.214	0.0105075	0.069*
Wetlands (% surface)	-0.009142	0.658	0.0093053	0.606
No. bird species	-0.0019871	0.013*	0.0002358	0.732
No. mammal species	0.0043117	0.050*	0.0008804	0.645
Biodiversity index (birds)	-0.0049562	0.796	0.0375811	0.026*
Biodiversity index (mammals)	0.0044307	0.153	-0.0024851	0.358
Protected area (% surface)	0.0124845	0.095*	-0.0022907	0.724
No. World Heritage sites	0.0725018	0.000***	0.0230795	0.172
Precipitation	0.0809019	0.617	0.0411375	0.771
Temperature	-0.1238078	0.520	-0.482493	0.005**
constant	-5.080993	0.050*	-13.43629	0.000***
R2		**0.77**		**0.90**

Table 2—4 Regression after stepwise removal of insignificant variables (international tourists)

International tourists	**Coefficient**	**P>|t|**
GDP per capita	1.141016	0.000***
Population density	0.5535895	0.000***
Country surface	0.3369491	0.000***
No. bird species	-0.0012682	0.064*
No. mammal species	0.003307	0.091*
Protected area (% surface)	0.0124776	0.069*
No. World Heritage sites	0.069751	0.000***
constant	-2.735177	0.061*
R2		**0.75**

Table 2—5 Regression after stepwise removal of insignificant variables (domestic tourists)

Domestic tourists	**Coefficient**	**P>|t|**
GDP per capita	1.355896	0.000***
Population density	1.128624	0.000***
Country surface	1.178035	0.000***
Landlocked	-1.023604	0.000***
Forests (% surface)	0.009947	0.006**
Biodiversity Index (birds)	0.0300601	0.043*
Temperature	-0.4111271	0.001**
constant	-15.43448	0.000***
R2		**0.91**

Statistical significance of 0.1%. 5% and 10% is indicated by ***. **. * respectively.

Table 2—6 Results of the coastal model specification

	International tourists		Domestic tourists	
	Coefficient	**P>|t|**	**Coefficient**	**P>|t|**
Expenditure	-0.1048533	0.506	-0.0009092	0.996
No. days	0.1601903	0.682	-0.6341121	0.160
GDP per capita	1.293295	0.000***	0.8272065	0.017*
Population density	0.4441927	0.005**	0.6268288	0.001**
Lenght of the coast	0.4292403	0.016*	0.8428607	0.000***
Lenght of the beach	0.1270152	0.538	0.2602183	0.271
Forests (% surface)	-0.0150006	0.248	0.0057872	0.694
Wetlands (% surface)	-0.1615523	0.191	-0.0244304	0.861
No. bird species	-0.0019662	0.108	0.0020829	0.135
No. mammal species	0.0046085	0.140	-0.0012422	0.724
Biodiversity index (birds)	0.0235213	0.499	0.0732136	0.070*
Biodiversity index (mammals)	0.005471	0.395	-0.0012242	0.867
Protected area (% surface)	0.0040114	0.753	0.0005831	0.968
No. World Heritage sites	0.0560247	0.033*	0.0496869	0.095*
Precipitation	-0.0252242	0.918	-0.3557953	0.210
Temperature	-0.0822542	0.774	-0.2322034	0.478
No. coastal regions	0.5216046	0.236	0.0658666	0.895
constant	-3.13274	0.278	-1.440321	0.660
R2		**0.79**		**0.86**

Table 2—7 Regression after stepwise removal of insignificant variables (international tourists)

International tourists	**Coefficient**	**P>|t|**
GDP per capita	1.067064	0.000***
Forests (% surface)	-.0107445	0.009**
No. mammal species	0.0032822	0.000***
No. World Heritage sites	0.1248667	0.000***
constant	3.413274	0.000***
R2		**0.65**

Table 2—8 Regression after stepwise removal of insignificant variables (domestic tourists)

Domestic tourists	**Coefficient**	**P>|t|**
GDP per capita	0.8001744	0.000***
Population density	0.3953085	0.000***
Lenght of the coast	0.5742607	0.000***
No. bird species	0.0024572	0.000***
Biodiversity index (birds)	0.037096	0.083*
No. World Heritage sites	0.1211523	0.000***
Precipitation	-0.6010711	0.000***
constant	2.72335	0.049*
R2		**0.76**

Statistical significance of 0.1%. 5% and 10% is indicated by ***. **. * respectively.

References

Bawa K.S. and Seidler R. (1998), Natural Forest Management and conservation of biodiversity in tropical forests, *Conservation Biology*, Vol. 12, No. 1, pp. 46 – 55

Bigano A., Hamilton J.M., Tol R.S.J. (2007), The impact of Climate Change on international and domestic tourism: A simulation study, *The Integrated Assessment Journal*, Vol. 7, Issue 1, pp. 25 – 49

Butchart SHM, Stattersfield AJ, Bennun LA, Shutes SM, Akçakaya H.R. (2004) Measuring Global Trends in the Status of Biodiversity: Red List Indices for Birds. *PLoS Biol*, 2(12): e383.

Christ C., Hillel O., Matus S., Sweeting J (2003), *Tourism and Biodiversity: Mapping Tourism's Global Footprint*, Conservation International and UNEP, p. 7.

Honey M. and Krantz D. (2007), *Global trends in coastal tourism*, Center on Ecotourism and Sustainable Development, Washington D.C.

Chase M.K., Kristan W.B., Lynam A.J., Price M.V., Rotenberry J.T. (2000), Single species as indicators of species richness and composition in California sage scrub birds and small mammals, *Conservation Biology*, Vol. 14, No. 2. pp. 474-487

Dritsakis N. (2004), Co-integration analysis of German and British tourism demand for Greece, *Tourism Management*, Vol. 25, pp. 111 – 119.

Eugenio-Martín J.L., Martín Morales N., Scarpa R. (2004), *Tourism and economic growth in Latin American countries: a panel data approach*, Nota di Lavoro 26.2004, Fondazione Eni Enrico Mattei, available on the website http://www.feem.it/Feem/Pub/Publications/WPapers/default.htm

European Environmental Agency (1995), *Europe's Environment: the Dobris Assessment*, State of the Environment – Report 1

Gibbs J.P.(2000), Wetland loss and biodiversity conservation, *Conservation Biology*, Vol. 14, No. 1, pp. 314 – 317

Gotelli N.J. and Coldwell R.K. (2001), Quantifying biodiversity: procedures and pitfalls in the measurement and comparison of species richness, *Ecology Letters*, 4 379 – 391

Hamilton J. M. (2004), *Climate and the destination choice of German tourists*, Nota di Lavoro 21.2004, Fondazione Eni Enrico Mattei, available on the website: http://www.feem.it/Feem/Pub/Publications/WPapers/default.htm

Hamilton, J. M., Maddison, D. J. & Tol, R. S. J. (2005a), 'Climate change and international tourism: A simulation study', *Global Environmental Change*, Vol. 15, No. 3, pp. 253–366.

Hamilton, J. M., Maddison, D. J. & Tol, R. S. J. (2005b), The effects of climate change on international tourism, *Climate Research*, 29, pp. 255–268.

Lise W and Tol R.S.J. (2002), Impact of climate on tourism demand, *Climatic Change*, Vol. 55, No. 4, pp.29–49

Lyndenmayer D.B. (1999), Future directions for biodiversity conservation in managed forests: indicator species impact studies and monitoring programmes, *Forest Ecology and Management*, 115, pp. 277 – 287

Maddison, D. (2001a), *In Search of Warmer Climates? The Impact of Climate Change on Flows of British Tourists*. In D. Maddison (Ed.), The amenity value of the global climate, pp. 53-76, London: Earthscan

Naidoo R., Adamovicz W. L. (2005), Biodiversity and nature-based tourism at forest reserves in Uganda, *Environment and Development Economics*, Vol. 10, pp.159 – 178

Noss R. (1990), Indicators for monitoring biodiversity: A hierarchical approach, *Conservation Biology*, Vol. 4, No. 4, pp.355 – 364

O'Neill R. V., Hunsaker C.T., Jones B.K., Riitters K.H., Wickham J.D., Schwartz P.M, Goodman I.A., Jackson B.L. and Baillargeon W.S. (1997), Monitoring Environmental Quality at the Landscape Scale, *BioScience*, Vol. 47, No. 8, pp. 513-519

Poria Y., Butler R.W., Airey D. W. (2003), *The core of heritage tourism*, School of Mangement Tourism Research, University of Surrey

Prendergast J. R. and Eversham B. C. (1997), Species Richness Covariance in Higher Taxa: Empirical Tests of the Biodiversity Indicator Concept, *Ecography*, Vol. 20, No. 2 (Apr., 1997), pp. 210-216

Ryan, C. (2002). Tourism and cultural proximity: Examples from New Zealand, *Annals of Tourism Research*, Vol. 29, pp. 952-971.

Van den Berg J. and Nijkamp P. (1998), Economic aspects of global change impacts and response strategies in the coastal zone of The Netherlands, *Journal of coastal conservation*, Vol. 4, No. 2, pp. 161 – 168

Wunder S. (2000), Ecotourism and economic incentives – an empirical approach, *Ecological Economics*, Vol. 32, pp. 465 – 479

Wendland K.J., Honzak M., Portela R., Vitale B., Rubinoff S., Randrianarisoa J. (2009), Targeting and implementing payments for ecosystem services: opportunities for bundling biodiversity conservation with carbon and water services in Madagascar, *Ecological Economics* (in press)

Witt, S. F., and Witt, C. A. (1995), Forecasting tourism demand: A review of empirical research, *International Journal of Forecasting*, 11, 447-475.

World Tourism Organization (2008), UNWTO World Tourism Barometer, Volume 6, No. 1, January 1st 2008

3. Assessing the impact of biodiversity on tourism flows: A model for tourist behaviour and policy implications

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Abstract

This analysis provides an example of how biodiversity can be measured by means of different indicators, and how the latter can be used to assess the influence of the biodiversity profile of a region on the tourism flows towards it. Previous studies have considered environmental amenities as one of the determinants of tourism destination choice. The central hypothesis of this paper is that the destination's biodiversity profile can be considered as a key component of environmental amenities. The main objective of this study is to propose a different perspective on this topic, considering the role of biodiversity on tourists' choice of destination and duration of stay. Domestic Irish tourist flows have been chosen as a case study. The first step of the analysis required the construction of biodiversity indicators suitable for developing a biodiversity profile of each Irish county. Subsequently, a model was developed so as to explain the total number of nights spent in any location as a function of a set of explanatory variables including information about the socio-demographic characteristics of respondents, biodiversity and the landscape profile of the county of destination and features of the trip. Results show that most of the biodiversity and landscape indicators included in the analysis turn out to be statistically significant in determining tourists' choices regarding the duration of their trip. As a result, policies pursuing biodiversity conservation appear to have a positive impact on the revenue of regional tourism.

Keywords: species diversity, habitat fragmentation, landscape diversity, trip demand, indicators, ecosystem services, human well-being

3.1 Introduction[9]

Previous studies that have analysed tourism demand have dealt with understanding the reasons underpinning tourists' attitudes towards a particular destination (Rugg, 1973; Seddighi et al, 2002). The traveller's choice of destination and duration have been described applying the classical framework of the consumer demand theory, according to which any commodity possesses certain characteristics which, in turn, generate utility for the consumer. However, a traveller does not derive utility from "consuming" his travel destination, but rather from staying in a particular destination for some period of time, thus enjoying the destination's attributes (Rugg, 1973).

Environmental amenities can be considered as one of the determinants of tourism destination choice. The type and the extent to which environmental resources surrounding a site have been proven to be closely linked to the profitability of the tourism sector and environmental quality is widely used as a basis for a marketable tourism attraction (Marcouiller and Prey, 2004). While the decision to make a trip depends greatly on the needs of the traveller, the choice of the destination is largely dependent on the features of the destination itself, such as sunshine, beaches, availability of sport and leisure facilities or the opportunity to enjoy a natural environment (Klenosky, 2002). In terms of competition with other destinations, either domestic or international, a larger supply of environmental amenities might give the destination site a competitive edge or advantage (Huybers and Bennet, 2003).

The central hypothesis of this paper is that the destination's biodiversity profile can be considered as a key component of environmental amenities. Biodiversity is defined as *"the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems"* (MEA, 2005). The need to quantify status and trends of biodiversity is widely recognised. In order to assess the conditions and trends of biodiversity completely it would be necessary to measure the abundance of all organisms over space and time, using the number of species, the species' functional traits and the interactions among species that affect their dynamics and functions. However, biodiversity is too complex an issue to be fully quantified using scales that are policy-relevant and its assessment can only be done by means of indicators. Against this background, this analysis provides an example of how biodiversity can be measured by means of different indicators, and how the latter can be used to assess the influence of the

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biodiversity profile of a region on the tourism flows towards it. The remainder of this paper is organised as follows: section 3.1 provides a literature review regarding tourism demand analysis; section 3.2 deals with the description of data sources; the data treatment process is explained in section 3.3. Finally, sections 3.4 and 3.5 focus on the application of the developed methodology to a specific case study, the Republic of Ireland, presenting a description of the biodiversity profile and tourism flows as well as the econometric model explaining such flows. Comments about the performance of biodiversity indicators as explanatory variables of the model conclude the analysis.

3.2 Background and literature review on tourism demand modelling

According to the existing literature, tourism flows can be explained by means of demand function specification, although modelling tourism demand is not a straightforward task. In fact, there is no universally accepted measure of tourism flows; however, the majority of previous studies adopt the number of visitors, the number of nights spent or tourism expenditures (Lim, 1997). It must be noted that each of these variables presents a number of shortcomings when used to characterise tourism demand for a specific location, since none of them is able to encompass all the relevant aspects. A literature review indicates tourism expenditure as the most appropriate measure of tourism demand; nonetheless, its adoption is often hindered by data scarcity (Proença and Soukiazis, 2005; Ledesma Rodriguez *et al*., 1999).

As far as explanatory variables are concerned, a wide range of potential factors can be found and the choice among them depends mainly on the type of data and the objectives of the research. In the literature it is possible to identify a set of widely used categories of tourism demand determinants. To begin with, socio-economic factors, such as income, household characteristics, cost of the trip, type of accommodation, mode of transportation and period of the year in which the trip takes place, are present in almost all the studies. Secondly, relative prices, exchange rates and security in the country of destination are usually deemed important when dealing with international travel (Lim, 1997; Proença and Soukiazis, 2005). Furthermore, the specific features of the destination, determining its attractiveness, such as climate, culture, history and natural environment are also receiving remarkable attention (Crouch, 1995; Lim, 1997; Song and Li, 2008; Witt and Witt, 1995). Here we focus on the effect of the natural environment, and more specifically of biodiversity, on tourism. There is a substantial literature on nature and recreation (Brander *et al*. 2007; Shrestha and Loomis, 2001, 2003). The difference between tourism and recreation is that the former involves at least one overnight stay. Recreation is therefore more focused, while tourism is more of a package deal: a holiday may entail nature, culture, entertainment, and relaxation. The impact of nature on tourism is therefore more diffuse than the impact of nature on recreation. However, the sample of tourists used in this study is representative of the population, while typical recreation studies suffer from selection bias.

Another aspect to take into consideration is the choice of the type of econometric model. Since the temporal horizon of statistical data and the specification of tourists' choice mechanisms are often limited and incomplete, many studies apply a panel data approach. This choice turns out to be suitable for analysing cross section data, characterised by a large number of observations and short time series. Finally, as a general rule, studies adopting the number of nights spent, the number of trips or the number of visitors as a dependent variable mostly apply count data models, so as to correct results for truncation and self selected bias effects (Hellström, 2002, Nunes and Van den Bergh, 2002).

The present study is consistent with the cited literature in that it considers the duration of stay as a count variable and it includes the previously described categories of explanatory variables. In addition, however, it seemed important to consider information on the travelling group, to account for individual, couple and family trips. Since the focus of this analysis is on domestic tourism, factors like relative prices, exchange rates and security situations have been deemed irrelevant. As far as the choice of the model is concerned, a GLS regression with correction for random effects and, subsequently a Poisson regression, were performed, since the available data were both cross section and count data.

Previous studies of tourism in Ireland focused on foreign visitors (Barry and O'Hagan, 1972; Hannigan, 1994; O'Leary and Deegan, 2005; Walsh, 1996) while research on Irish tourists is limited to outbound tourism (Gillmor, 1995; Lyons *et al*., 2007, 2008). This is the first study on Irish tourists in Ireland.

3.3 Description of data sources

3.3.1 Travellers' socio-demographic characteristics and trip information

Data about tourism has been taken from the Household Travel Survey, published by the Irish Central Statistics Office (CSO) on a quarterly basis. The purpose of the Household Travel Survey (HTS)[10] is to measure domestic and international travel patterns involving overnight stays and associated details, including expenditure, purpose of trip and type of

[10] The survey is one of several Central Statistics Office (CSO) tourism surveys conducted to comply with the requirements of the Council Directive 95/57/EC of 23 November 1995 concerning the collection of statistical information in the field of tourism.

accommodation used by Irish residents. The HTS is a random stratified sample. Each quarter, almost 13,000 households, approximately 1% of all private households, is randomly selected from the Electoral Register, where the selection is stratified by District Electoral Division. Tourism expenditure includes purchases of consumer goods and services inherent to travel and stay, purchases of small durable goods for personal use, souvenirs and gifts for family and friends. Purchases for commercial purposes, capital type investments and cash given to relatives or friends during the trip are excluded. The HTS households are sampled from the Electoral Register and are subjected to a postal survey. Data used in this paper refer to the period 2000-2003, due to the need to match the time horizons of the information regarding both tourism and biodiversity. The dataset includes both international and domestic tourism; however, for the purposes of this study, only the latter is considered. Since this survey does not include data about respondents' income, this information has been retrieved from the County Income and Regional GDP, also published by CSO.

3.3.2 Biodiversity and landscape indicators

Since this investigation focuses on Ireland as a case study, the *Natura 2000* database has been considered as a useful source of information in the indicator-building process. In view of implementing the requirements of the Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora and of the Council Directive 79/409/EEC on the conservation of wild birds, the European Commission has established a standard format for the collection of relevant information from member countries. They are in fact required to report on the physical characteristics of each site, as well as the number and conservation status of protected species and habitats.

The information contained in the database appears to be extremely detailed and, due to simplification requirements, it seems necessary to select the most relevant aspects in order to construct biodiversity indicators. It is worth recalling that the *Natura 2000* database provides a sort of "snapshot" of the biodiversity profile of European countries. In order to be able to evaluate trends and changes in those profiles, data should be available for a long time span for all countries and for all protected species and habitats.

As far as fauna and flora are concerned, six taxa, namely amphibians and reptiles, birds, fishes, invertebrates, mammals and plants, are assessed separately. Member states must provide information about size and density of the populations present in each site with respect to the population living on the national territory as a whole, along with conservation status and the degree of isolation of each population with respect to the natural range of its species.

It also seems important to account for the landscape profile in describing the environmental characteristics of a region. Once again the *Natura 2000* database was considered as a useful source of information, since the distribution of protected habitats could be interpreted as a proxy of the landscape features of a region. Habitats are classified according to a three level hierarchical sorting, which appeared excessively detailed to be taken completely into consideration. For the purposes of this analysis the higher and most aggregated level seemed to provide sufficient information. The habitat types considered are therefore: coasts, dunes, freshwater habitats, wetland low vegetation, Mediterranean dryland vegetation, grassland, bogs mires and fens, rocks and caves and forests.

3.4 Data treatment and construction of a biodiversity metrics

3.4.1 Review of existing indicators

Since biodiversity is too complex to be fully quantified, its assessment can only be done by means of indicators. The need for biodiversity indicators is widely recognised and various attempts to classify and describe potentially suitable indicators have been carried out. Different institutions have provided their own definitions; however, though the formulation may be different, there is substantial agreement on the relevant aspects to be taken into account in the description of biodiversity. The indicators proposed in this paper have been developed following the path traced by the United Nations and the European Union.

The United Nations Convention on Biological Diversity (CBD) acknowledges the role of indicators as information tools that summarise data on complex environmental issues and indicate the overall status and trends of biodiversity. The convention highlights seven focal areas in which the development of indicators seems to be necessary: 1) status and trends of the components of biological diversity, 2) threats to biodiversity, 3) ecosystem integrity and ecosystem goods and services, 4) sustainable use, 5) status of access and benefit sharing, 6) status of resource transfers and use and 7) public opinion.

The European Biodiversity Strategy (European Commission, 1998) was developed in the context of the CBD, and it calls for the development of a set of indicators corresponding to these focal areas. A report by the European Environmental Agency (EEA, 2007) provides a more detailed description of these indicators.

Within the scope of this study it has been chosen to focus on indicators related to status and trends of the components of biological diversity. The EEA presents a set of headline indicators to specify the content of this broad category. The remainder of this section therefore focuses on the advantages and shortcomings of these headline indicators, since they have been the starting point of the construction of regional biodiversity profiles.

To begin with, trends referring to abundance and distribution of selected species are thought to be relevant. The EEA considers abundance and distribution of selected species. Species abundance can be defined as the number of individuals of a population living in a particular area. Populations and species constitute one of the most essential components of biodiversity and viable populations indicate the presence of healthy habitats and ecosystems. This indicator can be easily aggregated and it is cost-effective, since most of the data are collected by professionals making it possible to enlarge data availability with little extra cost. However, long time series would be necessary to assess these trends appropriately.

Even though the EEA report does not consider species richness as a possible indicator of these trends, it seems important to review it, since it is the most intuitive and easy to compute. It can be defined as the number of different species recorded in a particular site and it can be expressed either per unit area or per habitat type. The main shortcoming of this indicator lies in the fact that it does not take into account that processes of abundance reduction can take place long before a change in the number of species. Moreover, it is largely dependent on the geographical scale considered. Finally, the indicator needs to be assessed for a large number of species, implying significant costs (Ten Brink, 2000).

The second headline indicator is related to changes in the status of protected species, including both Red List species and species of European interest, with a specific reference to the *Natura 2000* protected species. This indicator is policy-relevant and can be viewed as a measure of the success of protection policies. In our analysis, this indicator is represented by the degree of species conservation, calculated from the assessment contained in the *Natura 2000* database.

The third headline indicator refers to trends in the extent of selected biomes, ecosystems and habitats. The ability of an ecosystem to provide goods and services highly depends on the extension it covers, since a highly fragmented habitat could be less resilient and have reduced ability of recovering after a shock. Data is widely available since land cover change is the main driver of this indicator and this information is well mapped across a large number of countries. It is cost effective and easily aggregated from smaller to larger spatial scales.

Nonetheless, it does not deliver information on the conditions of the remaining ecosystems. For instance, habitat loss could be halted, but other drivers, such as direct exploitation, invasive species and pollution could still cause a decline of species and populations. In order to solve this problem, it could be interesting to add an indicator accounting for the habitats' degree of conservation. For this reason, the EEA report includes status of habitats of

European interest within this headline indicator. Finally, as already explained for species, a habitat richness indicator was added to the ones considered by the EEA since it could provide information about the number of habitats present in a specific region, with respect to the number of protected habitats recorded at a national level.

As far as genetic diversity is concerned, the EEA considers livestock genetic diversity, defined as the share of breeding female populations between introduced and native species. However, this definition excludes crops and trees from the analysis. Here we explore the possibility of using the degree of isolation of a population with respect to the geographical range of its species, as a genetic diversity indicator. In fact, a population living at the margins of its species geographical range has higher probabilities of being more genetically diverse. The calculation is done taking advantage of the species isolation assessment provided by the *Natura 2000* database. Finally, the coverage of protected areas is taken into account, both as nationally designated under European directives and as part of the *Natura 2000* network. The indicator does not describe the quality of management or whether the areas are protected from incompatible uses. Tables

Table 3–1 shows the linkages between the headline indicators proposed by the EEA and the ones developed for the purpose of this study.

**Introduce Tables

Table 3–1 about here**

It seems important to underline the fact that, in the reviewed literature, no examples were found of the use of biodiversity indicators as explanatory variables in a model describing tourist economic behaviour. This, therefore, represents one of the most remarkable innovative aspects of this study.

3.4.2 Construction of biodiversity and landscape profiles

Bearing in mind the suggestions given by the EEA, it has been necessary to further specify relevant indicators in order to define regional biodiversity and landscape profiles. Since all information was retrieved from the *Natura 2000* database, all indicators have been first computed at the site level and then aggregated at a regional level. Furthermore all indicators are related exclusively to species and habitats that are protected according the Habitats and Birds Directives. The database originally presents qualitative assessments of most of the relevant aspects, based on a scale ranging from A to C, therefore it has been necessary to attach a numerical value to each of the rankings.

The species richness indicator was computed as the ratio between the number of species present in each site and the total number of species living on the national territory. The indicator was first calculated separately for each of the six taxa considered in the database and then averaged so as to obtain a single value for each site. The idea underpinning this operation is the so-called “inter-species democracy”, implying that all species are considered equally important.

Species abundance was obtained taking information on population size and density as a starting point. In this case, the rankings reflect what share of each species’ national population is living in each particular site. “A” stands for a share from 100% to 15% of the total population, “B” from 15% to 2% and “C” from 2% to 0%[11]. In the case of species conservation, “A” means an excellent conservation status, “B” a good one and “C” an average one. Finally, as regards species isolation, “A” represents almost complete isolation, “B” suggests that the population is not completely isolated but lives at the margins of the distribution range while “C” implies that the population lives within an extended distribution range.

Amid the habitat-related information supplied by the database, it has been chosen to take into account habitat relative surface that represents a habitat area in each site with respect to the area covered by the habitat at a national level. In this case “A” stands for a percentage from 100% to 15%, “B” from 15% to 2% and “C” from 2% to 0% of the habitat surface at a national level. This information has been used to calculate the habitat abundance indicator.

Habitat richness has been calculated as the ratio between the number of habitats found in a site and the number of habitats recorded at a national level. The degree of conservation of habitat structure, functions and restoration possibilities was computed taking advantage of the database assessment. “A” stands for excellent, “B” for good and “C” for average conservation status, as previously explained for species.

In order to treat all this information in a homogeneous way and consistently with the definitions provided by the database itself, it has been decided to attach a value of 100 to ranking “A”, of 15 to ranking “B” and of 2 to ranking “C”. As a result, habitat and species indicators have been computed according to Equation (2.1):

$$Indicator = \frac{(No.\ "A" \times 100 + No.\ "B" \times 15 + No.\ "C" \times 2)}{No.\ habitats\ or\ species\ per\ site} \qquad (2.1)$$

[11] These thresholds are provided by the Natura 2000 database and have been taken as a starting point for the computation of the values of each indicator. Narrower intervals would be useful in order to provide a more precise measure of biodiversity; however, considering the extreme difficulty in achieving reliable data, the information contained in the database was deemed to be sufficiently detailed.

Unlike the previous indicators, coverage of protected areas provides the percentage of land covered by *Natura 2000* sites, which of course depends on the geographical scale considered. When focusing on one country it seems appropriate to choose administrative regions as a unit of analysis. All indicators can be subsequently aggregated at a regional level by calculating the mean of the values obtained by the sites belonging to each region. Values range from 0 to 100.

As far as the landscape profile is concerned, information regarding the surface covered by different habitat types at site level was retrieved from the database. Then these areas have been expressed as a share of protected area at a regional level; this result was assumed as a proxy of a region's land cover composition and landscape profile. The outcome of this indicator-building process has been the creation of a dataset encompassing relevant biodiversity and landscape diversity information.

3.5 Impact of biodiversity and landscape profiles on Irish tourism flows

3.5.1 Irish biodiversity and landscape profiles

The remainder of this paper deals with the empirical application of this protocol to a specific case study, namely Ireland. Results show that indicators are not only a useful tool for assessing trends and status of biodiversity in a specific region, but they can also find direct application in the assessment of biodiversity impacts on human well-being. This section provides a description of the values attained by biodiversity and landscape indicators at a county level. Subsequently, this information is merged with data from the Irish Household Travel Survey, in order to analyse the impacts of these indicators on tourism flows.

The Republic of Ireland has been chosen as a case study on the grounds of broad data availability and of the fact that in the Irish context, natural and cultural heritage is deemed to be a major cornerstone of the tourism industry, both at a local and at a national level (McManus, 1997).The first category of indicators refers to trends in abundance and distribution of selected species, encompassing species richness, abundance and conservation. The scores, presented in Table 3—2, do not show a remarkable performance in any of the counties. The highest scores are attained by the species conservation indicators in all counties, achieving the best results in the Leitrim and Carlow counties. Values for species richness are too close to zero to be detectable in the graph. As far as genetic diversity is concerned, the Sligo and Kildare counties show a higher average level of species geographical isolation. However, since the maximum value attained is 6.03, it seems that the contribution of any of the populations present in each site to the genetic patrimony of its species is, in general, relatively low.

When considering habitat-related indicators, abundance, richness and conservation, Table 3—2 shows that County Cavan has by far the highest value for the fragmentation indicator and County Dublin shows the lowest value. However, all counties show a low degree of habitat fragmentation. Scores recorded are considerably higher for habitat conservation, while values for habitat richness are all virtually zero.

The last category of indicators deals with the coverage of protected areas. The values have been calculated by summing up the surface covered by each site belonging to a county and then dividing this result by the total surface of the county under consideration. Results show a very different percentage of protected areas in the counties, where some of them, including Kerry, Clare, Galway and Mayo, have a substantial portion of their territory protected under Natura 2000, while others like Monaghan, Kilkenny, Kildare, Limerick and Meath designated less than 1% of their territory to Natura 2000 sites. Table 3—2 shows the values attained by each indicator in each county.

Introduce Table 3—2 about here

As regards landscape characteristics, analysis of the data contained in the Natura 2000 database reveals that the most common habitat type across Irish counties is represented by freshwater habitats, followed by low wetland vegetation and coastal habitats, while the rarest ones are Mediterranean dryland vegetation, grasslands and forests. Table 3—3 shows the surface covered by each of these habitat types.

Introduce Table 3—3 about here

On the other hand, Table 3—4 shows the composition of different habitat types across the different Irish counties, thus providing a snapshot of each county's landscape variety. County Carlow's protected areas appear to be dominated by bogs, mires and fens, since no other protected habitat is recorded in the region. By contrast, Donegal, Galway, Limerick, Offaly and Roscommon show remarkable landscape diversity, since all the nine habitat classes can be found in these counties. Cork, Dublin, Kerry, Louth, Mayo and Sligo are also very diverse, recording eight out of nine habitat categories.

Introduce Table 3—4 about here

3.5.2 Socio-demographic characteristics and travel specific features

As regards the travellers' socio-demographic characteristics, it is possible to say that the mean number of family members is slightly less than four, while on average the number of participants to a trip is two. The average traveller's age is of about 34 years and the average number of children participating in each trip appears to be nearly one. 47% of the travellers are men and the average disposable income amounts to 16,664 euros per capita.

As far as the specific features of the trip are concerned, it turns out that the average number of repeated trips to the same destination is nearly two and the average total cost of each trip is of 229.42 euros per person, in the period 2000-2003. The months in which the majority of journeys take place are the summer ones, from June to August. The accommodation categories chosen by the majority of travellers are hotels (41%), home rentals (14%) and guesthouses (13%). Table 3—5 shows summary statistics for socio-demographic and trip-specific characteristics.

Introduce Table 3—5 about here

3.6 Demand for tourism

3.6.1 Econometric model specification

The duration of stay of tourists in a particular destination has been considered as the dependent variable to be explained as a function of a set of independent variables that can be grouped into socio-demographic variables (X_1), cost of the trip (X_2), biodiversity and habitat profile (X_3), landscape profile (X_4), modes of transportation (X_5), month of departure (X_6), region of destination (X_7), accommodation category (X_8) and recreation group (X_9). To begin with, a GLS regression was performed and it has been chosen to introduce a correction factor for random effects adopting the household identification number as group variable. However, since the available data was retrieved from a survey in which only travellers have been interviewed, the econometric model specification and estimation method needs to be corrected for self-selection bias. Therefore, we estimate a Poisson count data model, correcting for both truncation and self-selection. This gives rise to model specification presented in Equation 2.1.

$$\text{Prob}(V=j)=F_p(j)=e^{(-\lambda)\lambda^j} \Big/ j! \qquad (2.1)$$

with[12]

$$\lambda = e^{\beta_0+\beta_1 X_1+\beta_2 X_2+\beta_3 X_3+\beta_4 X_4+\beta_5 X_5+\beta_6 X_6+\beta_7 X_7+\beta_8 X_8+\beta_9 X_9 \ +\varepsilon} \qquad (2.2)$$

Here j denotes the possible values for the number of days spent on the trip (j=1, 2 …), $F_p(.)$ the cumulative distribution function of the standard Poisson probability model, and λ (non-negative) Poisson parameter to be estimated.

Within the first set it has been chosen to consider number of members of the household, (county average) disposable income per person, age of the respondent and a dummy variable representing repeat visitors to the same destination. As far as species and habitat diversity characteristics are concerned, only species abundance and habitat fragmentation have been included in the model, since all the computed indicators were highly correlated with one another and the two selected indicators are deemed to be highly telling ones according to reviewed literature.

The share of protected area respect to the total county surface is generally considered a biodiversity indicator; however in this model it has been listed as a separate explanatory variable, since it appears to be a policy response indicator, rather than a biodiversity indicator. In addition, it seemed important to include variables describing landscape features of the destination. For this reason, the habitat categories specified above have been included in the model, with the exception of bogs, mires and fens which was dropped due to multicollinearity. The area covered by each habitat type has been expressed as a share of the total Natura 2000 protected surface per county.

The remaining variables included in the model are a set of dummy variables constructed so as to represent different features of the trip. As far as the modes of transportation are concerned, it has been chosen to consider air transportation, land transportation, including rail, buses, bicycle and cars, and other means. Furthermore a set of twelve dummies, representing the months of departure has been added. The region of destination has also been deemed relevant for the analysis, therefore eight dummies standing for the NUTS 3 regions, namely South-west, South-east, Midwest, Midlands, Mideast, Dublin, West and Border, were incorporated into the model. The type of accommodation chosen by travellers was also thought to play an important role in determining the number of nights spent at the destination. The Household travel survey classifies them into camping sites, guesthouses,

[12] The Poisson model has been formally tested against negative binomial models as can be seen from Table 7. The chi-squared value associated to the Likelihood ratio test of alpha = 0 is 3.3e+04, therefore suggesting that in this specific case the Poisson model better fits the data.

holiday homes, hotels, house rentals and visits to relatives; hence a dummy has been inserted for each of these categories.

Finally, the characteristics of the travel group were considered and three dummies corresponding to single, couple and groups of more than three people were introduced. In addition the number of children taking part to the trip was inserted as an explanatory factor.

3.6.2 Estimation results

Results show that biodiversity and land cover characteristics are highly significant. As can be seen from Table 3—6 and Table 3—7, the results of the two regressions performed are quite similar as far as the signs of the coefficients and the level of significance are concerned. In order to interpret the results of the Poisson regression and to quantify the influence of the different explanatory variables on the dependent variable, incidence rate ratios were computed.

When considering the respondents' socio-demographic characteristics, three of the four variables turn out to be statistically significant. Disposable income per person and the age of respondent are positively correlated with the duration of stay, reflecting the fact that larger income availability allows larger travel expenditures and that older people tend to stay longer in their destination. Older people may also be wealthier, but unfortunately we cannot capture this effect because we do not have micro-data on income. However, these variables have a very low impact on the number of nights, increasing the probability of the tourist spending an additional day by 1.4% and 0.1% respectively.

By contrast, trips by repeat visitors tend to be 12% shorter than first trips; this could be explained considering that frequent journeys to a site decrease the probability of long stays. It is worth noting that tourists' socio-demographic characteristics are likely to play a limited role in determining the duration of the trip, with respect to other variables.

The cost paid for the trip has a negative impact on its duration, as can be expected. For every 1% increase in costs, the number of nights decreases by 0.2%. Land transportation is positively correlated to travel duration. A possible explanation can be found in that this category of means of transportation, including private or hired vehicles, rail, buses or bicycles generally requires a longer time span to reach the destination, thus increasing the probability of overnight stays by 70%.

Another important factor in determining the number of nights is the period of the year in which the journey takes place. As can be expected, the summer months, from June to September are positively correlated and statistically significant, most probably due to larger time availability during the summer vacations, higher temperatures and favourable weather conditions, with a 26.5% probability of spending an additional day in June, 84.7% in July and 54.7% in August. On the contrary, January, February and November have a negative and significant impact on trip duration.

It is possible to interpret the results for different accommodation categories on the grounds of lower costs. Camping sites, holiday homes and home rentals appear to be positively correlated with trip length, increasing the probability of an additional day by 6.1%, 31.8% and 9.5% respectively. On the other hand, stays in hotels, guesthouses and visits to relatives turn out to have 28.8%, 28.8% and 14.3% probabilities of shorter duration. An interesting result is related to the regions of destination, since all of them are negatively correlated, although only the coefficient obtained for the South-East, Midwest, Midlands and Mid-East regions are significant.

Furthermore, trips taken by couples tend to have a shorter duration, with a reduction of the number of days by 3.3%, while those undertaken by groups of more than three people are likely to be longer; in fact the probability of spending an additional night increases by 15.1%. The number of children taking part in the trip is negatively related to trip duration, meaning that a larger number of children is likely to reduce the probability of staying an additional day by 4.1%.

Finally, it is important to analyse results for the impacts of the destination’s biodiversity and landscape profiles on the probability of observing longer trip lengths. The extent of protected areas in the region of destination is negatively correlated with the duration of stay, implying that trips towards a county with a higher share of protected areas out of the total surface are more likely to be shorter with respect to trips to other destinations. This result can be explained by the fact that a higher degree of protection of natural areas can limit the potential for tourist visits to the sites.

As far as species and habitat diversity are concerned, results show that both species abundance and habitat abundance are positively correlated and significant. Such an outcome is consistent with the hypothesis that higher species abundance increases the possibility of observing wild animals, exerting a positive impact on the probability of spending an additional day in the destination, increasing it by 12,2%. When it comes to habitat diversity, a higher habitat relative surface is here considered as a measure of endemicity. This can be defined as the degree to which a habitat is native or confined to a particular region. From the tourist’s perspective, this may be a factor increasing travel enjoyment, since it could imply the opportunity to see unique or rare habitat patches in their destination.

To conclude, the landscape profile can be analysed in order to identify which environmental features are able to influence the tourist’s choice about duration of stay. It turns out that coastal habitats are positively correlated to trip length, as well as wetland vegetation, Mediterranean dryland vegetation, rocky habitats and forests. A wider presence of these habitat and land cover types in the region of destination is likely to increase the probability of spending an additional night by 14.4%, 27.2%, 11.2%, 26.5% and 10.8%, respectively. By contrast, dunes, freshwater and grassland habitats show a remarkable negative correlation with trip length. It seems important to underline that these landscape categories have been developed exclusively on the basis of the Natura 2000 protected habitats, and are therefore limited in that they only refer to protected sites. Nonetheless, considering the noteworthy level of detail achieved by the Natura 2000 database, it was decided to use this information as a proxy of the different counties' real landscape features.

Introduce Table 3—6 and Table 3—7 about here

3.7 Policy discussion

3.7.1 Economic valuation of the welfare impact of a marginal change in the values of biodiversity indicators

In April 2002, the Parties to the Convention on Biological Diversity committed themselves to achieve a significant reduction in the current rate of biodiversity loss at a global, regional and national level by 2010. At the European level, EU Heads of State or Government agreed in 2001 "to halt the decline of biodiversity in the EU by 2010" and to "restore habitats and natural systems". A Biodiversity Strategy was adopted in 1998 and related Action Plans in 2001 (European Commission, 2006). In addition, biodiversity has been integrated into a whole set of European Union internal policies, such as the Lisbon Partnership for growth, jobs and environmental policy, the Common Agricultural Policy and the Common Fishery Policy.

Against this background, a further step to complement the results of this analysis has been the economic valuation of the welfare impact of a policy aimed at reducing biodiversity loss. In order to do this it has been decided to attach a monetary value to the three biodiversity indicators considered in the model. To be able to do this, the score of each indicator in each county has been multiplied by the impact coefficient obtained from the Poisson regression and by the average individual expenditure in the county.

$$Monetary\ value_{biodiversity\ indicator} = Expenditure\ per\ night_{county\ i} * \hat{\beta}_{biodiversity\ indicator} * \overline{biodiversity\ indicator\ score}_{county\ i} \quad (2.4)$$

The degradation of the biodiversity status would produce an economic loss that can be assessed using the revenues of the tourism sector. Any environmental protection policy would aim at reducing or mitigating this impact; therefore benefits deriving from protection can be interpreted as foregone costs. In order to estimate this amount in monetary terms, a scenario of policy inaction has been assumed, considering that, if no protection measures were adopted, a 10% decrease in the score of the species abundance indicator would be observed. This scenario is a purely hypothetical one and it aims at showing the welfare impact of a marginal change in the level of the biodiversity indicators.

The monetary value of this change has been computed applying the previously explained procedure. Finally, this result has been multiplied by the average number of days spent and the number of visitors in each county and then divided by the number of years over which the tourism survey was conducted.

$$Annual\ welfare\ change = \frac{Monetary\ value\ of\ changes_{biodiversity\ indicator} * No.\ visitors_{county\ i} * No.nights_{county\ i}}{No.years} \quad (2.5)$$

In the case of species abundance, the policy objective should be the maintenance of the current number of individuals of a species living in a particular area. Since species abundance appears to be positively correlated with trip duration, the policy's annual welfare impact can be interpreted as the foregone cost deriving from the maintenance of the current level of species abundance. As far as habitat abundance is concerned, the policy objective should be the prevention of habitat loss. Considering that also habitat abundance is positively correlated with trip duration, the annual welfare change has been computed according to the same procedure followed for species abundance.

The policy discussion is somehow different when it comes to the coverage of protected areas. In this case, since the indicator is negatively correlated with the number of days the tourist spends in his destination, the computation of the annual welfare change due to a 10% increase in its value produced negative results. This can be interpreted as the need to maintain the current extension of protected areas, which is not in contrast with the results obtained for the species and habitat abundance indicators. In fact, there are a number of policy options suitable for preventing biodiversity loss by improving the status and degree of conservation of species and habitats without increasing the share of protected areas.

It is worth noting that these monetary values can differ significantly across counties, therefore it has been decided to rank counties according to these values. This is particularly relevant if the objective is providing information to the policy-maker, who needs to decide where to allocate resources for environmental protection. Assuming that the costs of protection are fixed across counties, from a cost-benefit point of view, the policy-maker is not indifferent about where and what to protect. Table 3—8 presents annual welfare changes produced by a 10% change in the scores of biodiversity indicators.

Among the three indicators considered, species abundance is by far the one that produces a higher annual welfare change. This can be explained by remembering that the starting point of this economic valuation has been tourism expenditure and that species abundance may be the component of biodiversity that is more directly perceived by recreationists. Therefore, policy options focusing on the preservation of species abundance in particular are likely to have a higher positive welfare impact in terms of tourism expenditures.

Introduce Table 3—8 about here

3.7.2 Further discussion

In addition to the aforementioned results, ranking counties according to the annual welfare change produced by a variation in the indicators provides useful insights and hints for further discussion. In the econometric estimation exercise biodiversity richness indicators proved not to be statistically significant; nonetheless, it is possible to explore the role of this scientific information in the ranking of the counties from a cost-benefit point of view, analysing the economic efficiency in the allocation of limited financial resources to environmental protection. In order to do this, both the magnitude of the monetary estimate as well as the information regarding the counties' individual profile with respect to species and habitat richness were taken into account.

There turned out to be a direct correlation between both species and habitat abundance and richness; in fact, counties in which a 10% change in species and habitat abundance indicators has a higher monetary value are also characterised by higher scores in species and habitat richness indicators. Table 3—9 and Table 3—10 display these results.

**Introduce Table 3—9 and Table 3—10 about here*

Another interesting application of ranking counties is the possibility of exploring in deeper detail the link between changes in species abundance and annual welfare changes. So far the species abundance indicator has always been considered as encompassing five different taxa, namely birds, fishes, invertebrates, mammals and plants. However it is reasonable to expect that a higher abundance in each of these taxa with respect to the others would produce different impacts in terms of welfare changes. In order to address this point the ranking of counties according to the annual welfare change for species abundance has been analysed jointly with species abundance of each taxon.

The logarithm of the annual welfare change was computed and it has been regressed against bird, fish, invertebrates, mammals and plants species abundance indicators, as well as against their cross products, in order to investigate any complementarity or substitution effect among them. Results show that all taxa, individually considered, are positively correlated with the annual welfare change except fish which are negatively correlated. However, when taking into account the cross products of the indicators, it can be shown that a high joint fish and mammal species abundance is positively correlated with the annual welfare change, thus mitigating the negative impact of fish species abundance alone. This result reflects the fact that the presence of fish and mammal species is complementary in consumption, implying that it positively influences the welfare change in terms of tourism expenditure.

On the contrary, the cross products between bird and mammal species abundance and between invertebrates and mammal species abundance are negatively correlated with the welfare change. This signals substitutability between mammals and birds and mammals and invertebrates. Table 3—11 displays the results of this analysis.

**Introduce Table 3—11 about here*

3.8 Concluding remarks

The overall goal of this paper was to analyse the potential impact of biodiversity on tourists' decisions about the duration of their stay. The use of indicators as assessment tools of the status of biodiversity is widely acknowledged, however it can be difficult to define a protocol and to retrieve sufficient data to construct them. The first objective achieved by this paper is the use of an existing database, Natura 2000, as a basis for the indicator-building process. Different sets of indicators can be created, therefore it seems very important to carefully select the most relevant ones to be included in the analysis. In this specific case, since impacts on tourism were to be investigated, species abundance and habitat fragmentation were employed but different information could be needed in a different analysis.

The second objective attained is the empirical use of biodiversity indicators as explanatory variables in the analysis of tourism flows, assessing their influence on trip duration. As explained in the previous section, the results lead to the conclusion that, in the considered case study, the species and habitat diversity profiles can exert a positive influence on tourists' choices regarding the number of nights spent at the destination. Results are particularly satisfactory for species abundance and habitat fragmentation indicators, which increase the probability of spending an additional night by 12% and 7% respectively.

Another aspect that has been highlighted is related to land cover types. Following the classification provided by Natura 2000, it has been proven that the presence of different habitat types can cause a different impact on tourist choices. Tourists seem to prefer longer trips in regions characterised by coastal, low wetland vegetation, Mediterranean dryland vegetation, rocky habitats and forests. The probability of spending an additional night in such regions is respectively 14%, 27%, 11%, 26% and 10% higher. Since in many regions tourism is an important economic sector, giving a strong contribution to the well-being of the local populations, the results of this study can provide useful hints to policy-makers, when taking decisions regarding biodiversity protection.

The results of this analysis allow the description of a number of characteristics of Irish domestic tourists and their behaviour with respect to the choice of destination and length of stay. The present study is consistent with the tourism economics literature as far as the choice of explanatory variables is concerned. Environmental quality is often regarded as a relevant factor in describing tourist behaviour. However, unlike most previous studies, this analysis considers biodiversity and landscape profiles of the destination as a measure of environmental quality.

Therefore, an extensive work of elaboration of these profiles has been a necessary initial step. The outcome has been the creation of a set of eight indicators, which have been subsequently introduced as explanatory variables in the model. Nonetheless, only three of them have been maintained in the final model specification, since all of them turned out to be highly correlated among themselves. This depends mainly on the fact that these indicators are intended to measure different aspects of the same phenomenon, and exert considerable reciprocal influence on one another, since ecosystem health conditions directly affect species living conditions. As a result, only species abundance and habitat fragmentation have been included in the final model, due to their stronger explicative power and lower correlation score.

It would have been desirable to include species and habitat richness in the model, however, they have been considered as providing limited additional information. Nonetheless, it seemed interesting to use them to describe regional biodiversity profiles. Conservation indicators were excluded, since in this case, the evaluation provided by the Natura 2000 database, was considered much too subjective, being carried out by authorities managing the protected site. However, the role of this kind of indicators is important and further research would be necessary to develop a more scientifically sound measure of species and habitat conservation status.

The case of species isolation is somehow different in that it appears to have stronger objectivity; however the degree of geographic isolation of a species may not be easily perceived by tourists. Notwithstanding this, it seems useful to further develop and apply this indicator to other contexts or different case studies. When considering the landscape profile, eight out of nine habitat classes were included in the final model and performed very well, allowing some conclusions to be drawn on the attractiveness of different habitats. Alternatively, it seems possible to construct landscape indicators from land cover data, which are generally well mapped across a large number of countries. This possibility could also account for agricultural and anthropogenic landscapes that could enhance a destination's attractiveness.

All in all, more work is needed to understand the complex role played by biodiversity on tourism flows, although this study represents a first valid approximation.

Tables

Table 3—1 Streamlining of biodiversity indicators

CBD Focal area	EU headline indicators	EU proposed indicators	Variables created in this application	Variables retrieved from Natura 2000
Status and trends of biodiversity indicators	Trends in the abundance and distribution of selected species	Abundance and distribution of selected species	Species abundance	Species population
			Species richness	No. species per site
	Change in status of threatened and/or protected species	Red List Index of European species		
		Species of European interest	Species conservation	Species conservation
	Trends in the extent of selected biomes ecosystems and habitats	Ecosystem coverage	Habitat abundance	Habitat relative surface
			Habitat richness	No. habitats per site/ No. habitats at country level
		Habitats of European interest	Habitat conservation	Habitat conservation
	Trends in genetic diversity	Livestock genetic diversity	Species isolation	Species isolation
	Coverage of protected areas	Nationally designated protected areas		
		Sites designated under the EU Habitats and Birds Directives	Coverage of Natura 2000 protected areas	Site area

Source: EEA (2007), own elaboration

Table 3—2 Values of biodiversity indicators across Irish counties

County	Habitat abundance	Habitat Richness	Habitat Conservation	Species Richness	Species Abundance	Species conservation	Species Isolation	Coverage of protected areas
Carlow	1.54	0.05	9.55	0.11	4.14	17.82	2.32	25.39
Cavan	7.57	0.06	19.69	0.02	0.64	11.94	0.40	7.56
Clare	2.72	0.03	15.87	0.03	1.26	7.36	1.83	44.30
Cork	3.54	0.04	29.79	0.04	1.54	13.62	0.53	6.98
Donegal	4.27	0.05	31.15	0.03	2.31	15.70	1.57	29.38
Dublin	1.25	0.03	16.64	0.03	2.41	10.37	0.63	11.58
Galway	4.51	0.05	32.13	0.03	1.63	10.08	0.98	39.23
Kerry	4.16	0.05	29.84	0.05	3.29	13.82	1.90	44.32
Kildare	4.13	0.03	12.40	0.04	1.94	9.69	5.91	0.32
Kilkenny	2.00	0.02	15.00	0.00	0.07	0.43	0.07	0.15
Laois	2.94	0.03	12.17	0.01	1.78	3.42	4.40	3.16
Leitrim	4.82	0.06	63.17	0.02	1.40	21.00	0.53	5.26
Limerick	3.94	0.03	8.00	0.02	1.23	2.25	1.28	0.35
Longford	3.96	0.05	24.19	0.02	0.86	6.86	0.36	25.05
Louth	4.16	0.04	8.03	0.03	1.36	7.59	0.44	26.35
Mayo	4.31	0.04	26.30	0.03	2.56	13.82	2.38	35.78
Meath	3.08	0.04	5.25	0.01	0.10	0.75	0.10	0.49
Monaghan	2.00	0.05	10.67	0.03	0.40	0.40	0.40	0.04
Offaly	2.79	0.03	16.98	0.01	1.30	4.19	2.93	2.19
Roscommon	4.52	0.03	35.06	0.02	0.63	6.64	1.24	3.78
Sligo	4.84	0.05	31.50	0.04	2.08	11.69	6.03	23.93
Tipperary	1.97	0.04	23.64	0.00	0.15	3.57	0.15	2.21
Waterford	2.14	0.05	22.26	0.05	1.21	11.81	0.57	10.06
Westmeath	2.19	0.02	20.28	0.02	1.34	5.88	0.33	4.83
Wexford	3.26	0.05	19.89	0.03	1.91	9.16	0.56	27.56
Wicklow	3.51	0.04	16.62	0.01	1.86	5.92	0.69	26.73

Source: Natura 2000 database, own elaboration

Table 3—3 Surface covered by protected habitats per county (km2)

County	Coastal	Dunes	Freshwater	Wetland vegetation	Mediterranean dryland vegetation	Grassland	Bogs, mires and fens	Rocky	Forests
Carlow							8797.13		
Cavan			4837.27				5.85		284.86
Clare	19980.79	1.34	1381.10	42319.65	7.82	92.02	15.37	7814.50	125.93
Cork	11705.19	2983.58	921.64	1429.31	0.20	3035.56	5771.46	452.86	77.99
Donegal	5831.53	8608.12	40121.22	1507.83	143.02	400.03	11664.42	4666.96	954.74
Dublin	182.52	5.02	2445.62		33.82	144.84	48.60	4666.96	24.29
Galway	11848.97	8283.25	90870.49	9212.49	232.81	64.93	7086.46	2847.25	4478.27
Kerry	16147.02	22509.76	3849.44	61324.69		2458.84	2032.34	76.18	17037.08
Kildare						54.97	34.78		13.13
Kilkenny			10.02	27.60		156.79	0.08	10.92	3.34
Laois	3638.07	59.05		150.72			48.91		14.73
Leitrim	2357.89	785.96		1292.46			2377.98		
Limerick	35.27	72.66	74.89	94.14	3.58	26.21	9.01	6.92	0.24
Longford	11026.89	861.30		23.47			127.59	69.01	
Louth	155.00	2.62	5587.72	248.00		558.77	3.8	2108.04	137.21
Mayo	674.46	1844.01	16278.64	5773.15		1740.81	1746.21	24959.66	1858.49
Meath			299.70	9.68			567.10		
Monaghan			4.04	4.61	2.31		1.73		
Offaly	270.43	36.05	237.30	630.10	3.87	0.42	579.25	52.79	9.14
Roscommon	519.79	144.58	807.27	893.61	34.82	162.71	724.46	3.88	102.45
Sligo	9001.66	97.17	708.64	961.24		27.01	3495.99	63.17	7277.79
Tipperary	3202.09	33.79		526.97	18.77	360.11	19.71	18.73	0.07
Waterford	13150.36			526.97		164.01	30.11		
Westmeath	2601.52	8.26		16.70			215.57		3.01
Wexford	5133.76		16700.28	17.83			7515.42	0.49	15.20
Wicklow			53.10				12581.63		7.96

Source: Natura 2000 database, own elaboration

Table 3—4 Coverage of protected habitats per county (share of protected areas)

County	Coastal	Dunes	Freshwater	Wetland vegetation	Mediterranean dryland vegetation	Grassland	Bogs, mires and fens	Rocks and caves	Forests
Carlow	0.00	0.00	0.00	0.00	0.00	0.00	38.66	0.00	0.00
Cavan	0.00	0.00	33.11	0.00	0.00	0.00	0.04	0.00	1.95
Clare	14.33	0.00	0.99	30.36	0.01	0.07	0.01	5.61	0.09
Cork	22.48	5.73	1.77	2.75	0.00	5.83	11.08	0.87	0.15
Donegal	4.10	6.05	28.21	1.06	0.10	0.28	8.20	3.28	0.67
Dublin	1.71	0.05	22.94	0.00	0.32	1.36	0.46	43.77	0.23
Galway	4.91	3.43	37.67	3.82	0.10	0.03	2.94	1.18	1.86
Kerry	7.68	10.70	1.83	29.16	0.00	1.17	0.97	0.04	8.10
Kildare	0.00	0.00	0.00	0.00	0.00	10.00	6.33	0.00	2.39
Kilkenny	0.00	0.00	3.14	8.66	0.00	49.21	0.03	3.43	1.05
Laois	67.02	1.09	0.00	2.78	0.00	0.00	0.90	0.00	0.27
Leitrim	28.23	9.41	0.00	15.47	0.00	0.00	28.47	0.00	0.00
Limerick	3.72	7.66	7.89	9.92	0.38	2.76	0.95	0.73	0.03
Longford	40.34	3.15	0.00	0.09	0.00	0.00	0.47	0.25	0.00
Louth	0.72	0.01	25.86	1.15	0.00	2.59	0.02	9.76	0.64
Mayo	0.35	0.95	8.43	2.99	0.00	0.90	0.90	12.92	0.96
Meath	0.00	0.00	25.93	0.84	0.00	0.00	49.07	0.00	0.00
Monaghan	0.00	0.00	7.00	8.00	4.00	0.00	3.00	0.00	0.00
Offaly	6.16	0.82	5.41	14.36	0.09	0.01	13.20	1.20	0.21
Roscommon	5.40	1.50	8.39	9.29	0.36	1.69	7.53	0.04	1.07
Sligo	20.48	0.22	1.61	2.19	0.00	0.06	7.95	0.14	16.56
Tipperary	33.66	0.36	0.00	5.54	0.20	3.79	0.21	0.20	0.00
Waterford	71.17	0.00	0.00	2.85	0.00	0.89	0.16	0.00	0.00
Westmeath	30.54	0.10	0.00	0.20	0.00	0.00	2.53	0.00	0.04
Wexford	7.92	0.00	25.76	0.03	0.00	0.00	11.59	0.00	0.02
Wicklow	0.00	0.00	0.10	0.00	0.00	0.00	23.25	0.00	0.01

Source: Natura 2000 database, own elaboration

Table 3—5 Summary statistics of socio-demographic and trip-specific characteristics

Variable	Mean	St. deviation
Household population	3.96	1.60
No. trips	1.93	1.46
No. nights	4.36	4.94
No. persons	2.30	0.77
No. adult	2.50	1.07
No. children	1.14	1.31
Age	34.39	20.12
Gender	0.47	0.50
Disposable income	16,664.36	2,114.99
Cost paid in advance	64.11	75.32
Total cost	229.42	2,853.59
Coverage of protected areas	26.93	15.64
Species richness	0.03	0.01
Species abundance	1.92	0.82
Species conservation	10.74	3.68
Species isolation	1.29	1.08
Habitat richness	0.04	0.01
Habitat abundance	3.57	1.02
Habitat conservation	24.95	7.66
Air	0.01	0.11
Land	0.02	0.12
Other	0.97	0.16
January	0.04	0.19
February	0.06	0.25
March	0.09	0.29
April	0.08	0.26
May	0.07	0.26
June	0.12	0.32
July	0.14	0.35
August	0.19	0.39
September	0.07	0.25
October	0.06	0.24
November	0.04	0.19
December	0.04	0.21
South-East	0.28	0.45
South-West	0.20	0.40
Midwest	0.11	0.31
Midlands	0.02	0.14
Mid-East	0.03	0.18
Dublin	0.05	0.22
West	0.21	0.41
Border	0.09	0.29
Camping	0.10	0.30
Guesthouse	0.14	0.34
Holiday home	0.06	0.24
Hotel	0.42	0.49
Home rental	0.15	0.35
Visiting relatives	0.10	0.30
Other	0.04	0.19
Single	0.19	0.39
Couple	0.32	0.47
Group (>3)	0.49	0.50

Source: Natura 2000 database, CSO (2007)

Table 3—6 GLS regression results

	No. Nights	Coefficient	Std.Err	P>|z|
	(constant)	1.868	0.492	0.000***
Household socio-demographic characteristics	Household dimension	0.021	0.025	0.279
	Disposable income (county average)	0.079	0.018	0.000***
	Age of respondent	0.004	0.001	0.000***
	Repeat visitor	-0.533	0.050	0.000***
Cost paid for the trip	Cost	-0.005	0.000	0.000***
Coverage of protected areas	Protected areas	-0.022	0.006	0.000***
Species and habitat diversity indicators	Species abundance	0.453	0.101	0.000***
	Habitat abundance	0.283	0.076	0.000***
Protected habitats (landscape)	Coastal	0.511	0.228	0.025*
	Dunes	-1.551	0.326	0.000***
	Freshwater	-1.027	0.279	0.000***
	Wetland vegetation	0.860	0.315	0.006**
	Dryland vegetation	0.444	0.117	0.000***
	Grassland	-0.674	0.233	0.004**
	Rocky	1.313	0.378	0.001***
	Forests	0.610	0.201	0.002**
Modes of transportation	Air	0.280	0.242	0.172
	Land	2.405	0.215	0.000***
Month of departure	January	-0.506	0.182	0.005**
	February	-0.217	0.166	0.133
	March	-0.152	0.157	0.233
	April	0.017	0.162	0.636
	May	0.069	0.159	0.461
	June	0.787	0.153	0.000***
	July	3.201	0.153	0.000***
	August	1.914	0.148	0.000***
	September	0.330	0.158	0.037*
	October	-0.217	0.143	0.089*
	November	-0.170	0.157	0.193
NUTS 3 regions of destination	South-west	-0.310	0.415	0.316
	South-east	-0.955	0.463	0.039*
	Midwest	-1.022	0.448	0.023*
	Midlands	-1.139	0.477	0.017*
	Mideast	-0.834	0.394	0.035*
	West	-0.509	0.439	0.171
	Border	-0.987	0.454	0.030*
Accommodation categories	Camping	0.573	0.152	0.000***
	Guesthouse	-1.414	0.138	0.000***
	Holiday home	2.038	0.179	0.000***
	Hotel	-1.462	0.131	0.000***
	SC/rental	0.586	0.144	0.000***
	Visiting relatives	-0.731	0.143	0.000***
Recreationist group	Couple	0.099	0.069	0.106
	Group (>3)	1.157	0.089	0.000***
	children	-0.223	0.046	0.000***

GLS regression with correction for random effects. Group variable (i): household. R^2 within = 0.11; R^2 between = 0.19. Wald chi^2 = 3582.60. Prob > chi^2 = 0.0000

Table 3—7 Results of the Poisson regression analysis and incident rate ratios

	No. nights	Impact	IRR	Coefficient	P>|z|
	(constant)			0.962	0.000***
Household socio-demographic characteristics	Household dimension	0.001	1.001	0.001	0.579
	Disposable income (scale)	0.014	1.014	0.014	0.000***
	Age of respondent	0.001	1.001	0.001	0.000***
	Repeat visitor	-0.120	0.880	-0.128	0.000***
Cost paid for the trip	Cost	-0.002	0.998	-0.002	0.000***
Coverage of protected areas	Protected area	-0.006	0.994	-0.006	0.000***
Species and habitat diversity	Species abundance	0.122	1.122	0.115	0.000***
	Habitat abundance	0.079	1.079	0.076	0.000***
Protected habitats (landscape)	Coastal	0.144	1.144	0.135	0.003**
	Dunes	-0.306	0.694	-0.366	0.000***
	Freshwater	-0.181	0.819	-0.199	0.001***
	Wetland vegetation	0.272	1.272	0.240	0.000***
	Dryland vegetation	0.112	1.112	0.106	0.000***
	Grassland	-0.123	0.877	-0.131	0.004**
	Rocky	0.265	1.265	0.235	0.002**
	Forests	0.108	1.108	0.102	0.013*
Modes of transportation	Air	0.048	1.048	0.047	0.193
	Land	0.701	1.701	0.531	0.000***
Month of departure	January	-0.104	0.896	-0.110	0.002**
	February	-0.059	0.941	-0.060	0.055*
	March	-0.028	0.972	-0.029	0.229
	April	0.038	1.038	0.037	0.151
	May	0.038	1.038	0.037	0.150
	June	0.265	1.265	0.235	0.000***
	July	0.847	1.847	0.614	0.000***
	August	0.547	1.547	0.437	0.000***
	September	0.111	1.111	0.105	0.000***
	October	-0.021	0.979	-0.021	0.334
	November	-0.086	0.914	-0.090	0.008**
NUTS 3 regions of destination	South-west	-0.071	0.929	-0.074	0.261
	South-east	-0.232	0.768	-0.264	0.005**
	Midwest	-0.214	0.786	-0.241	0.008**
	Midlands	-0.249	0.751	-0.286	0.004**
	Mideast	-0.215	0.785	-0.242	0.002**
	West	-0.100	0.900	-0.105	0.161
	Border	-0.200	0.800	-0.223	0.014*
Accommodation categories	Camping	0.061	1.061	0.059	0.029*
	Guesthouse	-0.288	0.712	-0.340	0.000***
	Holiday home	0.318	1.318	0.276	0.000***
	Hotel	-0.288	0.712	-0.339	0.000***
	SC/rental	0.095	1.095	0.091	0.000***
	Visiting relatives	-0.143	0.857	-0.154	0.000***
Recreationist group	Couple	-0.033	0.967	-0.034	0.008**
	Group (>3)	0.151	1.151	0.141	0.000***
	children	-0.041	0.959	-0.042	0.000***

Log likelihood = -68197.735; Wald chi^2 = 8691.83 Prob > chi^2 = 0.0000. Statistical significance of 0.1%. 5% and 10% is indicated by ***. **. * respectively. Likelihood-ratio test of alpha= 0: chibar2(01) = 3.3e+04 Prob>= chibar2= 0.0000.

Table 3—8 Annual welfare change due to a 10% change in biodiversity indicators

County	Annual welfare change (habitat abundance)	Annual welfare change (species abundance)	Annual welfare change (Coverage of protected areas)
Carlow	€ 5,568	€ 23,093	-€ 6,965
Cavan	€ 80,402	€ 10,436	-€ 6,101
Clare	€ 268,740	€ 191,876	-€ 332,490
Cork	€ 557,431	€ 373,197	-€ 83,463
Donegal	€ 274,849	€ 229,271	-€ 143,646
Dublin	€ 81,616	€ 242,272	-€ 57,327
Galway	€ 991,090	€ 553,272	-€ 655,313
Kerry	€ 1,053,959	€ 1,290,072	-€ 853,775
Kildare	€ 26,293	€ 19,058	-€ 157
Kilkenny	€ 82,989	€ 4,272	-€ 487
Laois	€ 11,346	€ 10,612	-€ 924
Leitrim	€ 39,023	€ 17,516	-€ 3,236
Limerick	€ 88,870	€ 42,697	-€ 605
Longford	€ 6,588	€ 2,203	-€ 3,166
Louth	€ 39,169	€ 19,770	-€ 18,862
Mayo	€ 393,138	€ 360,107	-€ 248,029
Meath	€ 18,363	€ 920	-€ 223
Monaghan	€ 7,704	€ 2,379	-€ 13
Offaly	€ 19,872	€ 14,307	-€ 1,186
Roscommon	€ 25,054	€ 5,392	-€ 1,589
Sligo	€ 147,206	€ 97,575	-€ 55,221
Tipperary	€ 27,457	€ 3,304	-€ 2,335
Waterford	€ 151,162	€ 132,487	-€ 53,996
Westmeath	€ 22,940	€ 21,754	-€ 3,847
Wexford	€ 428,513	€ 388,550	-€ 275,462
Wicklow	€ 85,298	€ 69,641	-€ 49,318
TOTAL	€ 4,934,640	€ 4,126,033	-€ 2,857,739

Source: Natura 2000 database, own elaboration

Table 3—9 Correlation between monetary value of a change in species abundance and scores for species richness

County	Monetary value of change in species abundance	Monetary value of change in species abundance (% expenditure per night)	Species Richness
Carlow	€ 3	5%	0.11
Mean	€ 3	5%	0.11
Dublin	€ 2	3%	0.03
Kerry	€ 2	4%	0.05
Mayo	€ 2	3%	0.03
Mean	€ 2	3%	0.04
Kildare	€ 1	2%	0.04
Donegal	€ 1	3%	0.03
Laois	€ 1	2%	0.01
Galway	€ 1	2%	0.03
Sligo	€ 1	3%	0.04
Offaly	€ 1	2%	0.01
Westmeath	€ 1	2%	0.02
Wicklow	€ 1	2%	0.01
Limerick	€ 1	1%	0.02
Wexford	€ 1	2%	0.03
Leitrim	€ 1	2%	0.02
Cork	€ 1	2%	0.04
Louth	€ 1	2%	0.03
Waterford	€ 1	1%	0.05
Clare	€ 1	2%	0.03
Mean	€ 1	2%	0.03
Cavan	€ 0	1%	0.02
Monaghan	€ 0	0%	0.03
Longford	€ 0	1%	0.02
Roscommon	€ 0	1%	0.02
Tipperary	€ 0	0%	0.00
Kilkenny	€ 0	0%	0.00
Meath	€ 0	0%	0.01
Mean	€ 0	0%	0.01

Source: Natura 2000 database, own elaboration

Table 3—10 Correlation between monetary value of a change in habitat abundance and scores for habitat richness

County	Monetary value of change in habitat abundance	Monetary value of change in habitat abundance (% expenditure per night)	Habitat Richness
Cavan	€ 3	6%	0.056
Mean	€ 3	6%	0.056
Galway	€ 2	4%	0.050
Kildare	€ 2	3%	0.027
Limerick	€ 2	3%	0.025
Leitrim	€ 2	4%	0.056
Sligo	€ 2	4%	0.046
Mayo	€ 2	3%	0.038
Kerry	€ 2	3%	0.045
Mean	€ 2	3%	0.041
Donegal	€ 1	3%	0.047
Offaly	€ 1	2%	0.034
Kilkenny	€ 1	2%	0.017
Louth	€ 1	3%	0.039
Laois	€ 1	2%	0.025
Wicklow	€ 1	3%	0.042
Cork	€ 1	3%	0.039
Monaghan	€ 1	2%	0.051
Roscommon	€ 1	4%	0.034
Westmeath	€ 1	2%	0.018
Longford	€ 1	3%	0.046
Meath	€ 1	2%	0.038
Wexford	€ 1	3%	0.049
Clare	€ 1	2%	0.028
Waterford	€ 1	2%	0.047
Tipperary	€ 1	2%	0.040
Dublin	€ 1	1%	0.033
Carlow	€ 1	1%	0.047
Mean	€ 1	2%	0.037

Source: Natura 2000 database, own elaboration

Table 3—11 Results of the regression analysis of annual welfare change against the different components of species abundance and their cross products

Annual welfare change	Coefficient	P>|t|
Bird species abundance	0.9876984	0.000***
Fish species abundance	-6.194821	0.078*
Invertebrate species abundance	0.6121539	0.001**
Mammal species abundance	7.374116	0.004**
Plant species abundance	0.738841	0.010**
Fish*Mammal species abundance	5.739874	0.052*
Bird*Mammal species abundance	-1.021129	0.034*
Invertebrate*Mammal species abundance	-1.0081	0.036*
Mammal*Plants species abundance	-0.5609158	0.113

Prob > F= 0.0000; R^2 = 0.9434; Adjusted R^2 = 0.9134

Source: Natura 2000 database, own elaboration

References

Barry. K. and J.O'Hagan (1972). An Econometric Study of British Tourist Expenditure in Ireland'. Economic and Social Review . 3. (2). 143-161.

Brander. L.M.. P.J.H.van Beukering. and H.S.J.Cesar (2007). 'The Recreational Value of Coral Reefs: A Meta-Analysis'. Ecological Economics. 63. 209-218.

Crouch. G.I. (1995). 'A Meta-Analysis of Tourism Demand'. Annals of Tourism Research. 22. (1). 103-118.

EASAC(2005). A user’s guide to biodiversity indicators. European Academies Science Advisory Council

European Environmental Agency (2003). An inventory of biodiversity indicators in Europe. 2002. Technical Report n. 92.

European Environmental Agency (2007). Halting the loss of biodiversity by 2010: proposal for a first set of indicators to monitor progress in Europe. Technical report n. 11/2007

European Commission (1998). Communication from the Commission to the Council and the European Parliament on a European Community Biodiversity Strategy. COM (1998) 42

European Commission (2006). Communication from the Commission Halting the loss of biodiversity by 2010 — and beyond Sustaining ecosystem services for human well–being. COM (2006) 216

Gillmor. D.A. (1995). 'Evolving Air-Charter Tourism Patterns: Change in Outbound Traffic from the Republic of Ireland'. Tourism Management. 17. (1). 9-16.

Hannigan. K. (1994). 'A Regional Analysis of Tourism Growth in Ireland'. Regional Studies. 28. (2). 208-214.

Hellström J. (2002). An endogenously stratified bivariate count data model for household tourism demand. Umea economic Studies n. 583. Umea University. Sweden

Huybers T.. Bennett J. (2003). Environmental Management and the Competitiveness of Nature-Based Tourism Destinations. Environmental and Resource Economics. 24. 213 - 233

Klenosky D. (2002). The “Pull” of Tourism Destinations: A Means-End Investigation. Journal of Travel Research. 40. 385

Ledesma Rodriguez F.J. et al (1999). Panel data and tourism demand. The case study of Tenerife. Documento de trabajo 99-17 Fundacion de Estudios de Economia Aplicada (FEDEA)

Lim C. (1997). Review of international tourism demand models. Annals of Tourism Research. vol. 24. n. 4. pp 835 - 849

Lyons. S.. K. Mayor and R.S.J. Tol (2007). Holiday Destinations: Understanding the Travel Choices of Irish Tourists. Working Paper 210. Economic and Social Research Institute. Dublin.

Lyons. S.. K. Mayor and R.S.J. Tol (2008). The Climate Preferences of Irish Tourists by Purpose of Travel. Working Paper 225. Economic and Social Research Institute. Dublin.

Marcoullier D.W.. Prey J. (2005). The Tourism Supply Linkage: Recreational Sites and their Related Natural Amenities. The Journal of Regional Analysis and Policy. 35 (1)

McManus R. (1997). Heritage and Tourism in Ireland – an unholy alliance?. Irish Geography. 30 (2). 90-98

Millennium Ecosystem Assessment (2005). Ecosystems and Human Well-being: Biodiversity Synthesis. World Resource Institute. Washington D.C.

Nunes P.A.L.D. and van den Bergh J.C.J.M. (2002). Measuring the Economic Value of a Marine Protection Program against the Introduction of Non-Indigenous Species in the Netherlands. Tinbergen Institute Discussion Papers 02-057/3. Tinbergen Institute.

O'Leary. S. and J.Deegan (2005). 'Ireland's Image as a Tourism Destination in France: Attribute Importance and Performance'. Journal of Travel Research. 43. 247-256.

Proença S.A. and Soukiazis E. (2005). Demand for tourism in Portugal: a panel data approach. Discussion paper n. 29. Centro de Estudos da Uniao Europeia (CEUNEUROP). Facultade de Economia da Universidade de Coimbra

Rugg D. (1973). The choice of journey destination: A theoretical and empirical analysis. Review of Economics and Statistics. 55(1). 64 – 72

Seddighi H.R.. Theocharous A.L. (2002). A model of tourism destination choice: a theoretical and empirical analysis. Tourism Management. 23. 475 – 487

Shrestha. R.K. and J.B.Loomis (2003). 'Meta-Analytic Benefit Transfer of Outdoor Recreation Economic Values: Testing Out-of-Sample Convergent Validity'. Environmental and Resource Economics. 25. 79-100.

Shrestha. R.K. and J.B.Loomis (2001). 'Testing a meta-analysis model for benefit transfer in international outdoor recreation'. Ecological Economics. 39. 67-83.

Song. H. and G.Li (2008). 'Tourism Demand Modelling and Forecasting -- A Review of Recent Research'. Tourism Management. 29. 203-220.

Ten Brink B. (2000). Biodiversity Indicators for the OECD Environmental Outlook and Strategy. A feasibility study. RIVM Report 402001014. National Institute of Public Health and the Environment. The Netherlands

Walsh. M. (1996). 'Demand Analysis in Irish Tourism'. Journal of the Statistical and Social Inquiry Society of Ireland. 207. (4). 1-35.

Witt. S.F. and C.A.Witt (1995). 'Forecasting Tourism Demand: A Review of Empirical Research'. International Journal of Forecasting. 11. 447-475.

4. The influence of landscape diversity on tourist destination choice: A regional perspective

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Abstract

Landscape features and composition can play a major role in determining the tourist destination choice. Previous studies have been addressing the issue of measuring landscape characteristics and two main types of metrics have been identified, namely composition and configuration. This analysis aims at assessing the impact of landscape diversity on regional tourism flows, using landscape composition metrics as diversity indicators. In addition, it seemed interesting to analyse the impact of the relative abundance of selected landscape categories. This paper focuses on Tuscany, a well-known touristy region in Italy, therefore the selected landscape types are vineyards, olive groves and arable land.

After computing the composition and relative abundance indicators for all Tuscan municipalities, these indicators have been included as explanatory variables in a regression model encompassing socio-demographic and geographical characteristics of each municipality, accommodation availability, the share of protected area on the municipal territory and in its surroundings, the number of quality wines produced in each municipality and the types of tourism attraction factors. This model has been run for the total number of tourist arrivals, and subsequently for international and domestic flows. Results allow concluding that landscape diversity indicators can be usefully employed in the description of the tourist destination choice and that landscape richness proves to be positively correlated to the volume of tourism flows. In addition, vineyard landscape and the production of quality wines appear to exert a positive influence on tourism flows, especially when international arrivals are considered.

Keywords: Landscape composition, landscape metrics, international tourism, domestic tourism, quality wine production

4.1 Introduction

The landscape profile plays a widely acknowledged role among the attraction factors of any tourist destination. The identification of landscape metrics and indicators has been addressed by a vast array of studies, which highlighted the importance of measuring landscape characteristics, both from a composition and a configuration perspective. The former aspect refers to the different typologies of landscape elements, while the latter addresses their spatial distribution.

The present study aims at describing the impact of landscape diversity on the tourist destination choice. The primary objective has been the identification and the construction of a set of appropriate indicators, taking into account the peculiarities of the tourism sector. The second step has been the specification of an econometric model assessing the impacts of landscape diversity on the volume of tourism flows towards particular destinations, namely the municipalities of Tuscany, Italy.

This paper is organised in two main parts. The first, including sections 4.2 to 4.4, presents a review of the relevant literature on the determinants of tourism demand and of the most widely used landscape metrics, highlighting the appropriateness of each of them for describing specific phenomena. In addition, a detailed description of the indicators computed for the purpose of this study is provided.

The second part, composed by sections 4.5 to 4.7 is devoted to the use of those indicators to analyse tourist behaviour in the various Tuscan municipalities. A description of the features of landscape and tourism flows towards the different areas of Tuscany is provided and, subsequently, a first econometric model analyses the influence of landscape diversity, among other explanatory variables, on the total number of tourist arrivals in each municipality. Finally, the number of visitors is disentangled into its international and domestic component and the effects of landscape diversity are assessed on each of them separately.

The outcome of this analysis allows drawing some conclusions on the suitability of the selected landscape diversity indicators in the analysis of the tourism destination choice and on the similarities and differences between the international and domestic segment of tourism flows towards Tuscany.

4.2 Literature review on the determinants of tourism demand and landscape amenities

The number of tourist arrivals is the most popular measure of tourism demand used in the reviewed literature. This variable can be further disaggregated according to the purpose of the visit, for instance holiday, business and visiting friends and relatives (Turner and Witt, 2001), the origin of the travellers (Bigano et al, 2007) or the means of transportation used (Rosselló-Nadal, 2001). Some studies adopt tourist expenditure or tourism sector revenue or employment as the dependent variable (Li et al, 2004; Witt et al, 2004).

Most of the reviewed studies include economic variables such as income, tourism prices, distance and cost of transportation, as well as exchange rates as explanatory variables to describe tourist arrivals (Dritsakis, 2004; Witt and Witt 1995; Hamilton et al., 2005; Bigano et al., 2007; Lise and Tol, 2002). Income is generally found to affect tourism demand in a positive way, while distance and cost, as well as the price level can be expected to deliver an opposite result.

Population density is assumed to affect international tourism determining a proportional increase in departures (Hamilton et al., 2005 a). However, as far as inbound tourism is concerned, its impact is more ambiguous since, on the one hand, tourists may be attracted towards densely populated countries, as this implies a larger number of towns and cities as well as of tourism facilities and infrastructure. On the other hand, if a high population density entails a lack of natural and wilderness areas, those areas may become unattractive to tourists (Hamilton, 2004).

Several studies have been focusing on the relationship between climate and tourism demand. Temperature is often considered as the most relevant climatic variable, since most climate parameters, such as humidity, cloudiness and weather extremes, tend to depend on temperature. In addition this variable is generally well monitored and the relevant data are available and reliable (Bigano et al., 2007). Hamilton et al. (2005 a; b) found that climate change shifts international tourist towards higher altitudes and latitudes. Lise and Tol (2002) include temperature, precipitation and number of average number of sun hours per day in order to describe the climatic conditions of the destination.

Environmental amenities are considered by most studies as a relevant component of tourism demand determinants and they can be viewed as a growth factor for the tourism industry (Wunder, 2000; Naidoo and Adamovicz, 2005; Green, 2001). Tourists appear to attach a value to different types of landscapes. Hamilton (2006) analysed the impact of different types of coastal landscape on the price of tourism accommodation and found out that the length of open coast contributes to increase this value.

Agricultural landscape has been found to exert an influence on visitors’ decisions (Fleitscer and Tsur, 2000; Hellerstein et al., 2002). Madureira (2006) and Job and Murphy (2006) pointed out that the traditional vineyard landscape is one of the major tourism attraction factors of the Douro valley in Portugal and of the Mosel valley in Germany. Analogous arguments have been made for olive grows, which were found to be positively correlated to tourism flows towards the Greek islands (Loumou et al., 2000).

Furthermore, among the relevant tourism pull factors, several studies consider the types of tourism attractions of which a destination can take advantage, for instance art and local culture (Medina, 2003; Poria, 2003; Hamilton, 2004). Moreover, different segments of the tourism market can be identified depending on the characteristic landscape of the destination. For example, mountain and seaside destinations can be analysed with reference to their capacity to attract different types of tourism, whose consumption behaviour may differ (Manente et al.,1996).

Finally, tourists may be attracted by specific products, particularly wine and gastronomic productions, linked to the territory of the region they chose to visit. An example, are the "wine routes"[13], Tourists who follow a wine route have the opportunity to visit wine farms, to take part in wine tasting, purchase wine, visit a vineyard or a local museum that gives them information about the wine traditions and history of the region. Often there is also an opportunity to stay in agri-tourist accommodation, taste the culinary specialities of the area and buy products typical of the region (Brunori and Rossi, 2000; Telfer, 2001; Correia et al., 2004).

The present study is consistent with the reviewed literature in the selection of dependent and explanatory variables to be included in the model. Nonetheless, the reviewed studies rarely take into account simultaneously all the different aspects that could influence the tourists' destination choice, such as climate, landscape features, socio-demographic characteristics of the destination, tourism attraction factors and the presence of typical wines and gastronomic products, as it is done in the present paper. In addition, another innovative aspect of this analysis is the disaggreagation of tourism flows in their international and domestic components, with the aim of identifying differences in their choice patterns.

4.3 Review of existing landscape metrics

Landscape can be defined as a spatially heterogeneous area presenting at least one factor of interest (Turner et al., 2001). The spatial structures of landscapes are associated with the composition and configuration of landscape elements; the former refers to the number and occurrence of different types of landscape elements, while the latter encompasses their physical or spatial distribution within a landscape (McGarigal et al. 1994).

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[13] Wine routes are defined as sign-posted itinerary, through a well defined area, whose aim is the 'discovery' of the wine products in the region and the activities associated with it (Brunori and Rossi, 2000).

A whole set of mathematical indices have been developed in order to provide an objective description of different aspects of landscapes structures and patterns (McGarigal et al. 1994) and it is important to remind that no single metric can adequately capture the pattern on a given landscape. Several suggestions have been made for a meaningful set of metrics that minimize redundancy while capturing the desired qualities (Riitters et al. 1995). A vast array of previous studies has reviewed the most commonly used landscape metrics, highlighting advantages and shortcomings of each (Hargis, 1998; Turner, 2005; European Commission, 2000; Botequilha Leitão and Ahern, 2002).

Literature review highlights that landscape structure encompasses two main components: composition and configuration. Composition metrics measures proportion, richness, evenness and diversity. Examples include the number of classes, patch density and the Shannon’s diversity index. The number of land cover classes is the simplest way of capturing the diversity of the earth's surface, counting the number of different categories in a unit area. This metric presents the undoubted advantage to be easily calculated and interpreted. But, as in all richness measures, the result might be misleading, because the area covered by each class and thus its importance is not considered (European Commission, 2000).

Patch density reflects the number of patches within the entire reference unit on a per area basis, therefore it depends on the size of the smallest spatial unit mapped and the number of different categories considered. This index is a good reflection of the extent to which the landscape is fragmented and it enables comparisons of units with different sizes (European Commission, 2000; Lausch and Herzog, 2002; Wu et al., 2002; Herold et al., 2002).

Shannon’s diversity index quantifies landscape diversity on the basis of two components, richness and evenness. Richness refers to the number of patch types, while evenness represents the proportional area distribution among patch types (European Commission, 2000; Flather and Sauer, 1996). This is one of the most commonly used measures of landscape diversity, nonetheless, it tends to underestimate the real diversity if used on small samples.

Configuration metrics, on the other hand, account for shape and size of landscape patches and the most common examples of these metrics are edge density, the contagion index and the interspertion and juxtaposition index (Botequilha Leitão and Ahern, 2002; European Commission, 2000). An edge refers to the border between two different classes. Edge density, expressed in m/ha, equals the length of all borders between different patch types in a reference area divided by the total area of the reference unit. Edge density is a measurement of the complexity of the shapes of patches and an expression of the spatial heterogeneity of a landscape mosaic. Like patch density, edge density is a function of the size of the smallest mapping unit defined, since the smaller the mapping unit the better the spatial delineation measurement and the higher the edge length (European Commission, 2000; Hargis, 1998; Cissel et al., 1999).

The interspersion and juxtaposition index considers the neighbourhood relations between patches. Each patch is analysed for adjacency with all other patch types and the index captures the extent to which patch types are interspersed i.e. equally bordering other patch types. The index is calculated with as similar strategy to the Shannon Index but it is normalised for the number of landscape classes (European Commission, 2000; Lausch and Herzog, 2002; Coppedge et al., 2002).

4.4 Construction of landscape metrics using the CORINE Land Cover inventory

Among the issues that need to be addressed when developing a landscape metrics there are data availability and comparability. The CORINE Land Cover Inventory is the only data set providing a synoptic but broad overview of land cover and land use at European level, enabling cross border investigations and comparisons at European level. For this reason, within the scope of this analysis, it has been chosen to use this information in order to construct landscape diversity indicators.

The CORINE Land Cover Inventory is based on satellite images as the primary information source[14]. The data presented in the inventory is clustered into 44 classes covering agricultural areas as well as urban and natural surfaces. These classes are organized on a hierarchical scale, displayed in Table 4—1.

Insert Table 4—1about here

Composition indicators seemed to be more likely to influence tourist perceptions and choices than configuration indicators, which, in turn, would be most appropriate in order to analyse functionalities and the degree of fragmentation of landscapes and ecosystems. For this reason, it has been chosen to use the data provided by the CORINE database to construct two composition indicators, landscape richness and patch density, as well as the relative abundance of selected landscape types. This paper applies the selected indicators to the Tuscany region in Italy and the unit of analysis of is the municipality geographical scale.

Landscape richness, has been computed as the number of different land cover categories recorded in each municipality divided by the number of classes recorded in the whole region. All the classes included in the CORINE Land Cover database have been considered and

[14] The minimum mapping unit, i.e. the smallest cartographic unit mapped, is 25 ha, ideally presenting a square of 5x5 mm on a map of scale 1:100000.

Table 4—1 shows the ones existing in Tuscany, which have been used in the calculation of both landscape richness and patch density.
Patch density has been calculated according to Equation (4.1):

$$Patch\ Density = \frac{n_j}{A_j} \quad (4.1)$$

where n_j is the number of patches recorded in municipality j and A_j is the area of municipality j. The score can be read on a scale ranging from 0 to 1.
Since neither the number of land cover classes nor patch density provide information on the surface covered by the different patches, it has been decided to include the relative abundance of three landscape types, namely arable land, vineyards and olive groves, expressed as a share of the municipal area. These land cover categories are generally acknowledged to exert a significant impact on tourist perception and tourism demand, as highlighted by the literature review. The relative abundance has been computed according to Equation (4.2):

$$\mathrm{Re}\,lative\ Abundance_{ij} = \frac{A_{ij}}{A_j} \quad (4.2)$$

where A_{ij} represents the surface covered by land cover type i in municipality j and A_j the total area of municipality j. Once more, the score can be read on a scale ranging from 0 to 1.

4.5 The Tuscany case study

The remainder of this paper will be devoted to the assessment of the impact of the landscape metrics described in the previous section on international and domestic tourism flows towards the Italian region of Tuscany adopting 2007 as a reference year. To begin with a description of the chosen explanatory variables and of the data sources will be provided and, landscape features and the main tourism attraction factors will be identified for each province of the region. Finally, an econometric model will be developed in order to describe the number of tourist arrivals as a function of a set of explanatory variables, including landscape characteristics and its results will be analysed.

4.6 Description of the selected variables and data sources

A large cross-section dataset has been constructed, using a set of different sources, and adopting 2007 as the reference year. As regards international and domestic tourism arrivals, data have been retrieved from the Tuscany regional administration, as well as the availability of accommodations, the share of budget accommodation solutions and the types of tourism attraction of each municipality.

The surfaces covered by each land cover category and the information needed to construct the selected landscape metrics have been obtained from the CORINE Land Cover database, as discussed in the previous section. The share of municipal territory covered by Natura 2000 sites has been computed from the information contained in the Natura 2000 database and overlapped to the area of the municipality, using ArcGis. The same procedure has been followed to compute the number of existing Natura 2000 sites in a range of 10, 15, 20, 25 and 50 km around the municipality.

Average yearly temperature and precipitation have been computed with a spatial resolution of 1 squared km. Each grid point is associated to a single meteorological observation in a dataset covering the period 1996-2007.[15]. Finally, the information on the number of high quality wines, DOCG and DOC[16] wines in this specific case, produced on the territory of each municipality has been retrieved from the Italian federation of sommeliers and hotel and restaurant owners (FISAR, 2007). Table 4—2 displays the variables used in this study and the data sources.

Insert Table 4—2 about here

4.6.1 Landscape diversity indicators for Tuscany

The administrative territory of Tuscany is divided into ten provinces namely, Arezzo, Florence, Grosseto, Livorno, Lucca, Massa Carrara, Pisa, Pistoia, Prato and Siena[17]. As far

[15] Entries of this dataset are daily observed values of minimum and maximum temperature and precipitation. This data has been provided by the Department of Agronomic Sciences and Agro-Forestry Territorial Management of the University of Florence, Italy.

[16] Quality wine produced in a specified region (QWPSR) is the generic EU term for quality wines such as the French AC, the Italian DOC/G, the Spanish DO/DOCa, and the German QbA/QmP. For DOC wines the "Disciplinare di Produzione" establishes the zones of production and collection of grapes, the cultivars allowed for wine-making, the type of land on which cultivation is possible, a maximum yield, production and ageing technologies, the characteristics of the final product and the possible label qualification of the commercialized product. DOCG wines have achieved, in addition to the DOC qualification and peculiar qualities, a well-established international reputation.

[17] There are thirty-nine municipalities in the Arezzo province, forty-four in Florence province, twenty-eight in the Grosseto province, twenty in the Livorno, thirty-five in the Lucca province, seventeen in

as the relative abundance of the selected landscape categories is concerned, agricultural land covers a significant portion of the various provincial territories, ranging from the 41% in Pistoia province to the 13% in Grosseto province. By contrast, vineyards represent a maximum of 2% of the territory, namely in the Pistoia, Lucca and Massa Carrara provinces. Olive groves cover slightly larger extensions with respect to vineyards, ranging from the 7% of the Pistoia and Lucca provinces to the 3% of Grosseto and Siena provinces.

As regards landscape richness, the number of different land cover categories recorded in each province, the highest score, 0.27 on a scale ranging from 0 to 1, is recorded in the Livorno province, while the lowest, 0.22, is achieved by the Pistoia province. When it comes to patch density, Pistoia reaches the higher score, 0.0027, followed by Livorno, 0.0023, and Lucca, 0.0021, while Grosseto and Siena obtain the lowest scores with 0.0007 and 0.0010 respectively. The remarkable difference in the scores of landscape richness and patch density can be explained by the fact that the former provides a measure of richness in absolute terms, which could be biased towards larger provinces. On the contrary, the latter accounts for the dimension of the administrative units. The scores of each province in the different landscape metrics are reported in Table 4—3.

Insert Table 4—3 about here

4.6.2 Tourism flows to Tuscany: state and trends

As regards the volume of tourism flows, 2007 data show that the Florence province is attracting the highest number of tourist arrivals in absolute terms, and they mostly visit the city monuments and art works. Other provinces that experience considerable inbound tourist flows for cultural purposes are Pisa, Siena, Arezzo and Lucca. Seaside tourism proves to be relevant for the provinces of Livorno, Grosseto, Lucca and Massa Carrara, while countryside tourism flows appears to be particularly significant for Siena, Florence, Pisa and Pistoia (Regione Toscana, 2008). The relevant figures are displayed in Table 4—4.

Insert Table 4—4 about here

According to the World Tourism Organization in 2007 worldwide tourism flows have experienced an expansion, thus confirming the medium and long term growing trend, with international arrivals growing by 6 % with respect to 2006. In absolute terms, Italy has achieved a good position in the international scene, recording a 3.3 % increase in

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the one of Massa-Carrara, thirty-nine in the Pisa province, twenty-two in the Pistoia province, seven in the Prato province and thirty-six in the Siena province.

international inbound tourism flows. However, this variation appears to be below the one achieved in 2006, as well as below the global trend for 2007 (WTO, 2008).

In the specific case of Tuscany, 2007 can be considered as a positive year with increases in both the international and the domestic component of tourism flows, scoring an increase of 2.7% and 1.1% respectively. However these gains have not been homogeneously distributed across the different provinces and types of tourism resources, such as art, mountain, coast and countryside. Among art cities, Lucca obtained remarkably positive results, while Pisa, Siena and Florence have experienced more modest increases (Regione Toscana, 2008). Those provinces characterized by mountainous territory have recorded a very good performance during 2007, while the increase in tourism arrivals in coastal areas has slowed down with respect to the previous year. The Tuscany regional administration states that tourism in Tuscany is gradually expanding to areas with lower tourism intensity and lower level of economic development, for instance mountain areas.

4.7 Model specification and estimation results

In order to estimate the impact of landscape diversity on the tourism destination choice, a regression model has been constructed according to the specification displayed in Equation (3):

$$\ln Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + \beta_4 X_{4i} + \beta_5 X_{5i} + \beta_6 X_{6i} + u_i \qquad (3)$$

The number of tourist arrivals in each municipality is adopted as the dependent variable[18]. The selected explanatory variables are the socio-demographic and geographical characteristics of each municipality(x_1), accommodation availability (x_2), the share of protected area on the municipal territory and the number of neighbouring protected sites (x_3), landscape metrics (x_4), the number of DOCG and DOC wines produced in each municipality (x_5) and the types of tourism attraction factors (x_6)[19].

The estimation results show that the spatial dimension of the municipality is positively correlated to the total number of incoming tourists. As far as the availability of accommodation possibilities is concerned, the total number of bed places in any type of

[18] The logarithmic transformation of the number of tourists was performed as this appeared to fit the data better than the linear form; this choice is consistent with the majority of recreation studies that apply this functional form.

[19] It would have been interesting to include a variable referring to tourist income. However, the data on tourist flows has not been retrieved froma survey, as it was the case for chapter 3, therefore such an information was not available. Moreover, the country of origin of international tourists and the región of origin of domestic ones was not available too.

accommodation exerts a positive influence on the total number of tourists. This is consistent with the results obtained for the municipality area, suggesting that space availability is appreciated by tourists and that, at the same time, a larger space and accommodation availability enables to host a higher number of visitors.

The elevation with respect to the sea level is negatively correlated to the dependent variable. On the contrary, an increasing share of the municipality mapped as a Natura 2000 protected area and the number of protected areas within a range of 25 km from the municipality are found to positively influence the number of tourist arrivals. This can be interpreted both as an interest in the protection of the environment and a preference for a larger availability of natural areas.

As regards the landscape metrics, landscape richness, representing the number of different land cover categories recorded in a municipality, is positively correlated to the number of visitors. This suggests that tourists are attracted by landscape diversity and that landscape richness can be easily perceived by them. On the contrary, patch density does not seem to influence the visitors' perceptions, since it scales the number of different land cover categories to the spatial dimension of the municipality and this difference does not appear to be significant in determining tourist destination choices.

As far as the specific landscape types are concerned, vineyards are the only significant variable among the considered ones. A larger surface covered by vineyards increases the number of tourist arrivals. Consistently with this result, the number of DOCG wines produced in the municipality exerts a positive influence on tourist arrivals. This signals an interest both in vineyard landscape and in top quality wine as a product. In addition, this reveals a potentially crucial role played by marketing and advertisement, since DOCG wines appear to be, not only the highest quality Italian wines, but also those which have achieved particular popularity and international reputation.

When considering the types of tourism attractions, it has been chosen to include art, seaside, mountain, countryside and other destinations, the latter including thermal baths, religious and lake destinations. It is interesting to notice that art and seaside destinations seem to attract more tourists than countryside destinations, although this outcome is partly compensated by the findings that vineyards, a specific countryside landscape category, are found to exert a positive influence on tourist flows. Table 4—5 displays these results.

Insert Table 4—5 about here

These results contain several insignificant variables and there is reason to suspect multicollinearity. A stepwise removal of the insignificant variables has been performed and the results are displayed in

Table 4—6. These results show that the removal of insignificant variables does not substantially alter the explanatory power of the model[20].

**Insert

Table 4—6 about here**

4.7.1 Disaggregating the results according to the tourists' origin: a model for international and domestic tourism

The outcome of the analysis presented above stimulates another relevant question concerning tourist destination choice; therefore, it seems interesting to provide a deeper analysis of this behaviour taking into account the origin of the tourists. In order to address this question it has been decide to run two additional versions of previously specified model, where the dependent variable has been changed to the number of international and domestic tourism respectively.

Consistently with the previous results, the municipality spatial dimension and the accommodation availability turn out to be positively correlated to both international and domestic tourist arrivals. Once more elevation with respect to the sea is also negatively correlated in both cases. The share of protected area in the municipality and the number of Natura 2000 sites present in a 25 km range around the municipality records a positive and significant impact on international and domestic flows, while the number of sites in a 50 km range is positively correlated only to the number of international tourists.

When it comes to landscape metrics, it can be noted that landscape richness is significant and exerts a positive influence on the number of incoming visitors, both in the international and in the domestic case. However, if specific landscape types are considered, olive groves seem to have a negative influence on both segments but are significant only in the domestic case. On the other hand, vineyards appear to have a positive and significant impact on international flows, while the result is not significant for the domestic ones. As highlighted in the previous model, the number of DOCG wines produced in the municipality seems to attract international tourists more than domestic ones. This result is consistent with the

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[20] In order to test for significant differences between the parameters of international and domestic arrivals, the dependent variable, i.e. the number of total tourists, has been regressed against the difference between international and domestic arrivals. The p-value of this difference turned out to be 0.004, therefore the parameters are statistically different, with a confidence level of 90%.

findings of the previous model and conveys the idea that the popularity of Italian wines, and not only their quality, may be a substantial pull-factor especially for international tourists.

As far as the types of tourism attractions are concerned, art, seaside and other attractions appear to attract a higher number of tourists with respect to countryside destinations, in the international as well as in the domestic case. Mountain destinations seem to be positively correlated to the number of domestic tourists. Table 4—7 presents these results.

Insert Table 4—7 about here

Once more these results contain several insignificant variables and sample size and multicollinearity appear to be issues. A stepwise removal of the insignificant variables has therefore been performed and the results are displayed in Table 4—8 for international tourists and in Table 4—9 for domestic tourists. These results show that accommodation availability and the share of budget accommodation are significant in both models and, as highlighted in the previous paragraph, the removal of insignificant variables does not alter substantially the explanatory power of both models.

Insert Table 4—8 andTable 4—9 about here

4.8 Discussion and further research needs

The principal aim of the present paper was to assess the suitability of different landscape diversity metrics in describing the tourist destination choice. In addition, it seemed interesting to ascertain the potential differences in the impact of those metrics on the behaviour of international and domestic tourists. On the basis of the results described in the previous section, it seems possible to draw some conclusions on the use of landscape metrics as explanatory variables in a model explaining the tourists' destination choice. To begin with, it seems useful to notice that the correlation coefficients among the selected indicators are relatively low; therefore the choice of including all of them in the regression models appears to be justified. Table 4—10 shows that the strongest positive correlations exist between the presence of vineyards and olive groves and between landscape richness and olive groves.

** Insert Table 4—10 about here**

Landscape richness proved to be positively correlated to the number of tourism arrivals in the model concerning total tourists as well as in the models for international and domestic tourists respectively. This outcome suggests that, on the one hand, the indicator succeeds in describing landscape diversity at a level that is easily perceived by tourists, and, on the other hand, that tourists are attracted by the visual component of landscape diversity, regardless their origin.

The performance of the patch density indicator is more ambiguous, since it is not significant in any of the three models and the sign of the coefficient is negative for the total and domestic tourist models, while it is positive for the international one. This can be interpreted as a signal that patch density, although being a scientifically sound and acknowledged indicator, may not be useful in the interpretation of tourist behaviour, since it scales landscape richness to the area of the municipality under consideration. The choice of destination highly depends on the tourist perceptions and landscape richness can be easier to capture for the tourist than the number of landscape categories per unit of area.

When it comes to the three landscape categories for which relative abundance has been considered, vineyards turn out to be the only category with an unambiguous positive impact, both in the total tourist model and in the one for international tourists. This is consistent with the results of reviewed studies that highlighted the value of vineyards and wine production areas as a tourism attraction factor. This finding is also supported by the positive influence exerted by the number of DOCG wines.

Another interesting outcome of this analysis is that some differences can be highlighted between the determinants of international and domestic tourism demand. The two segments present some clear similarities, since they are both positively influenced by the spatial extension of the municipality, by accommodation availability, by landscape richness and by seaside and art destinations.

However some discrepancies can be identified, since the international visitors appear to be positively influenced by the presence of vineyard landscape and high-quality and internationally renowned wines. In addition, they seem to be attracted by the number of protected areas in a 25 and 50 km range around the municipality. Domestic tourists do not seem to be influenced by vineyard landscapes and wine production, but appear to be more interested in the share of the municipality mapped as Natura 2000 protected area and in the number of protected sites found in a more restricted area around the territory of the municipality. This consideration seems to indicate that domestic tourists are less influenced by those factors directly linked to the popularity and reputation of the destination.

In order to analyse this issue in more detail, it could be interesting to repeat the analysis, including other typical products as well as variables qualifying the tourists' behaviour during their stay at the destination. Finally, another potential expansion of the scope of this study would be the inclusion of the impact of different climate change scenarios on the different landscape metrics and on the current landscape composition.

Tables

Table 4—1 CORINE Land Cover classification and classes considered in the development of landscape metrics

Code	Description	Landscape richness and Patch Density	Relative abundance
1.1.1	Continuous urban fabric	X	
1.1.2	Discontinuous urban fabric	X	
1.2.1	Industrial or commercial units	X	
1.2.2	Road and rail networks	X	
1.2.3	Port area	X	
1.2.4	Airport	X	
1.3.1	Mineral extraction sites	X	
1.3.2	Dump sites		
1.3.3	Construction sites	X	
1.4.1	Green urban areas	X	
1.4.2	Sports and leisure facilities	X	
2.1.1	Non-irrigated arable land	X	X
2.1.2	Permanently irrigated land		
2.1.3	Rice fields	X	
2.2.1	Vineyards	X	X
2.2.2	Fruits and berries plantations	X	
2.2.3	Olive trees	X	X
2.3.1	Pastures	X	
2.4.1	Annual crops associated with permanent crops	X	
2.4.2	Complex cultivation patterns	X	
2.4.3	Principally agriculture with natural vegetation	X	
2.4.4	Agro-forestry areas		
3.1.1	Broad-leaved forest	X	
3.1.2	Coniferous forest	X	
3.1.3	Mixed forest	X	
3.2.1	Natural grasslands	X	
3.2.2	Moors and heathland	X	
3.2.3	Sclerophyllous vegetation	X	
3.2.4	Transitional woodland shrubs	X	
3.3.1	Beaches, dunes and sand plains	X	
3.3.2	Bare rock	X	
3.3.3	Sparsely vegetated areas	X	
3.3.4	Burnt areas	X	
3.3.5	Glaciers and perpetual snow		
4.1.1	Inland marshes	X	
4.1.2	Peat bogs		
4.2.1	Salt marshes	X	
4.2.2	Salines		
4.2.3	Intertidal flats		
5.1.1	Water courses	X	
5.1.2	Water bodies	X	
5.2.1	Coastal lagoons	X	
5.2.2	Estuaries		
5.2.3	Seas and oceans		

Source: CORINE Land Cover Database

Table 4—2 Description of the data sources

Variable	Unit	Year	Source
International arrivals	000	2007	Regione Toscana
Domestic arrivals	000	2007	Regione Toscana
Area of the municipality	ha	2007	Regione Toscana
Population	000	2001	Regione Toscana
Accommodation availability	number	2007	Regione Toscana
Share of budget accommodation	%	2007	Regione Toscana
Natura 2000 (share of municipality area)	%	2007	Natura 2000 database; ARCGIS
Elevation above sea level	m	2007	Regione Toscana
No. DOC	number	2007	FISAR
No. DOCG	number	2007	FISAR
Landscape richness	0-100 scale	2007	CORINE Land Cover Database
Vineyards	0-100 scale	2007	CORINE Land Cover Database
Olives	0-100 scale	2007	CORINE Land Cover Database
Arable land	0-100 scale	2007	CORINE Land Cover Database
Temperature	°C	2007	University of Florence
Precipitation	mm	2007	University of Florence
N2000 sites within 25 km	number	2007	CORINE Land Cover Database; ARCGIS
N2000 sites within 50 km	number	2007	CORINE Land Cover Database; ARCGIS
Art (main tourism attraction)	dummy	2007	Regione Toscana
Seaside (main tourism attraction)	dummy	2007	Regione Toscana
Mountain (main tourism attraction)	dummy	2007	Regione Toscana
Other (main tourism attraction)	dummy	2007	Regione Toscana

Table 4—3 Scores in the landscape metrics for Tuscan provinces

Province	Patch density	Landscape richness	Non-irrigated arable land	Vineyards	Olive groves
Arezzo	0.0015	0.24	0.23	0.01	0.04
Firenze	0.0015	0.26	0.22	0.01	0.04
Grosseto	0.0007	0.24	0.13	0.01	0.03
Livorno	0.0023	0.27	0.25	0.01	0.04
Lucca	0.0021	0.24	0.36	0.02	0.07
Massa Carrara	0.0017	0.24	0.19	0.02	0.04
Pisa	0.0018	0.24	0.22	0.01	0.04
Pistoia	0.0027	0.22	0.41	0.02	0.07
Prato	0.0014	0.25	0.34	0.00	0.06
Siena	0.0010	0.23	0.20	0.01	0.03

Source: CORINE Land Cover Database, own elaboration

Table 4—4 Descriptive statistics of 2007 tourist arrivals in Tuscany by origin and tourism resource

	Art		Mountain		Countryside		Seaside		Other		Tourist arrivals	
Province	**International**	**Domestic**	**International**	**Domestic**	**International**	**Domestic**	**International**	**Domestic**	**International**	**Domestic**	**International**	**Domestic**
Arezzo	101,711	200,215	8,972	31,709	17,367	21,799	0	0	16,833	13,194	144,883	266,917
Firenze	2,173,899	907,746	38,370	32,057	97,112	83,679	0	0	508,059	270,861	2,817,440	1,294,343
Grosseto	21,275	39,401	18,146	43,318	2,140	4,747	172,264	682,760	10,737	75,107	224,562	845,333
Livorno	0	0	0	0	5,759	10,470	336,057	836,087	8,540	12,516	350,356	859,073
Lucca	151,601	142,508	13,364	36,353	0	0	204,813	337,780	2,881	5,058	372,659	521,699
Massa Carrara	8,529	21,596	108	690	2,506	7,017	50,930	149,942	2,297	7,462	64,370	186,707
Pisa	404,581	337,232	0	0	61,914	49,573	0	0	42,900	46,407	509,395	433,212
Pistoia	40,439	55,975	5,987	43,451	33,485	56,094	0	0	485,238	212,972	565,149	368,492
Prato	132,703	77,027	524	3,387	7,102	7,570	0	0	271	535	140,600	88,519
Siena	404,663	335,393	2,069	17,335	168,665	110,748	0	0	142,701	245,022	718,098	708,498
Total	**3,439,401**	**2,117,093**	**87,540**	**208,300**	**396,050**	**351,697**	**764,064**	**2,006,569**	**1,220,457**	**889,134**	**5,907,512**	**5,572,793**

Source: Regione Toscana, 2008

Table 4—5 Estimation results for total tourist arrivals

Total arrivals	Coefficient	P>|t|
International arrivals	-0.0000108	0.000***
Domestic arrivals	0.0000347	0.000***
Area	0.0000285	0.308
Population	1.21E-07	0.979
Accommodation availability	-0.00003	0.576
Budget accommodation (%)	0.2913449	0.364
Natura 2000 (%)	0.8411141	0.052*
Elevation	-0.000812	0.060*
No. DOCG	0.4469044	0.056*
No. DOC	0.0433712	0.728
Landscape richness	4.684212	0.003**
Patch density	-0.2066283	0.322
Vineyards	8.865242	0.430
Olive groves	10.19913	0.105
Arable land	-11.36906	0.341
Temperature	-0.0006245	0.737
Precipitation	-0.0002363	0.513
N2000 within 25 km	0.0527898	0.004**
N2000 within 50 km	0.0226036	0.033*
Art	0.6595062	0.001**
Seaside	0.8660954	0.018*
Other	0.7189911	0.000***
Mountain	0.2071622	0.399
constant	4.690348	0.002**
R2		**0.69**

Statistical significance of 0.1%. 5% and 10% is indicated by ***. **. * respectively

Table 4—6 Stepwise removal of insignificant variables for total tourist arrivals

Total tourists	Coefficient	P>|t|
International arrivals	-7.45e-06	0.000***
Domestic arrivals	0.0000253	0.000***
Natura 2000 (%)	0.9946106	0.018*
Elevation	-0.0005932	0.048*
No. DOCG	0.5138158	0.001**
Landscape richness	3.953111	0.003**
N2000 within 25 km	0.047703	0.002**
N2000 within 50 km	0.0257187	0.004**
Art	0.8008124	0.000***
Seaside	0.823439	0.005**
Other	0.7096752	0.000***
constant	6.268388	0.000***
R2		**0.61**

Statistical significance of 0.1%. 5% and 10% is indicated by ***. **. * respectively

Table 4—7 Estimation results for international and domestic tourist arrivals

	International arrivals (log)		Domestic arrivals (log)	
	Coefficient	**P>|t**	**Coefficient**	**P>|t**
Area	0.0000609	0.084*	0.0000512	0.087*
Population	3.62E-06	0.403	2.11E-06	0.566
Accommodation availability	0.0001577	0.000***	0.0001297	0.000***
Budget accommodation (%)	-0.1911164	0.627	-0.1847275	0.580
Natura 2000 (%)	0.8380846	0.131	1.057952	0.025*
Elevation	-0.0011598	0.035*	-0.0008967	0.055*
No. DOCG	0.599629	0.045*	0.1285795	0.612
No. DOC	-0.041819	0.792	0.0215898	0.873
Landscape richness	4.652505	0.019*	4.988705	0.003*
Patch density	0.020274	0.938	-0.1780922	0.420
Vineyards	15.63429	0.053*	8.728372	0.202
Olive groves	-10.41637	0.495	-22.67116	0.081*
Arable land	5.260943	0.713	16.5401	0.173
Temperature	0.001044	0.662	-0.0015204	0.454
Precipitation	-0.0001918	0.676	-0.0003675	0.346
N2000 within 25 km	0.04647	0.045*	0.0653792	0.001**
N2000 within 50 km	0.0315707	0.019*	-0.0034708	0.760
Art	0.522895	0.036*	1.095901	0.000***
Seaside	0.7626002	0.066*	1.722162	0.000***
Other	0.7396348	0.003**	0.7512623	0.000***
Mountain	-0.3401643	0.279	0.6765477	0.012*
constant	5.104989	0.006**	4.715393	0.003**
R2		**0.61**		**0.62**

Statistical significance of 0.1%. 5% and 10% is indicated by ***. **. * respectively

Table 4—8 Stepwise removal of insignificant variables for international tourist arrivals

International tourists	**Coefficient**	**P>|t|**
Accommodation availability	0.0001775	0.000***
Elevation	-0.0014126	0.000***
No. DOCG	0.567085	0.004**
Landscape richness	5.639014	0.001**
N2000 within 25 km	0.0462402	0.014*
N2000 within 50 km	0.0344174	0.002**
Art	0.698643	0.001**
Other	0.698643	0.001**
constant	5.151075	0.000***
R2		**0.55**

Statistical significance of 0.1%. 5% and 10% is indicated by ***. **. * respectively

Table 4—9 Stepwise removal of insignificant variables for domestic tourist arrivals

Domestic tourists	**Coefficient**	**P>|t|**
Area	0.000043	0.000***
Accommodation availability	0.0001375	0.000***
Natura 2000 (%)	1.143903	0.010*
Elevation	-.0005457	0.070*
Landscape richness	4.18549	0.003**
N2000 within 25 km	0.042743	0.024*
Art	1.020351	0.000***
Seaside	1.260545	0.000***
Other	0.6244953	0.001**
constant	5.914244	0.000***
R2		**0.59**

Statistical significance of 0.1%. 5% and 10% is indicated by ***. **. * respectively

Table 4—10 Correlation coefficients among the selected landscape metrics

	Landscape richness	**Patch density**	**Arable land**	**Vineyards**	**Olive groves**
Landscape richness	1				
Patch density	0.1076	1			
Arable land	0.1095	-0.0518	1		
Vineyards	0.003	0.0748	0.0845	1	
Olive groves	0.1933	-0.0288	0.1558	0.2487	1

References

Bigano A., Hamilton J.M., Tol R.S.J. (2007), The impact of Climate Change on international and domestic tourism: A simulation study, *The Integrated Assessment Journal*, Vol. 7, Issue 1 (2007), Pp. 25-49

Botequilha-Leitão A., Ahern J. (2002), Applying landscape ecological concepts and metrics in sustainable landscape planning, *Landscape and urban planning*, 59, (2002), pp. 65-93

Brunori G. and Rossi A. (2000), Sinergy and coherence through collective action: Some insights from wine routes in Tuscany, *Sociologia Ruralis*, Vol. 40, No. 4, pp. 409 – 423

Correia L.M, Passos Ascençao M.L., Charters S., Wine routes in Portugal: A case study of the Bairrada Wine Route, *Journal of wine research*, Vol. 15, Nº 1, 2004, pp. 15-25

Cissel J.H., Swanson F. J., Weisberg P.J. (1999), Landscape management using historical fire regimes: Blue River, Oregon, *Ecological Applications*, 9(4), 1999, pp. 1217-1231

Coppedge B.R., Engle D.M., Fuhlendorf S.D., Masters R.E., Gregory M.S. (2002), Landscape cover type and pattern dynamics in fragmented southern Great Plains grasslands, USA, *Landscape Ecology*, 16: 677–690, 2001

Dritsakis N. (2004), Co-integration analysis of German and British tourism demand for Greece, *Tourism Management*, 25 (2004), Pp. 111 – 119

Flather C.H., Sauer J.R. (1996), Using landscape ecology to test hypotheses about large scale abundance patterns in migratory birds, *Ecology*, Vol. 77, Issue 1, pp.28-35

Fleischer A., Tsur Y., Measuring the Recreational Value of Agricultural Landscape, *European Review of Agricultural Economics*, Vol. 27, No. 3, September 2000. Available at SSRN: http://ssrn.com/abstract=244353

FISAR (2007), Elenco dei Vini DOC e DOCG d'Italia, Centro Tecnico Nazionale F.I.S.A.R, available on the website http://www.fisar.com/index.asp?notizia=1448&codice=66

Green G. P. (2001), Amenities and community economic development; strategies for sustainability, *Journal of Regional Analysis and Policy*, 31: 2, pp. 61 – 75

Hamilton J. M. (2004), *Climate and the destination choice of German tourists*, Nota di Lavoro 21.2004, Fondazione Eni Enrico Mattei, available on the website: http://www.feem.it/Feem/Pub/Publications/WPapers/default.htm

Hamilton, J. M., Maddison, D. J. & Tol, R. S. J. (2005a), Climate change and international tourism: A simulation study, *Global Environmental Change*,15(3), Pp. 253–366.

Hamilton, J. M., Maddison, D. J. & Tol, R. S. J. (2005b), The effects of climate change on international tourism, *Climate Research*, 29, pp. 255–268.

Hamilton J. (2006), Coastal landscape and hedonic price accommodation, *Ecological Economics*, Volume 62, Issues 3-4, 15 May 2007, Pages 594-602

Hargis C.D., Bissonette J.A., David J.L. (1998), The behavior of landscape metrics commonly used in the study of habitat fragmentation, *Landscape Ecology*, 13: 167–186, 1998

Hellerstein D., Nickerson C., Cooper J., Feather P., Gadsby D., Mullarkey D., Abebayehu T., Barnard C. (XXXX), *Farmland Protection: The Role of Public Preferences for Rural Amenities*, Agricultural Economic Report No. 815., http://purl.umn.edu/33963

Herold M., Scepan J., Clarke K.C. (2002), The use of remote sensing and landscape metrics to describe structures and changes in urban land uses, *Environment and Planning*, Volume 34, pp. 1443-1458

Lausch A., Herzog F. (2002), Applicability of landscape metrics for the monitoring of landscape change: issues of scale resolution and interpretability, *Ecological Indicators*, 2 (2002) 3–15

Li G., Song H., Witt, S. F. (2004), Modeling Tourism Demand: A Dynamic Linear AIDS Approach, *Journal of Travel Research*, 43, 141-150

Lise W, Tol R.S.J. (2002), Impact of climate on tourism demand, *Climatic Change* 55(4):429–49

Loumou A, Giourga C, Dimitrakopoulos P, Koukoulas S. (2000), Tourism Contribution to Agro-Ecosystems Conservation: The Case of Lesbos Island, Greece, *Environmental Management*, 26(4):363-370

Job H. and Murphy A. (2006), Germany's Mosel Valley: Can Tourism Help Preserve Its Cultural Heritage?, *Tourism Review International*, Volume 9, Number 4, 2006 , pp. 333-347(15)

Madureira L. (2006) *Multi-attribute valuation of Douro Valley winescape based upon qualitative data for individual's attitudes regarding nature-related and rural heritage attributes*, Universidade de Trás-os-Montes e Alto Douro, http://aerna2006.de.iscte.pt/papers/S5B_Madureira.pdf

Manente M., Minghetti V., Costa P. (1996), Tourism demand segmentation and consumption behaviour: An economic analysis, *Tourism Review*, Vol. 51, no. 3, pp. 53-62.

McGarigal, K. & Marks, B., Fragstats (1994), *Spatial Pattern Analysis Program for Quantifying Landscape Structure*, Forest Science Department, Oregon State University, Corvallis

Medina L.K. (2003), Commoditizing culture: Tourism and Maya identity, *Annals of Tourism Research*, Volume 30, Issue 2, April 2003, Pages 353-368

Naidoo R., Adamovicz W. L. (2005), Biodiversity and nature-based tourism at forest reserves in Uganda, *Environment and Development Economics*, 10 (2005), pp.159 – 178

Poria Y., Butler R.W., Airey D. W. (2003), The core of heritage tourism, School of Mangement *Tourism Research*, University of Surrey

Riitters K.H., O'Neil1 R.V., Hunsaker C.T., Wickham J.D., Yankee D.H., Timmins S.P.,Jones K.B., Jackson B.L. (1995), A factor analysis of landscape pattern and structure metrics, *Landscape Ecology*, Vol. 10 no. 1 pp 23-39 (1995)

Rosselló-Nadal J. (2001), Forecasting turning points in international visitor arrivals in the Balearic Islands, *Tourism Economics*, Volume 7, Number 4, pp 365-380

Smith W and Grassle F. J. (1977), Sampling Properties of a Family of Diversity Measures, *Biometrics*, Vol. 33, No. 2 (Jun., 1977), pp. 283-292

Telfer D.J. (2001), Strategic alliances along the Niagara Wine Route, *Tourism Management*, Volume 22, Issue 1, February 2001, Pages 21-30

Turner L.W. and Witt S.F. (2001), Factors influencing demand for international tourism, *Tourism Economics*, Volume 7, Number 1, pp. 21-38

Witt, S. F., and Witt, C. A. (1995), Forecasting tourism demand: A review of empirical research, *International Journal of Forecasting*, 11, 447-475.

Witt, S. F., Song, H., and Wanhill, S. P. (2004), 'Forecasting tourism-generated employment: The case of Denmark', *Tourism Economics*, 10, 167-176.

World Tourism Organization (2008), UNWTO World Tourism Barometer, Volume 6, No. 1, January 1st 2008

Wu J., Shen W., Sun W., Tueller P.T. (2002), Empirical patterns of the effects of changing scale on landscape metrics, *Landscape Ecology*, 17, pp. 761–782

Wunder S. (2000), Ecotourism and economic incentives – an empirical approach, *Ecological Economics*, 32 (2000), pp. 465 – 479

5. Agricultural pressures on biodiversity conservation: An analysis of the effectiveness of Natura 2000 network in Italy

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Abstract

Agricultural activities are widely recognized as one of the most important pressures affecting biodiversity (OECD, 2001). However, the impact of agricultural activities may not be limited to the area in which those activities are performed. The purpose of this paper is to analyse the impacts of agricultural activities on a set of European areas brought together under the Natura 2000 framework. Natura 2000 is an ecological network of protected sites across the European Union member states. Natura 2000 sites mostly cover semi-natural areas, therefore human activities, including agriculture, are allowed inside or around them. Against this background, it has been chosen to perform a critical analysis of the compatibility between agricultural activities and biodiversity conservation, choosing Italy as a case study. A set of composite indicators, accounting for species and habitat diversity and agricultural pressure, has been created. Subsequently, an econometric model has been developed so as to describe species diversity as a function of site geographic location, physical characteristics, level of institutional protection and agricultural pressure. Results confirm that agricultural pressures inside and outside the site are negatively correlated to species diversity. Some activities, such as cultivation, grazing, use of pesticides and burning practices have a particularly strong negative impact on species diversity.

Keywords: Agricultural activities, Pressure indicators, Biodiversity indicators, Protected areas, Natura 2000

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[21] This study has been realized in collaboration with Dr. Mattia Cai, University of Padova and Fondazione ENI Enrico Mattei (FEEM), Dr. Chiara Travisi and Matteo Baglioni, Fondazione ENI Enrico Mattei (FEEM)

5.1 Introduction

Agricultural activities are mainly practiced on lands that were previously covered by forests or other natural habitats. This, in turn, involves the introduction of species of interest primarily to humans, which necessarily entail modifications and conversion of natural habitats and their communities. These impacts are also mapped at all levels of life diversity, from genes to species and ecosystems, and can affect the diversity of wild as well as domesticated species (Harvey et al., 2004).

The combination of this complex of factors undermines the capacity of agricultural areas to serve as habitat for wild species and their ability to effectively regulate populations of pests which affect crop productivity (Soil Association, 2000; Defra, 2003). As a result, a widespread decline in farm species abundance and diversity, across many taxonomic groups, has been observed both in Europe and worldwide (Stolton et al., 1999; Gliessman, 1999; Kegley, 1999; Edge 2000; Soil Association 2000; Bugg and Trenham, 2003, Benton et al., 2003). The observed loss of biodiversity has also resulted in a reduced capacity of agro-ecosystems to perform many essential functions such as purification of water, internal regulation of pests and diseases, carbon sequestration, and degradation of toxic compounds (Altieri, 1999).

However, agricultural activities exert an impact on biodiversity not only in the areas where they are performed but also in surrounding areas. An interesting issue arises with respect to the impact of those activities on sites devoted to biodiversity protection. Protected areas are defined as areas of land or sea dedicated to the protection and maintenance of biological diversity and natural cultural resources, managed through legal or other means [22](IUCN, 1994). The purposes of protected area management range from scientific research, to preservation of species, genetic diversity and maintenance of environmental services, to tourism, recreation, education and sustainable use of natural ecosystems resources. Due to the different priorities accorded to these management objectives, the level of institutional protection can vary across countries and regions, from strict protection to sustainable resource management.

The purpose of this paper is to develop a methodology to evaluate the magnitude of the impacts of agricultural activities on the status of biodiversity inside protected areas, exploiting the information contained in the Natura 2000 database. Natura 2000 is a network of protected areas across EU Member states, aiming at the conservation of biodiversity resources in Europe. Most of the habitats covered by this network are situated in agricultural

[22] The definition of protected areas adopted in this study is derived from the IV World Congress on National Parks and Protected Areas. (IUCN, 1994)

or wooded areas. These are semi-natural areas, created and maintained by human activity, and, in many cases, their natural characteristics would disappear if agricultural work or animal rearing were to cease. Therefore, the idea underpinning the Natura 2000 network is the management of protected sites through sustainable productive activities, rather than the exclusion of human activities (European Commission, 1999). The complete network of Natura 2000 sites constitutes a highly connected system from a functional point of view. As a matter of fact, the network does not only include important natural sites across European countries, but also contiguous land stripes in order to connect natural areas with similar ecological functions.

The remainder of this paper is structured as follows. Section 5.2 and 5.3 provide a review of relevant literature dealing with the impacts of different agricultural activities on biodiversity and a review of the most widely used agricultural pressure indicators. Section 5.4 describes the structure of the Natura 2000 network and database and Section 5.5 defines a protocol for constructing biodiversity and agricultural pressure indicators using the information extracted from the database. Section 5.6 describes the general features as well as the biodiversity and agricultural pressure profiles of the Italian Natura 2000 sites, identified as a case study. Section 5.7 specifies an econometric model to analyse the status of species diversity as a function of the geographical and physical characteristics, habitat diversity, level of institutional protection and pressure from agricultural activities. Section 5.8 discusses the results and Section 9 draws conclusions and policy considerations.

5.2 Literature review on the impacts of agricultural activities on biodiversity

A vast array of previous studies has addressed the issue of the impacts of agricultural activities on biodiversity. The literature review highlighted that some specific activities are generally associated to particularly negative effects on different components of biodiversity. Such impacts are amplified by an increasing human population and a limited arable land surface, which have resulted into an increased demand for agricultural productivity leading to more intensive agricultural practices on a global basis. In response, higher yielding crop varieties have been coupled with increased inputs in the form of fertilizers, irrigation, and pesticides and more intensive practices such as greater tillage of soil and fewer crop rotations and fallows. In addition, the simplification of agro-ecosystems and the removal of non-crop vegetation, like hedgerows, shelter belts and field margins, from farming areas, have contributed to the homogeneity of agricultural landscapes by reducing botanical and structural variation.

Irrigation practices, though essential to support agricultural production, can cause significant damage especially to wetlands and wildlife. Intensive cultivation practices place high demands on water supplies. Wetlands can be lost due to draining and direct conversion to agricultural land or because of water removal from rivers and streams for use in irrigation (Lemly, 2000).

The use of pesticides, in particular herbicides, fungicides, rodenticides and insecticides, poses both known and unknown risks to biodiversity, impacting wildlife on many different levels. Each of these impacts has the potential to interfere with the reproductive success of wildlife and further reduce the habitat quality and biodiversity of agricultural and surrounding ecosystems (Edge, 2000). It is estimated that a relatively limited percentage of the applied pesticides reach their target, while the remaining amount is released into surrounding ecosystems and enters the food chain, affecting animal populations at every trophic level (Gliessman, 1999). Birds exposed to sub-lethal doses of pesticides are often afflicted with chronic symptoms that affect their behaviour and reproductive success (Kegley, 1999). Pesticides are also known to negatively affect insect pest-predator population dynamics in agro-ecosystems (Landis, 2002) and to disproportionately effect insect predator populations, resulting in pest population resurgences and the development of genetic resistance of pests to pesticides (Flint, 1998). Finally, wetlands can be functionally lost due to contamination of the water supplies from agricultural pesticides in surface runoff from irrigated fields (Lemly, 2000)

Grazing practices are also deemed to have negative impacts on biodiversity and their severity and persistence may vary seasonally and as a function of livestock type, stocking density, timing, and duration. The environmental effects of changes in livestock farming are linked to the polarization of farming between intensification in favourable regions and abandonment of extensive systems in marginal areas. Traditional livestock grazing systems tend to be associated with higher biodiversity richness and high-value farmland. Therefore both intensification of livestock production and abandonment of pastoral systems can lead to biodiversity loss (EEA, 2007).

Finally, fire and burning practices exert their most obvious impact during a brief span of time, followed by a recovery period. However, in woody vegetation spots, species lacking persistence or post-fire recruitment may be extirpated from the site (Keeley et al., 2003).

5.3 Review of biodiversity and agricultural pressure indicators

The need for biodiversity indicators is widely recognised and international and European political institutions have provided their own definitions. Besides some differences in the formulation, there is substantial agreement on the relevant aspects to be taken into account in the description of biodiversity. The indicators proposed in this paper have been developed following the path traced by the United Nations and the European Union.

The United Nations Convention on Biological Diversity (CBD) acknowledges the role of indicators as information tools that summarise data on complex environmental issues and indicate the overall status and trends of biodiversity. The convention highlights seven focal areas in which the development of indicators seems to be necessary, including the status and trends of the components of biological diversity[23].

The European Biodiversity Strategy (European Commission, 1998) was developed in the context of the CBD, and it calls for the development of a set of indicators corresponding to the same focal areas. A report by the European Environmental Agency (EEA, 2007) provides a more detailed description of these indicators. Within the scope of this study it has been chosen to focus on indicators related to status and trends of the components of biological diversity as well as those referring to the threats to biodiversity. The indicators proposed in this paper have been developed bearing in mind the classification provided by the EEA.

The first group of indicators refers to trends in the abundance and distribution of selected species. For the purpose of this paper, two indicators are proposed within this category, species richness and species abundance. Species richness is the most intuitive indicator and the easiest to compute. It can be defined as the number of different species recorded in a particular site and it can be expressed either per unit area or per habitat type. The main shortcoming of this indicator lies in the fact that it does not take into account that processes of abundance reduction can take place long before a change in the number of species is observed (Ten Brink, 2000).

Species abundance can be defined as the number of individuals of a population living in a particular area. Populations and species constitute one of the most essential components of biodiversity and viable populations indicate the presence of healthy habitats and ecosystems. This indicator can be easily aggregated and it is cost-effective, since most of the data are

[23] The focal areas identified by the Convention are the status and trends of the components of biological diversity, threats to biodiversity, ecosystem integrity and ecosystem goods and services, sustainable use, status of access and benefit sharing, status of resource transfers and use and public opinion.

collected by professionals making it possible to enlarge data availability with little extra cost (EEA, 2007; EASAC, 2005).

The second category of indicators foreseen by the EEA refers to trends in the extent of selected biomes, ecosystems and habitats. As explained for species, two indicators have been considered, habitat richness and habitat abundance. Habitat richness provides information about the number of habitats present in a specific area. This indicator, like species richness, does not reflect the conservation status of the considered habitats.

Habitat abundance, instead, reflects the ability of an ecosystem to provide goods and services, since this ability highly depends on the extension covered by the habitat, since a highly fragmented habitat tends to be less resilient and have reduced ability of recovering after a shock. Data is widely available since land cover change is the main driver of this indicator and this information is well mapped across a large number of countries. This indicator is cost effective and easily aggregated from smaller to larger spatial scales. Nonetheless, it does not deliver information on the conditions of the remaining ecosystems, since habitat loss could be halted, but other drivers, such as direct exploitation, invasive species and pollution could still cause a decline of species and populations (EASAC, 2005)

The third category of indicators concerns genetic diversity, defined as the variety of alleles and genotypes present in a population that is reflected in morphological, physiological and behavioural differences between individuals and populations (Frankham *et al*., 2002). In this paper we explore the possibility of using the degree of isolation of a population with respect to the geographical range of its species, as a genetic diversity indicator. In other words it has been assumed that a population living at the margins of its species geographical range has higher probabilities of being more genetically diverse, since the distance hinders the breeding possibilities with other populations of the same species.

When considering threats to biodiversity, the EEA report defines three indicators, namely nitrogen deposition, trends in invasive alien species and the impacts of climate change on biodiversity. However, these indicators appeared still broad and, with the exception of the first one, not relating specifically to agriculture. As a consequence, it has been chosen to follow a review of indicators describing the level of agricultural pressure on the environment and on biodiversity, produced by OECD in 2001.

A first distinction needs to be made between indicators dealing with farm management capacity and those dealing with farm management practices. The former concerns the investment in the capacity of the agricultural sector to build and transfer knowledge to improve on-farm management practices leading to a more environmentally sustainable agriculture. The latter encompasses overall trends of farming methods, the development of appropriate institutions and standards, as well as various aspects of farm management which have significant effects on the environment (OECD, 2001). These include nutrient management, pest management, soil and land management, and irrigation and water management. Since this paper is dealing with the impact of agricultural activities on biodiversity conservation, an overview of the second category of indicators will be provided, focusing in particular on the adopted farming practices producing the more relevant pressure on biodiversity, namely the use of nutrients, pesticides and water.

Nutrient balance is defined as the physical difference between nutrient, generally nitrogen and ammonia, inputs into, and outputs from, an agricultural system, per hectare of agricultural land (OECD, 2001). This indicator establishes a link between agricultural nutrient use and changes in environmental quality. A nutrient balance surplus or deficit, at least over the short term, does not unambiguously indicate a beneficial or harmful environmental or resource impact, it only shows the potential for environmental damage or unsustainable use of soil resources, not actual pollution or resource depletion. Nutrient balances do, however, provide a practical, and relatively low cost, estimate of potential environmental and resource sustainability effects (OECD, 2001; EEA, 2007). This indicator has been used to study the critical load producing changes in vegetation (Nordin et al., 2005) and to analyse the relationship between plant diversity and soil composition (Aerts et al., 2003).

Pesticide use gives a measure of trends over time, based on pesticide sales or use data. The definition and coverage of pesticide use data vary across countries, which limits the use of the indicator as a comparative index. A large number of countries report data on pesticide sales, which can be used as a proxy for their use. The main shortcoming of this indicator is that for some countries, series are either incomplete, especially over recent years, or do not exist. Moreover, a change in pesticide use may not be equivalent to a change in the associated risks because of the great variance in risks posed by different products. Previous studies have assessed the impact of pesticides use on aquatic species diversity (Relyea, 2003) and on the diversity of plant, vertebrate and invertebrate groups (McLaughlin and Mineau, 1995).

Water use intensity is defined as the share of agricultural water use out of the total national water utilisation. The indicator reveals the overall importance of the agricultural sector in total water utilisation, and whether the changing use of water by agriculture relative to other uses, both economic and environmental, is potentially intensifying the pressure on available water resources. As a result of the lack of data on total agricultural water use for a number of countries, the irrigation water use total can be used as a proxy. The main shortcoming of this indicator is that annual fluctuations may reflect changes in irrigated area and the composition of agricultural production as well as changes in water used by other sectors in the economy and fluctuations in climatic conditions. It should be noted that the computation of both biodiversity and agricultural pressure indicators requires data that may be difficult to retrieve and to compare across countries. In this paper we maintain that, at the EU level, this information can be found in the Natura 2000 database. Although this database refers only to protected areas across EU Member States, it represents a useful source, since it contains indications of both biodiversity components and human activities performed inside or around protected areas.

5.4 The Natura 2000 network and the structure of the database

Natura 2000 is an ecological network of protected sites aiming at guaranteeing the long-term survival of European biodiversity. This network was established according to the Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora, known as the Habitat Directive, and of the Council Directive 79/409/EEC on the conservation of wild birds, known as the Birds Directive[24]. The provisions of these directives identified a list of species and habitats to be protected throughout the European Union. In view of implementing these requirements, the European Commission has established a standard format for the collection of relevant information from member countries, in order to create an overall database, the Natura 2000 database.

The information is requested to each site managing authority and it includes the geographic location, the surface covered and the altitude of the site, as well as the biogeographic region to which the site belongs[25]. Furthermore, an evaluation of the conditions of protected habitats and species is required. In addition to that, a general description of the main features of the site needs to be provided, including geological, morphological and landscape characteristics as well as the dominant vegetation types. The protection status of the site under the national or regional legislation must be reported. Finally, information on the mapping of human activities inside and around the site, as well as their influence and intensity need to be

[24] The Natura 2000 network encompasses two types of protected sites, Special Protection Areas (SPA) and Special Areas of Conservation (SAC). The first category has been instituted by the Birds Directive, although it also includes protection areas for migratory species created by the Ramsar Convention on Wetlands. The second category covers sites created by the Habitat Directive in order to maintain species and natural habitats in a satisfactory conservation status. Natura 2000 sites are therefore characterized by the presence of habitat and animal and plant species of community interest.

[25] The considered biogeographic regions are the boreal, continental, atlantic, alpine, mediterranean and macaronesian regions.

provided. Since this information will be used to construct the indicators employed in this analysis a brief description of the structure of the database will be provided.

As far as the species ecological status is concerned, six taxa, namely amphibians and reptiles, birds, fishes, invertebrates, mammals and plants, are assessed separately, according to a set of criteria. The evaluation is based on a scale ranging from A to C. To begin with, an estimate of the size and density of each species' population living on the site is required. Ranking "A", indicates that the site population represents from 100% to 15% of the total number of specimen living on the national territory, "B", reflects a share ranging from 15% to 2% and "C", from 2% to 0%.

Secondly, the degree of geographical isolation of each population in each site with respect to the natural range of the species is required. This can be interpreted as a measure of the contribution of a given population to its species' genetic diversity, since a more isolated population is unlikely to breed with other populations of the same species, thus preserving peculiar genetic characteristics. Ranking "A" signals an almost complete isolation, "B" suggests that the population is not isolated but lives on the margins of the area of distribution, while "C" implies that the population lies in an extended distribution range.

As regards habitats, a measure of habitat relative surface, reflecting the area covered by each habitat at the site level in relation to the total area covered by the same habitat type at the national level is also required. The associated rankings can be A, indicating a share ranging from 100% to 15%, B, from 15% to 2% and C, from 2% to 0%. The Natura 2000 survey also reports information with respect to human activities performed inside or around protected sites. The types of activities considered in the database are classified in nine categories, namely agriculture and forestry, fishing, hunting and collecting, mining and extraction of materials, urbanisation and industrialisation, transportation and communication, leisure and tourism, pollution, human induced changes in wetlands and marine environment and natural biotic and abiotic processes. For the purpose of this paper only agricultural and forestry activities have been taken into consideration. Within this broad category the Natura 2000 database identifies 22 specific activities graphically displayed in Figure 5-1.

Insert Figure 5-1 about here

Site managers are required to state whether these activities are deemed to have high, medium or low intensity and whether their influence is positive, neutral or negative. Moreover they need to report the percentage of the site affected by each activity. Table 5—1 presents the codes employed by the Natura 2000 database to identify the different types of influence and degrees of intensity.

Insert Table 5—1 about here

5.5 Developing biodiversity and agricultural pressure indicators using the Natura 2000 database

The biodiversity and agricultural pressure indicators reviewed in Section 3 have been adapted to the needs of this study and to the information contained in the Natura 2000 database. All indicators have been calculated at the site level. Species diversity indicators were first calculated separately for each of the six taxa considered in the database and then averaged so as to obtain a single value for each site. Since for the purpose of this paper the indicators will be used to analyse the impact of agricultural activities on biodiversity in protected areas, the scale of analysis is the country level. The specific case study, Italy, will be presented in the following section.

The species richness indicator was computed as the ratio between the number of species present in each site and the total number of species living on the national territory. The underlying idea is the so-called "inter-species democracy", implying that all species are considered equally important. Species abundance was obtained using information on population size and density, which reflects what share of a species' national population is living in each particular site.

As far as habitat diversity is concerned, it has been chosen to take into account the ratio between the number of habitats found in a site and the number of habitats recorded at a national level, in order to create the habitat richness indicator. The habitat relative surface has been used to calculate the habitat abundance indicator.

As explained in section 4, the database originally presents ordinal scale assessments of species and habitat information, based on a scale ranging from A to C. As a consequence, it has been necessary to attach a numerical value to each of the rankings. In order to treat all this information in a homogeneous way and consistently with the definitions provided by the database itself, it has been decided to attach a value of 100 to ranking "A", of 15 to ranking "B" and of 2 to ranking "C"[26]. As a result, habitat and species indicators have been computed according to Equation (5.1)

$$Indicator = \frac{(No.\ "A" \times 100 + No.\ "B" \times 15 + No.\ "C" \times 2)}{No.\ habitats\ or\ species\ per\ site} \qquad (5.1)$$

[26] This is an arbitrary choice and alternatives are possible. For instance, it could have been decided to attach the mean value of each interval to those rankings. However, since these indicators are used to produce biodiversity profiles at the site level, with the objective of comparing different locations, the choice of the value exerts a limited influence on the results of the analysis.

The outcome of this process has been the creation of five indicators, namely species richness, abundance and isolation and habitat richness and abundance. The score of each indicator is normalized on a scale ranging from 0 to 1. In addition to these single indicators, it seemed useful to create a composite indicator, taking into account simultaneously richness and abundance, both for species and habitats. This choice is justified since, as pointed out while reviewing the indicator, species richness conveys important information but it does not appear to be a sufficient indicator of species diversity on its own. Therefore it seemed useful to couple this piece of information with the one relating to abundance, multiplying the respective scores for each species and each habitat, according to Equation (5.2).

$$Composite\ Indicator = Richness * Abundance \tag{5.2}$$

As far as pressures from agricultural activities are concerned, the data available from the Natura 2000 database are not sufficiently detailed so as to compute the different indicators reviewed in Section 3. In addition, the database already provides information on influence and intensity of agricultural activities implemented inside or around protected areas. It has therefore been chosen to compute two composite indicators, one for agricultural pressures within the site and one for pressures in the surrounding areas. The main difference between them is that the spatial dimension can be considered only for activities taking place inside the sites, while for the site surroundings, it is possible to retrieve the number of different activities performed together with the influence and intensity of their impacts. The agricultural pressure index inside the sites has been computed according to Equation (5.3),

$$Agricultural\ Pressures_{IN} = \left(\frac{\sum_n A_n^i c_n^i Influence_n^i Intensity_n^i}{A^{i=I}} \right) \tag{5.3}$$

where A^i_n stands for the area of the entire n^{th} Natura 2000 site dealing with the i^{th} impact, c^i_n represents the percentage of A^i_n directly covered by an activity originating the i^{th} impact. $Influence^i_n$ is the positive, neutral or negative pressure exerted by the i^{th} activity on the n^{th} site, while $Intensity^i_n$ stands for the high, medium or low intensity of the pressure. Finally, $A^{i=I}$ represents the total area of Natura 2000 sites dealing with any agricultural activity. This index highlights activities covering larger areas within the sites. As a general rule this delivers a rather complete measure of the relevance of impacts, but it is limited to activities being implemented inside protected sites.

In order to take into account agricultural activities around the sites, a separate index has been computed, according to Equation (5.4). This index conveys information on influence and intensity of pressures arising from each activity, however, since no information is available on the surface affected by outside activities, this index lacks the spatial dimension.

$$Agricultural\,\mathrm{Pr}\,essures_{OUT} := \sum_{n}\left(presence_{n}^{i}\,Influence_{n}^{i}\,Intensity_{n}^{i} \right) \qquad (5.4)$$

The scores attained by both agricultural pressure indices can be read on a scale ranging from -1 to 1. The development of this set of biodiversity and agricultural pressure indicators is not only a result per se, since it allows an empirical measurement of biodiversity status and the pressures it is subject to, but it can also serve as an input for an additional step of the analysis, since the indicators can be used as explanatory variables when modelling the linkages between biodiversity and agricultural activities. The following sections will demonstrate their potential in describing and analysing an empirical case study, namely the Italian Natura 2000 sites.

5.6 The Italian case study

5.6.1 Descriptive statistics of the Italian Natura 2000 sites

In order to introduce the application of the previously described agricultural pressure and biodiversity indicators, it seems important to provide a deeper analysis of the features of the Italian Natura 2000 sites. Italy counts 1.328 sites, accounting for about 8 % of the EU 25 sites. The North-Eastern area of the country appears to host the highest number of sites, while Sardinia records the lowest number with only 9 sites. The relative dimensions of these regions must be taken into account in order to better appreciate the real distribution of these sites. At the national level 3.7 million hectares are protected under Natura 2000 and their distribution among the regions is strongly uneven. The North-East region records the highest coverage of protected areas out of the total regional surface with 24%. Sardinia and Sicily, by contrast, have the least coverage of protected areas. Table 5—2 provides the classification of NUTS 2 macro-regions in Italy, the number of sites and the distribution of Natura 2000 protected area across the regions.

Insert Table 5—2 about here

Natura 2000 sites can be assigned different levels of institutional protection, depending on their importance of the site in terms of protected species and habitats as assessed by the national government. In the Italian case, Natura 2000 sites are clustered into twenty-six different categories, each of which guarantees a high, medium, low or no institutional protection. A single site can be listed under two or more different categories, since a portion of a site can belong to a highly protected category, for instance a National Park, while the rest may not be granted any institutional protection.

As a matter of fact, 480 Italian sites are listed, at least partially, as receiving no institutional protection. However, regional and county parks and regional and county natural reserves, both classified as highly protected, include 273 and 305 sites respectively, with coverage of 92% and 87% of the protected surface. In addition, the lowest levels of protection, like private reserves and hunting farms, cover a very low proportion of Natura 2000 sites. Table 5—3 presents these categories as well as the number of sites covered, totally or partially, by them.

Insert Table 5—3 about here

As regards the distribution of protected sites across different biogeographic regions the majority of Italian sites, 46%, belong to the continental region, 37% to the alpine region, while only 17% pertain to the Mediterranean one. This seems to be linked to the previously highlighted lower number of designated sites and coverage of protected areas in southern Italy.

5.6.2 Agricultural pressures

Italian Natura 2000 sites affected by agricultural activities are 718. However, information is available only for 570 sites, covering about 43 % of the sites. The number of sites dealing with agriculture is close to zero in Sardinia, Lazio and Emilia-Romagna, while they reach 80% in Sicily and 74% in Campania. Nonetheless, only about 64% have provided information on human activities, which may entail an underestimation of the real agricultural pressures. The area covered by Natura 2000 sites impacted by agricultural activities is about one half of the national total, covering more than 1.8 million hectares.

The most common activities occurring in the Italian sample appear to be cultivation, grazing and forestry. Furthermore, artificial planting, abandonment of pastoral systems and burning practices are reported in nearly 18% of sites. Finally, modification of cultivation practices, mowing and cutting, use of pesticides and animal breeding represent around 7% of recorded activities.

The computation of the agricultural pressure indicators for each activity highlights that grazing and forestry appear to generate the most relevant pressures, the second being more ambiguous in terms of influence, since its positive effects nearly compensate the negative ones. It seems interesting to notice that mowing and cutting is the only activity giving rise exclusively to positive pressures, while, cultivation and grazing practices may also produce positive effects on protected sites, although negative impacts are predominant. On the contrary, the use of pesticides, fertilisation and irrigation, together with animal breeding and burning appear to produce predominantly negative and significant pressures. Table 5—4 displays the score attained by the agricultural pressure index for each activity.

Insert Table 5—4 about here

As far as agricultural pressures inside the sites are concerned, Calabria and Sicily regions attain the most negative scores, while Liguria, Lombardy and Marche record a slightly positive score. When considering pressures on the surroundings of protected areas, it appears that Veneto and Puglia attain the most negative scores, while Liguria and Abruzzo obtain a positive value. It is worth recalling that the interpretation of a positive score in the agricultural pressure index differs depending on where agricultural activities are implemented. As a matter of fact, a positive pressure index inside the site signals that the surface covered by positive or neutral impact activities is higher than the surface affected by negative ones. By contrast, a positive score of the pressure indicator around the site means that the number of positive or neutral activities is higher than the number of negative ones, since this index does not account for the spatial dimension. Table 5—5 presents the distribution of the area covered by Natura 2000 protected sites across the Italian regions as well as the value attained by agricultural pressure indices inside and outside protected sites.

Insert Table 5—5 about here

The agricultural pressure indices are also suitable for considering vectors of activities. In the Italian sample, as far as pressures inside the sites are concerned, cultivation activities are strongly correlated to the use of pesticides, fertilization and irrigation, being implemented in 72%, 55% and 80% of the sites where those activities are performed. In addition cultivation appears to be present in 67% of the sites where restructuring of agricultural landholding takes place. The use of pesticides is highly correlated with fertilisation and grazing activities are performed in 75% and 55% of the sites where animal breeding and stock feeding take place.

Forestry activities appear to be correlated with animal breeding and stock feeding, being present respectively in 70% and 50% of the sites were those activities are reported. In 50%

of the sites in which forest re-planting and stock feeding take place, burning practices are also implemented.

As regards activities outside the sites, cultivation is again strongly correlated with the use of pesticides, fertilisation and irrigation, being reported for the 75%, 73% and 73% of the affected sites respectively. The latter three activities also show very high correlation among themselves. In 50% of the areas in which forestry takes place, cultivation is also performed and, in the 57% of cases, forestry is also associated with grazing activities. In 50% of the areas used for animal breeding cultivation takes place, and the same goes for the use of pesticides, fertilisation, irrigation and grazing. Burning practices are associated to grazing activities in the surroundings of 71% of protected sites.

5.6.3 Biodiversity profiles

As far as biodiversity profiles are concerned, the scores for species richness appear to be low, the highest being reached by Campania and the lowest by Valle d'Aosta. By contrast this region attains one of the higher scores, together with Lazio and Sicily when it comes to species abundance. The highest values for species isolation are recorded for Abruzzo and Campania.

Habitat diversity indicators tend to deliver better results across all regions, with higher scores for richness and abundance, in particular for Lazio, Puglia and Lombardy. As already mentioned in the section concerning the indicators development process, two composite indicators, one for habitat and one for species have been added to the individual indicators. Abruzzo and Puglia reach the highest values in the habitat composite indicator while the highest values for species are recorded in Lazio and Abruzzo. Their scores confirm the trend highlighted for individual indicators, since the species indicator attains lower scores than the habitat one across all regions. Table 5—6 shows the scores attained by biodiversity indicators at the regional level.

Insert Table 5—6 about here

5.7 Model specification and estimation results

Since biodiversity is a multifaceted concept that must be analysed taking into account, simultaneously, all the aspects highlighted in the previous paragraph, it seems interesting to use the developed biodiversity and agricultural pressure indicators in order to formally test the relationship between biodiversity conservation and agricultural activities occurring inside protected areas or their surroundings.

Biodiversity and agricultural pressure indicators, together with site geographical features and the degree of institutional protection, have been included as explanatory variables in a multiple regression model[27]. The species composite indicator has been considered as the dependent variable to be explained in terms of a set of variables including site geographic location (x_1), site physical features(x_2), biodiversity indicators, namely habitat diversity and species isolation, (x_3), the degree of institutional protection the site is granted (x_4) and the pressures exerted by agricultural activities inside the site and in its surroundings (x_5).
The model specification is presented in equation (5.5):

$$\log y = \beta_0 + \beta_1 \log x_1 + \beta_2 \log x_2 + \beta_3 \log x_3 + \beta_4 \log x_4 + \beta_5 \log x_5 + \varepsilon \qquad (5.5)$$

As regards the physical characteristics of the site, the mean altitude is found to exert a positive impact on the overall status of protected species, either influencing the number of species or the number of individuals living in a site. As far as the biogeographic region is concerned, alpine sites appear to attain a lower score in species diversity with respect to sites located in the continental region, while in the Mediterranean region species diversity appears to be higher. Variables referring to site geographic location are classified in four macro regions, North-east, North-west, Centre and South. Results show that central and southern regions are negatively correlated to overall species diversity with respect to the North-west and North-east regions.
When considering biodiversity, it seemed useful to include in the model two indicators that appear to be closely linked to the overall status of species diversity, the habitat composite indicator and species isolation. They are both positively correlated with the dependent variable and significant. This means that a more diverse and abundant natural habitat exerts a positive impact on species diversity. Moreover, it can be argued that the more isolated a population is, with respect to the geographical range of its species, the higher the level of species diversity. Furthermore, a high degree of institutional protection is positively correlated with the species diversity of the site. This can be read as a policy response to the risk of biodiversity loss, since sites hosting particularly valuable or risk-prone species and habitats tend to be granted higher protection, resulting in a better conservation of species.
When it comes to pressures generated by agricultural activities, it can be noted that both the index for inside activities and the one for outside activities are negatively correlated with the score of the species composite indicator, though only the latter is significant. These pressure indices take into account simultaneously impacts and intensity of agricultural activities,

[27] The logarithmic transformation of the dependent and explanatory variables was performed as this appeared to fit the data better than the linear form.

therefore this result signals that a more intense pressure exerted on the site leads to a lower level of species diversity. Table 5—7 presents the estimation results.

Insert Table 5—7 about here

The analysis of the plot of residuals of the first model showed a potential problem of heteroskedasticity. In order to correct for this, it has been decided to redefine the model using employing the site area, as a weighting factor[28]. Results provided by this model confirm the ones provided by the first one, with a slight increase in the goodness of fit of the model. In addition the agricultural pressure index for inside activities becomes significant. Results are displayed in Table 5—8.

Insert Table 5—8 about here

5.8 Further analysis: indirect impacts of agricultural activities on tourism flows

The analysis performed in the previous paragraphs has provided an example of how agricultural pressure indicators can be used to assess the impacts of agricultural activities on biodiversity. However, biodiversity appears to be a crosscutting issue, affecting other economic sectors, for instance tourism. It seems therefore interesting to explore the use of the agricultural pressure indicators constructed for the purpose of this study to investigate the impacts of biodiversity and agricultural pressure on tourism flows.

In order to do this the total number of tourist arrivals in each Italian region has been regressed against two habitat and species diversity indicators, namely richness and abundance[29]. Results show that all the variables are significant in explaining the variance of tourism flows towards the different Italian regions and that species richness and habitat abundance exert a positive influence on the number of tourists visiting the region. On the other hand, species abundance and habitat richness turn out to be negatively correlated to tourist arrivals. These results are displayed in Table 5—9.

Insert Table 5—9 about here

[28] Unlike least squares, however, each term in the weighted least squares criterion includes an additional weight, w_i, that determines how much each observation in the data set influences the final parameter estimates. The weighted least squares criterion that is minimized to obtain the parameter estimates is:

$$\sigma^2 = \sum_{i=1}^{n} w_i [y_i - f(\vec{x}_i; \vec{\hat{\beta}}_i)]^2$$

[29] The data concerning tourism flows towards the different Italian regions has been retrieved from the Italian institute of statistics and refer to year 2004, since the species and habitat diversity indicators have been computed for the years 2000-2004.

Having established a correlation between species and habitat diversity and tourist arrivals, it seems interesting to analyse the indirect effect of agricultural activities on tourism. Tourism flows towards the Italian regions have been regressed against the two indicators reflecting agricultural pressures inside and outside Natura 2000 sites. The outcome of this regression indicates that negative pressures of agricultural activities inside Natura 2000 sites are negatively correlated to the number of tourists visiting the regions where those sites are located. The results are presented in Table 5—10.

Insert Table 5—10 about here

This correlation would deserve a more detailed study in order to develop a precise model, taking into account all the variables influencing tourist demand. However this is beyond the scope of this paper, which is to demonstrate the potential use of the proposed indicators to assess the impacts of agricultural activities on biodiversity and, indirectly, on other sectors, such as tourism.

5.9 Conclusions

The present paper has demonstrated that an existing database, Natura 2000, can be used to compute both biodiversity and agricultural pressure indicators for the EU Member States. These indicators can be computed for each protected site and aggregated at the desired geographical scale. In addition, they are consistent with the indicators developed by international and European institution and to the ones used in the literature on biodiversity conservation.

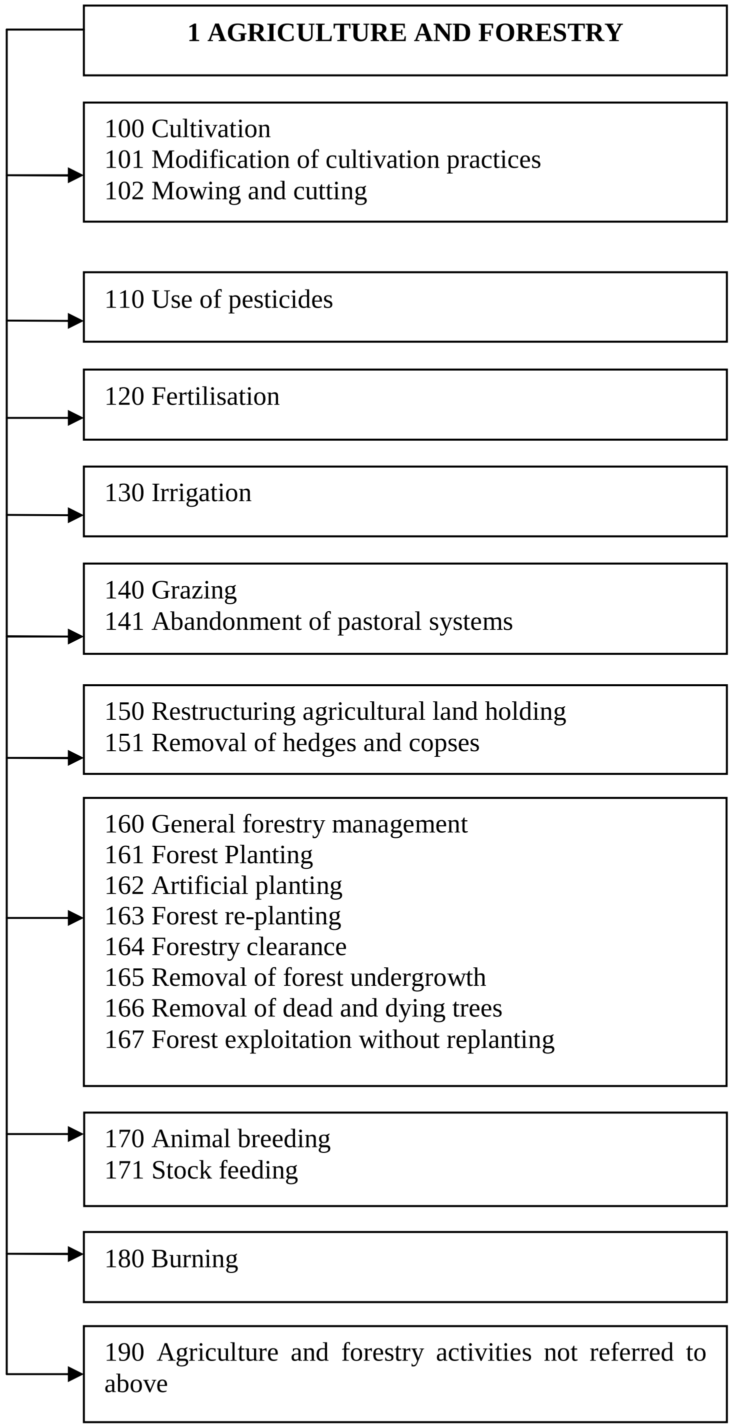
The achieved results allow concluding that a significant link exists between the score in the species diversity indicator and the pressure index accounting for the impact of agricultural activities performed inside Natura 2000 sites. As a consequence, species diversity tends to be higher in site in which the pressure from agricultural activities happens to be lower. Nonetheless, this does not imply that a tighter protection would necessary result in an increase in species diversity. The idea underpinning the creation of the Natura 2000 network that certain human activities performed inside a site can contribute to biodiversity conservation is not contradicted by the empirical results for the Italian case study. However, biodiversity protection policies need to be focused on avoiding the most negative impacts enhancing the positive interactions among activities rather than forbidding the implementation of the negative ones.

The agricultural pressure indices, created to reflect the overall level of agricultural pressure on a site, deliver negative and significant results. The overall performance of biodiversity and agricultural pressure indicators is satisfactory and, since the data are available at the EU level, the model can be replicated and results obtained for different countries could be easily compared. Such comparisons could be interesting since the choice regarding the level of protection granted to sites and the site surface affected by different activities may vary substantially across countries.

Finally, agricultural pressure indicators proved to be useful also for the analysis of indirect impacts of agricultural activities on other economic sectors, for instance tourism. This appears to be an interesting input for further research and could constitute the focus of a separate study.

Figures

Figure 5-1 Classification of agricultural activities in the Natura 2000 database



Source: Natura 2000 database, own elaboration

Tables

Table 5—1 Influence and intensity of agricultural activities

Influence $^{i}_{n}$	:= +1 if the i-th activity has a positive (+) pressure := 0 if the i-th activity has a neutral (=) pressure := -1 if the i-th activity has a negative (-) pressure
Intensity $^{i}_{n}$	:= 2 if the i-th activity has a high-intensity pressure := 1 if the i-th activity has a medium-intensity pressure := 0.5 if the i-th activity has a low-intensity pressure

Source: Natura 2000 database, own elaboration

Table 5—2 Description of NUTS 2 regions in Italy

NUTS 2	Description	Number of sites	Area (%)
IT	Italy	1328	100%
IT1	North-West	195	13%
IT2	Lombardy	190	8%
IT3	North-East	375	24%
IT4	Emilia-romagna	136	6%
IT5	Centre	227	12%
IT6	Lazio	48	7%
IT7	Abruzzo-molise	32	13%
IT8	Campania	27	6%
IT9	South	37	7%
ITA	Sicily	47	3%
ITB	Sardinia	9	0%

Source: Natura 2000 Database, own elaboration

Table 5—3 Typologies of institutional protection in the Italian sample

Description provided by the Natura 2000 database	Level of institutional protection	No. Sites
No protection	None	480
National park	High	101
National natural reserve	High	69
Cross-regional natural park	High	3
Regional natural park	High	273
Regional natural reserve	High	305
Natural monuments	High	3
Fauna protection oasis	Medium	97
Natural beauty	Medium	244
Urban green area	Medium	1
Land use rights limitation for hydro-geological issues	Medium	289
Safeguard areas for superficial water and groundwater resources for human consumption	Medium	7
Private potection areas	Low	8
No-hunting areas	Low	1

Source: Natura 2000 database, own elaboration

Table 5—4 Score of the agricultural pressure index by activity

Activity	Negative impacts	Positive impacts	Agricultural pressure index
Cultivation	-0.024	0.009	-0.015
Modification of cultivation practices	-0.002	6.61E-05	-0.002
Mowing and cutting	-8.24E-05	0.002	0.002
Use of pesticides	-0.012	0	-0.012
Fertilisation	-0.0058	5.39E-06	-0.0054
Irrigation	-0.002	0.0001	-0.002
Grazing	-0.085	0.008	-0.077
Abandonment of pastoral systems	-0.024	0.003	-0.0204
Restructuring of agricultural land holding	-0.0007	0	-0.0007
Removal of hedges and copses	-0.0003	0	-0.0003
General forestry management	-0.039	0.029	-0.0107
Forest planting	-3.86E-05	3.21E-05	-6.54E-06
Artificial planting	-0.010	0.001	-0.008
Forest re-planting	0	8.49E-06	8.49E-06
Forestry clearance	-0.0001	0	-0.0001
Removal of forest undergrowth	-0.001	2.03E-05	-0.0015
Removal of dead and dying trees	-0.001	6.45E-05	-0.0014
Forest exploitation without replanting	-0.001	0	-0.0013
Animal breeding	-0.010	0.0005	-0.0102
Stock feeding	-0.001	0	-0.0017
Burning	-0.043	0	-0.043
Agriculture and forestry activities	-0.015	1.88E-05	-0.0154

Source: Natura 2000 database, own elaboration

Table 5—5 Descriptive statistics and scores of the agricultural pressure indicators across Italian regions

Region	Number of sites	Area	Alpine sites	Continental sites	Mediterranean sites	Sites affected by agricultural activities	Agricultural pressure index (IN)	Agricultural pressure index (OUT)
Piedmont	136	288884	65	71	0	26	-1.88E-05	-1.447
Valle d'Aosta	27	114103	27	0	0	3	0	-0.029
Liguria	32	69738	20	11	1	21	9.42E-06	0.75
Lombardia	190	296006	99	91	0	35	4.77E-06	-0.381
Trentino A. A.	195	327745	195	0	0	21	-7.17E-06	-1.812
Veneto	119	442048	44	75	0	53	-3.59E-05	-2.347
Friuli V.G.	63	143783	25	38	0	37	-5.26E-06	-2.2
Emilia Romagna	139	246889	0	139	0	129	0	0
Toscana	86	179924	0	33	53	59	-3.03E-05	-1.226
Umbria	40	74161	0	35	5	24	-3.56E-05	-1.591
Marche	101	211110	0	101	0	31	4.37E-06	-0.917
Lazio	48	249019	7	1	40	28	0	0
Abruzzo	30	497867	12	17	1	23	0	0.25
Molise	2	813	0	0	2	0	-9.60E-06	-1.25
Campania	27	214803	0	0	27	15	7.69E-06	0
Puglia	16	207124	0	0	16	1	0	-2.454
Basilicata	17	34068	0	0	17	2	-1.69E-05	-0.875
Calabria	4	27081	0	0	4	2	-0.0001099	-0.5
Sicily	47	125215	0	0	47	19	-0.0001671	-2.16
Sardinia	9	16137	0	0	9	5	-7.78E-06	-0.5

Source: Natura 2000 database, own elaboration

Table 5—6 Scores of biodiversity indicators across Italian regions

Region	Species richness	Species abundance	Species Isolation	Habitat richness	Habitat Abundance	Species composite	Habitat Composite
Piedmont	0.029	0.032	0.047	0.045	0.008	0.012	0.013
Valle d'Aosta	0.009	0.043	0.04	0.005	0.008	0.013	0.00
Liguria	0.047	0.018	0.028	0.011	0.007	0.006	0.008
Lombardia	0.035	0.015	0.039	0.102	0.014	0.005	0.006
Trentino A. A.	0.016	0.012	0.028	0.01	0.029	0.002	0.007
Veneto	0.041	0.026	0.064	0.095	0.023	0.01	0.011
Friuli V.G.	0.044	0.024	0.044	0.026	0.015	0.008	0.008
Emilia Romagna	0.067	0.018	0.047	0.033	0.006	0.013	0.026
Tuscany	0.04	0.02	0.04	0.09	0.04	0.01	0.04
Umbria	0.033	0.009	0.025	0.091	0.004	0.005	0.020
Marche	0.02	0.02	0.04	0.01	0.05	0.01	0.13
Lazio	0.045	0.045	0.093	0.231	0.031	0.025	0.014
Abruzzo	0.061	0.036	0.161	0.094	0.088	0.024	0.342
Molise	0.056	0.008	0.05	0.075	0.15	0.004	0.00
Campania	0.095	0.036	0.053	0.019	0.036	0.017	0.069
Puglia	0.077	0.025	0.153	0.191	0.00625	0.019	0.188
Basilicata	0.064	0.021	0.049	0.137	0.056	0.012	0.035
Calabria	0.05	0.02	0.05	0.11	0.08	0.01	0.00
Sicily	0.029	0.041	0.08	0.127	0.002	0.016	0.106
Sardinia	0.054	0.009	0.01	0.004	0.016	0.011	0.004

Source: Natura 2000 database, own elaboration

Table 5—7 Estimation results for the linear model

Species composite indicator	Coefficient	P>|t|
constant	-6.871	0.019*
Alpine region	-1.950	0.068*
Mediterranean region	1.375	0.054*
Mean altitude	0.457	0.058*
Centre	-1.950	0.073*
South	-2.978	0.061*
Habitat composite indicator	0.313	0.027*
Species isolation	0.330	0.004**
High institutional protection	0.672	0.042*
Agricultural pressure indicator (IN)	-0.268	0.138
Agricultural pressure indicator (OUT)	-1.820	0.001**
	R2	**0.97**

Statistical significance of 0.1%. 5% and 10% is indicated by ***. **. * respectively

Table 5—8 Estimation results for the model using the site area as a weighting factor

Species composite indicator/ site area	Coefficient	P>|t|
constant	-7.267	0.013*
Alpine region	-1.905	0.052*
Mediterranean region	1.400	0.041*
Mean altitude	0.458	0.051*
Centre	-1.918	0.057*
South	-2.940	0.048*
Habitat composite indicator	0.310	0.023*
Species isolation	0.373	0.004**
High institutional protection	0.676	0.030*
Agricultural pressure index (IN)	-0.309	0.094*
Agricultural pressure index (OUT)	-1.893	0.001**
	R2	**0.98**

Statistical significance of 0.1%. 5% and 10% is indicated by ***. **. * respectively

Table 5—9 Impact of biodiversity on regional tourist arrivals

Total tourists	Coefficient	P>|t|
Species richness	0.0330701	0.008**
Species abundance	0.0316	0.029*
Habitat richness	0.0392714	0.084*
Habitat abundance	0.0415061	0.002**
constant	0.2220154	0.000***

Statistical significance of 0.1%. 5% and 10% is indicated by ***. **. * respectively

Table 5—10 Impact of agricultural activities on regional tourist arrivals

Total tourists	Coefficient	P>|t|
Agricultural pressures (IN)	-0.416733	0.080*
Agricultural pressures (OUT)	-0.707258	0.332
constant	9.804828	0.003**

Statistical significance of 0.1%. 5% and 10% is indicated by ***. **. * respectively

References

Aerts R., de Caluwe H. and Beltman B., (2003), Is the relation between nutrient supply and biodiversity co-determined by the type of nutrient limitation?, *OIKOS 101*, pp.489–498

Dupouey J. L., Dambrine E., Laffite J. D., Moares C. (2002) Irreversible impact of past land use on forest soils and biodiversity, *Ecology*, Vol. 83, No. 11, pp. 2978-2984.

EASAC(2005), A user's guide to biodiversity indicators, *European Academies Science Advisory Council*

European Environmental Agency (2003). *An inventory of biodiversity indicators in Europe*, Technical Report n. 92.

European Environmental Agency (2007). *Halting the loss of biodiversity by 2010: proposal for a first set of indicators to monitor progress in Europe*, Technical report n. 11/2007

European Commission (1999), *Agriculture, Environment, Rural Development: Facts and Figures - a Challenge for Agriculture*, Luxembourg, http://ec.europa.eu/agriculture/envir/report/en/index.htm

European Commission (2005), Natura 2000 *Conservation in partnership*, Luxembourg 2005, http://ec.europa.eu/environment/nature/info/pubs/docs/nat2000/conservation_in_partnership.pdf

FAO (2004), *The Scope of Organic Agriculture, Sustainable Forest Management and Ecoforestry in Protected Area Management*, Environment and Natural Resources Working Paper No. 18, http://www.fao.org/docrep/007/y5558e/y5558e00.htm#toc

Florax R.J, Travisi, C.M. and Nijkamp, P. (2005). A meta-analysis of the value of reducing pesticide risk exposure, *European Review of Agricultural Economics*, 32, 141–167.

Foster, V. and Mourato, S. (2000). Valuing the multiple impacts of pesticides use in the UK: a contingent ranking approach, *Journal of Agricultural Economics*, 51, 1–21.

Frankham R, Ballou J.D, Briscoe D.A. (2002). *Introduction to conservation genetics*, Cambridge University Press.

IUCN (1994), *Guidelines for Protected Area Management Categories*, CNPPA with the assistance of WCMC. IUCN, Gland, Switzerland and Cambridge, UK.

Lambert, J., Poisson, F. and Champlovier, P. (2001), *Valuing benefits of a road traffic noise abatement programme: a contingent valuation study*, INRETS-LTE, France. Paper in Internoise 2000 Proceedings 5, 3413–3418, Nice 27–30 August, 2000.

Lemly A.D., Kingsford R.T. and Thompson J.R. (2000), Irrigated Agriculture and Wildlife Conservation, *Environmental Management*, Vol. 25, No. 5, pp. 485–512

McLaughlin A. and Mineau P. (1995), the impact of agricultural practices on biodiversity, Agriculture, *Ecosystems & Environment*, Volume 55, Issue 3, pp. 201-212

Millennium Ecosystem Assessment (2005), *Ecosystems and Human Well-being: Biodiversity Synthesis*, World Resources Institute, Washington, DC.

Nijkamp, P. and Vreeker, R. (2000), Sustainability assessment of development scenarios: methodology and application to Thailand, *Ecological Economics* 33, 7–27.

Nordin A., Strengbom J., Witzell J., Näsholm T. and Ericson L. (2005), Nitrogen Deposition and the Biodiversity of Boreal Forests: Implications for the Nitrogen Critical Load, *AMBIO: A Journal of the Human Environment*, Volume 34, Issue 1 (February 2005), pp. 20 – 24

OECD (2000). *Framework for integrating socio-economic analysis in chemical risk management decision-making*. OECD, ENV/JMMONO-2000-5.

OECD (2001), *Environmental indicators for agriculture*, Volume 3 Methods and results, OECD

Relyea R.A. (2005), The impact of insecticides and herbicides on the biodiversity and productivity of aquatic communities, *Ecological Applications*, Vol. 15, No. 2, pp. 618-627

Ten Brink B. (2000), *Biodiversity Indicators for the OECD Environmental Outlook and Strategy. A feasibility study*, RIVM Report 402001014. National Institute of Public Health and the Environment. The Netherlands

Conclusion

This thesis focuses on the different applications of biodiversity indicators and their policy implications. Chapter 1 provides a review of the existing indicators, identifying the political and institutional framework in which those have been developed. In addition it defines a protocol for the development of biodiversity indicators, using the information made available by an existing database, the Natura 2000. The remaining chapters provide empirical applications of those indicators in order to address different research questions.

Chapter 2, 3 and 4 are focused on the assessment of the impacts of biodiversity and landscape on tourism flows. The analyses are performed at three different geographical scales. Chapter 2 assesses the impact of biodiversity on both international and domestic flows at the worldwide level, Chapter 3 focuses on the impacts of biodiversity on domestic tourism flows at the national level while Chapter 4 is centred on the effects of landscape diversity on domestic and international tourism flows towards Tuscany, Italy.

It seems important to point out that the level of detail and resolution of the biodiversity and landscape indicators heavily depends on the considered geographical scale. As a matter of fact, for the studies focusing on the national and sub-national level it has been possible to define measures of species, habitat and land cover abundance, whereas, when dealing with the global level, it has been necessary to limit the analysis to species and habitat richness.

In all of the three case studies, results allow concluding that biodiversity and landscape diversity, measured via the indicators, exert a positive impact on tourism flows. It seems useful to provide an overview of the significance of the various indicators across the different spatial scales and types of tourism. It is possible to notice that species and landscape richness indicators proved to be particularly significant in explaining regional and worldwide tourism case studies. On the other hand, species and habitat abundance indicators turn out to be significant when focusing on the national and worldwide spatial scales.

In addition to this analysis, Chapter 3 provides an example of how a monetary value can be attached to different biodiversity indicator and aggregated to obtain an economic valuation of the importance of biodiversity conservation for the tourism activities of the various Irish counties.

In Chapter 2 and 4 an additional step has been taken so as to differentiate the impacts of biodiversity on two components of inbound tourism flows, the international and domestic ones. It turns out that, both at the global and sub-national scale, international tourists seem to be more influenced by those characteristics of the destination that are widely known and on which tourism advertising campaigns would focus. On the other hand, domestic tourists seem to be more interested in the presence and conservation status of species, habitats and landscapes of higher relevance for local residents.

Chapter 5, unlike the previous ones, explores the potential use of biodiversity indicators in order to assess the impact of economic activities, in particular agriculture, on biodiversity conservation in protected areas. The results show that different agricultural practices produce different effects on the level of biodiversity in protected sites; some of them , such as cultivation, grazing, the use of pesticides and burning practices, entail strong negative impacts, whereas others, for instance mowing and cutting and forestry management, can produce remarkable positive pressures. Against this background, the focus of conservation policies should be on the valorisation of positive impacts and the limitation of negative ones, rather than on establishing a strict protection regime.

The analysis provided in chapter 5, addresses the potential use of pressure indicators in order to assess, in addition to the impacts of agriculture on biodiversity, also the impact of agriculture on tourism flows, via the level of biodiversity. It turns out that the relationship between biodiversity and tourism flows, found in the previous chapters of this thesis, holds also for the Italian case study. In addition, agricultural activities have been found to exert an influence, not only on biodiversity, but also, indirectly, on tourism flows.

The conclusion that can be drawn from this thesis is that biodiversity and landscape indicators can be employed to answer to several research questions. As a matter of fact it appears that, in addition to having a measurement function, those indicators are useful in the determination of the impacts of biodiversity on economic sectors, for instance tourism. Moreover they can be employed as benchmarks for the evaluation of the effectiveness of policy decisions. Finally, they can be used to define priorities and policy objectives, thus becoming decision-making tools for biodiversity conservation.

Estratto per riassunto della tesi di dottorato

Studente: Giulia Macagno matricola: 955271

Dottorato: Analisi e Governance dello Sviluppo Sostenibile

Ciclo: 22°

Titolo della tesi: Linking biodiversity, ecosystem services and economic activities: an indicator-based assessment

Riassunto:

Il fondamento di ogni scelta politica riguardante la biodiversità risiede nella possibilità di misurarne lo stato di conservazione e l'evoluzione. Il concetto di biodiversità si presenta come estremamente complesso, pertanto la scelta di quantificarne i principali elementi facendo ricorso a diversi indicatori appare appropriata. Obiettivo di questa tesi è l'identificazione del rapporto esistente tra la biodiversità e il benessere umano, tramite l'analisi dell'impatto della diversità di specie, habitat e paesaggio su settori economici differenti, tra cui il turismo. Inoltre, essi costituiscono un punto di riferimento per la definizione di scelte politiche e per la valutazione della loro efficacia, diventando così strumenti imprescindibili per il decisore politico.

Abstract:

At the very basis of biodiversity conservation stands the need to be able to quantify status and trends of biodiversity. Biodiversity is too complex to be fully quantified at policy-relevant scales and its assessment can only be done by means of indicators. This thesis establishes a link between biodiversity, measured via indicators, and human well-being, through the impact exerted by biodiversity on different economic sectors, for instance tourism. Moreover they can be employed as benchmarks for the evaluation of the effectiveness of policy decisions. Finally, they can be used to define priorities and policy objectives, thus becoming decision-making tools for biodiversity conservation.

Firma dello studente

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