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Case Study

# Mapping Habitat Quality in the Lombardy Region, Italy

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## Abstract

This paper reports a case study which examines the how mapping ecosystem services can be used to identify areas of significant natural value to be protected or restored. We mapped habitat quality in Lombardy (northwest Italy) using the InVEST (Integrated Valuation of Ecosystem Services and Tradeoff) model. Model outputs were used to approximate the spatial distribution of ecological quality across the region provided a framework to support the implementation of the Lombardy Regional Landscape Plan. This resulted in a proposal for introduction of new protected areas in the updated Landscape Plan, while other areas were proposed to be removed.

## Keywords

Ecosystem services, Landscape planning, Mapping, Habitat quality, Legislative tools

## Introduction

Mapping ecosystem services can help evaluate the impact of a project or policy on human well-being and help policy makers visualise outcomes (Maes et al. 2012). The inclusion of an ES mapping framework in spatial planning and in the decision-making process is dependent on spatially explicit information on existing pressures on and predicted threats to the environment (Millenium Ecosystem Assessment 2005). The limitations of mapping are evident: the need for reliable, accurate, public geographic datasets is increasing, and the supply of such data only partially satisfies the demand for it (Benini et al. 2010). These weaknesses still need to be overcome.

Nonetheless, planners and policy makers have become more aware of ES mapping, and the gap between analytical tools and their practical application for planning purposes will be filled in the near future (Arcidiacono et al. 2015).

Thus far, a lack of ES mapping has hindered research in the field of project and process sustainability (Maes et al. 2012), which in turn has negatively impacted the economic assessment of planning decisions on natural capital (de Groot et al. 2002, Tol 2005, Baral et al. 2014, Lopes et al. 2015). Indeed, when it concerns local policies, economic assessment also requires biophysical indicators, and not merely general biodiversity maintenance costs to be measured (Costanza et al. 1997, Tol 2005). Measuring ES in monetary terms can help policy makers quantify the long-term benefits of natural capital conservation (Kumar and Kumar 2008, Maes et al. 2012).

In recent years, ES mapping has become key as its practical application can offer more accurate analyses than traditional land use planning tools. Although they broadly acknowledge the importance of doing so, traditional methods used to identify "protected areas" are no longer appropriate, and do not consider ES a proxy of an area's "natural value" (Naidoo et al. 2008). As a result, many protected areas have not preserved their environmental structure as well as other non-protected areas (Del Carmen Sabatini et al. 2007).

Here we present a case study based on mapping ecosystem services. This paper reports a study which used InVEST to outline the spatial distribution of the habitat quality index. The indicator was used to determine areas of significant natural value to be protected and/or restored and, consequently, to draw up the new legislative framework of the Lombardy Regional Landscape Plan.

## Lombardy's Regional Landscape Plan

Lombardy's Regional Landscape Plan (Piano Paesaggistico Regionale, PPR) was used to test and validate a possible ES mapping method for framing the legislative approach to landscape conservation. The PPR serves as a support for sub-regional and local planning levels by establishing and setting out the rules that local government entities must apply, particularly with regard to landscape protection. In July 2014, a new version of the PPR was introduced to provide a regulatory aspect based on a new analysis of environmental and landscape values.

The current Landscape Plan identifies areas of significant natural value (e.g. mountain areas within 150 metres of a river or 300 metres of a lake or glacier, etc.) in accordance with article 17. During the review process, it was decided to review the perimeter of areas of significant natural value in mountainous regions, considering an "altitude-based" methodology not appropriate for landscape planning purposes as it only takes into account quantitative factors (altitude) as opposed to qualitative ones (such as environmental and landscape values). Indeed, some flat Alpine corridors were reconsidered in view of their high level of biodiversity in proximity to built-up areas. The ES mapping method was then compared to the existing altitude-based method, and the former was considered a superior method which could be used to supplement the "traditional" approach to defining areas of significant natural value (Salata 2014).

## Material and methods

One approach involving ES mapping for planning purposes is the creation of a multilayer analysis of Soil Quality Indicators (SQI) (Peccol and Movia 2012), which provides basic information regarding land/soil characteristics (Culshaw et al. 2006). Such an analysis forecasts the environmental effects of the land take process on ecosystem services, and requires an integrated analysis across different disciplines (Breure et al. 2012). However, few analyses based on SQIs include ES values.

In our case study, InVEST (version 3.1.0) was used to provide both biophysical and monetary/economic values of individual ecosystem services. InVEST helps planners to produce a spatial assessment of ES indicators, and is used to integrate decision-making processes across different levels (Chan et al. 2006, Naidoo et al. 2008).

Input was obtained mainly by collecting highly detailed environmental data from the Lombardy Region online GIS dataset, and then refined, explained and adjusted. In some cases the data were simplified by grouping and reclassifying information or summarising results from subsequent multi-layered analysis (Chan et al. 2006).

The Habitat Quality function of InVEST was applied to the entire Lombardy region and raster output was interpolated with the polygons representing land of significant natural value in mountainous regions identified by the previous Plan.

The Habitat Quality indicator expresses (with values ranging from 0 to 1) overall ecological quality based on proximity of the habitat to human land uses and the degree of disturbance caused by them. Habitat Quality was considered a synthetic indicator, allowing it to be used as a proxy of the ecological state of the Region. The following inputs were used for the model:

- Current Land Use/Land Cover (LULC). In the case of Lombardy, the LULC database chosen was the Destinazione d'Uso dei Suoli Agricoli e Forestali (DUSAF) database developed by ERSAF (Regional Agency for Services to Agriculture and Forestry) in 2012 and based on the Corine Land Cover legend. This database uses a scale of 1:10,000 (minimum mapping unit of 0.16 hectares), a raster resolution of 30x30 m, and the third level of the Corine Land Cover legend.

- Threats, broken down into the following aspects:
    - the maximum distance over which each threat affects habitats, expressed in kilometres;
    - a weighted impact of each threat on habitats, expressed with 1 as the highest and 0 as the lowest;
    - the decay of threat, distinguished as linear or potential, depending on the function expressed;
    - polygonal maps of threats.

The threats considered in the case study and the value assigned to the different aspects were estimated by comparing studies of scientific literature and input with a raster resolution of 30x30 m. Each individual threat was also distributed in a GIS raster file with the attribute value indicated in the User's Guide (1 for threats and 0 for the area external to the threats) (Table 1).

Table 1.

Threats used as input for habitat quality and parameter values used to parameterise the InVEST model

| Threat | Maximum distance (km) | Weight | Decay |
|---|---|---|---|
| Infrastructure (highways, roads, railways) | 1 | 0.65 | Linear |
| Areas of human land use (anthropic areas, industrial areas, dumps, construction sites, urban green areas) | 0.4 | 0.8 | Linear |

- The vulnerability of the habitat to threats. This input is composed of values that range from 0 to 1. The value 1 refers to a completely vulnerable habitat (without any restrictions), while 0 corresponds to habitat less likely to be vulnerable to threats. In the Lombardy case study, the restrictions included are the protected areas established at national, regional and local levels since the 80's, the urban green areas such as urban parks or recreational parks, and the primary and secondary element of the Regional ecological network of Lombardy, recognised as a priority infrastructure of the PTR that constitutes a guideline for regional and local planning (Table 2).
- The habitat type and its sensitivity to threats using a score from 0 to 1. Scores were assigned using the Biological Territorial Capacity index (Ingegnoli and Giglio 2008), which is based on: (1) the concept of resistance stability; (2) the principal types of ecosystems of the ecosphere; (3) their metabolic data (biomass, gross primary production, respiration, R/PG, R/B).

Table 2.

Vulnerability to degradation used to parameterise the HQ module of the InVEST model

| ID Protected areas as a potential restriction to habitat degradation | Access |
|---|---|
| Natura 2000 network (Site of Community Importance and Special Protection Areas) | 0.00 |
| National and Regional parks / Secondary element of the Regional Ecological Network / Priority area for biodiversity conservation | 0.20 |
| Local parks | 0.80 |
| Primary element of the Regional Ecological Network | 0.10 |
| Remaining territory | 1 |

## Results and discussion

Fig. 1 shows the distribution of the habitat quality values. There is a sharp and clear north-south gradient with high habitat quality values in the mountains and low values in the plain area.

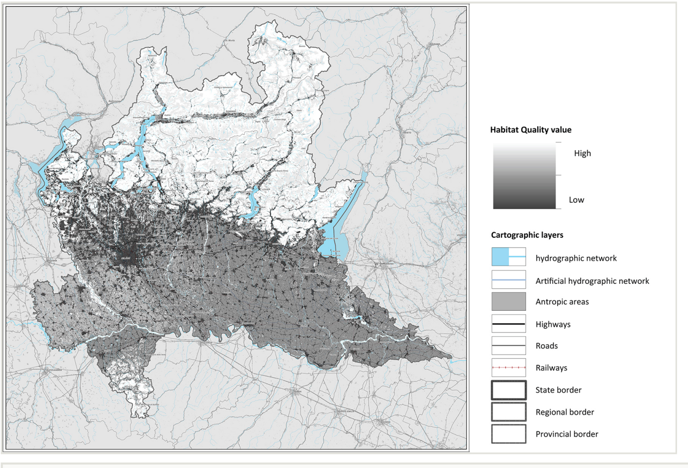


Figure 1.

Map of the Habitat Quality indicator based on a regional parameterisation of the InVEST model for Lombardy, Italy

The Habitat Quality indicator was spatially aggregated using the administrative borders of municipalities, generating a municipal HQ value. The new dataset was obtained from the sum of each LULC cluster (squared meters) weighted with its specific HQ value (0-1 values) and then divided by the overall municipal area. The composite indicator, called “Weighted average of HQ value”, shows the average distribution of the Habitat Quality indicator for each municipality (Fig. 2).

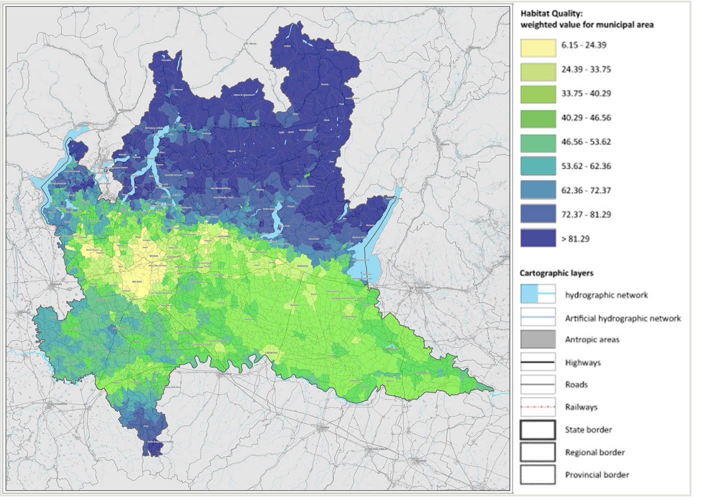


Figure 2.

Weighted average of Habitat Quality values per municipality for Lombardy, Italy

The HQ indicator was used to re-shape the protected areas designated by the regional law (art. 17). The high natural areas identified with the InVEST model follow more or less the existent delineation, of areas with an altitude of less than 1,600 meters and other surfaces located at an altitude of above 1,600 meters, where Habitat Quality values are not generally high.

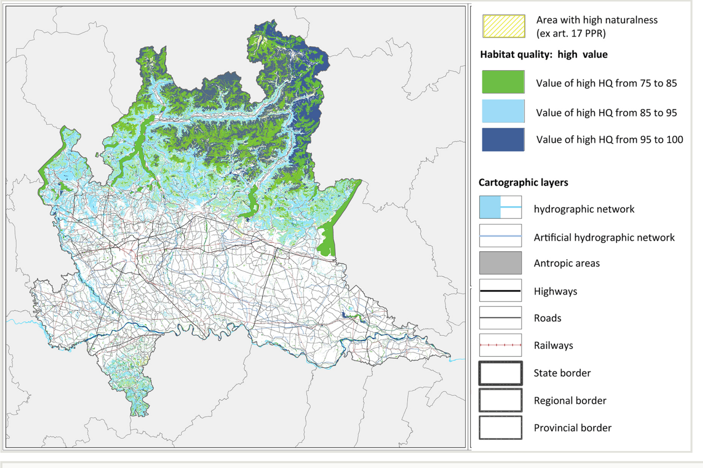


Figure 3.

Overlay between area with high natural value designated under art. 17 of the Landscape Regional Plan and area with a high value of Habitat Quality based on the habitat quality indicator derived from the InVEST model

Moreover, Figures 1 and 2 show that high natural value areas are not dependent on their linear buffer distance from natural elements (e.g. rivers, lakes, forests and woods, glacier) because the overall distribution is associated with interaction between different ecosystems rather than linear criteria. For instance, it is notable that in the Alpine mountains the natural value is higher than on the plain where settlements and infrastructures increase the anthropic pressure on the environment, while slopes with natural and semi-natural LULC (e.g. forests, shrubs, woods, grasslands) maintain a high value, except where the LULC is dominated by a bare surface (e.g. rocks, glaciers) (Fig. 3).

The application of the HQ indicator in the Landscape Plan of Lombardy overcomes uncertainties in the definition of areas with high natural value that need to be preserved and uses a new approach to update and amend the regional plan using the latest scientific knowledge. This case study may be relevant for other applications of the HQ indicator in other planning tools which focus on other policy competences at different territorial scales.

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