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Habitat functioning and connectivity assessment to support land-use planning: a case study in an Alpine valley floor

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Abstract

The land-use and cover changes are the major causes of the biodiversity loss. This is particularly true in the contexts of Alpine valley floor, where increasing human-driven pressures affect remnant habitats and fragile ecosystems. To pursue biodiversity conservation, aiming environmentally sustainable development, spatial planning should maintain landscape ecological functions in order to guarantee the habitats and supporting processes for as many species as possible. Besides, planners as well as other stakeholders involved in land-use changes need value-based information or at least information easily obtainable that provides clear insights on the ecological consequences of these land-use changes.
Currently, the assessments of the ecological impact of project or plan proposals have several shortcomings. Spatial planning often disregards the different biodiversity components, just focused on species richness of protected areas. Most of landscape-oriented indices fails especially in providing an understanding of disruptive changes of ecological processes.
A former project, to which I contributed, was meant to provide an assessment of biodiversity assets for the Trento Province (northern Italy) in order to support environmental decision by a decision support system: the Information System of Ecological Value, or *Sistema Informativo della Sensibilità Ambientale* (SISA). This has been furnishing to planners value-based information, through a reliable and transparent evaluation, based on expert judgments, but this has some limitations for contexts of the valley floor and concerning ecological processes.
The attempt to solve the above mentioned shortcomings and the SISA limitations fostered the motivation behind this study. To this end, a methodology for ecological assessment was proposed. The overall objective is to support land-use planning towards development of ecologically sustainable landscapes. In particular, the ecological assessment concerns the main processes supporting local biodiversity in

human dominated and fragmented landscapes: habitat functioning and functional connectivity. The study has focused on one specific environmental context, i.e. the landscapes of the Alpine valley floor.
A secondary objective of the study was to develop a decision support system easily applicable by environmental agency officers or planners. This means requiring as few data as possible in order to permit reliable evaluation of planning ecological consequences even in the cases where poor data sets are available. These objectives were pursued through the following steps and intermediate objectives:

- Review the current studies on ecological/biodiversity impact assessment applications, in order to identify the shortcomings and key-issues that need to be addressed (chapter 2).
- Description of the relevant characteristics of targeted environment. In this study the chosen environment was Alpine valley floor, showing it requires urgent attention regarding biodiversity conservation (chapter 3).
- Development of a methodology for the assessment of landscape ecological functioning, attempting to overcome the literature limitations reported from literature review (chapter 4)
- Application of the proposed methodology on a case study within Alpine valler floor, to test the applicability and usefulness of the proposal (chapter 5 and 6).

The study derived the main theoretical foundation from landscape ecology; in particular, the main theoretical references were meta-population and spatial graph theory.
The proposed approach starts by acknowledging that patches of habitats are open or constrained by landscape barriers and interact with others throughout habitat networks. The evaluation approach relies on a dynamic, rather than a static, interpretation of ecosystems and living communities, by considering spatial attributes of habitat functioning. This is meant to include more components of biodiversity, rather than simple species number. Thus, different ecosystems could have been valued not only by the presence of species, but also by the virtue of the processes acting in the landscape and sustaining them.
The assessment framework involves three nested levels, each characterized by its own objects and properties, according to the complexity of hierarchical systems. The quality of each object depends on the quality of nearby objects at the same level and on the quality of upper-level (or lower-level) objects. This enables to evaluate "emergent properties" of a landscape; consequently allows assessing cumulative impacts on habitat functioning due to land-use changes, as shown in the case of master plans' mosaic for study area. The overall habitat loss resulted larger than that resulted by summation of single habitat losses.
The connectivity analyses include both structural and functional characteristics, using barrier effect and spatial graph concepts. Besides the distances, the species response to landscape features and finer-scale movement decisions are considered. The spatial graph of connectivity allows evaluating importance of patches by their contribution to overall connectivity. Thus, it permits to visualize remnant possible paths for species dispersal in highly fragmented areas. Moreover, the spatial-graph based approach allows assessing indirect impacts due to fragmentation. Since the loss of a habitat-node may affect not only nearby habitats but even the functioning of the whole habitat network, it is possible to scan the impacts "spreading" along the habitat networks.
The methodology output consists in a GIS-layer and rule sets hierarchically structured in a geodatabase. Once a land use changes, by performing the rule sets is possible update all related information providing assessment for land-use change scenarios (i.e. planning or project proposal).

The qualitative multi-attribute evaluation, proposed at the end of methodology procedure, performs a clear separation between prediction and assessment of impacts, according to guidelines for environmental impact assessment. This evaluation is meant to translate species-specific assessments into ecological relevance values. This makes the proposed methodology suitable for EIA applications and consequently may support the same environmental decision targeted by the SISA project.