



## Characterizing the fragmentation level of Italian's National Parks due to transportation infrastructures



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### ABSTRACT

In the last decades, due to the population increase and the relative need of new land to cultivate, expand urban centers and develop transportation networks, most of the Italian natural protected areas are subject to different typologies of human pressures that generally cause habitat fragmentation. This process represents a major concern for biodiversity conservation and a key driver of species loss.

The main purpose of this paper was to investigate levels of natural habitat fragmentation due to roads and railways networks in the Italian National Parks (INP<sub>s</sub>) through the use of an Infrastructural Fragmentation Index (IFI).

All the operations (geospatial analysis, image classification, and fragmentation analysis) were performed using a Geographic Information System (GIS) software for elaborating a national database. The obtained results include an IFI value for each natural territorial unit inside any INP. Moreover, in order to highlight which are the INP<sub>s</sub> characterized by higher infrastructural fragmentations, an IFI weighted mean was calculated for each INP. These results represent important indicators for the prioritization of biodiversity conservation interventions and the planning of a INP<sub>s</sub> sustainable management.

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### Introduction

One of the main threats to biodiversity arising from the past and present human activity is the fragmentation of natural habitats. This process produces a surface reduction and a progressive isolation of the natural areas that alters the structure and dynamics of several sensitive plant and animal species (Turbé et al., 2010). Through the fragmentation process, natural surfaces become spatially segregated, generating progressively isolated fragments of natural ecosystems localized into an anthropogenic territorial matrix. Among the main causes of territorial fragmentation there are transportation infrastructures. In this regard, Geneletti (2006a) sustained that, although transportation infrastructures are important for society providing connectivity for people, they represent the primary cause of habitat fragmentation. In fact, the infrastructure development has led to the loss, modification and fragmentation of natural habitats in those areas characterized by high human population density. Furthermore, the intersection of ecological corridors with road or rail networks acts as a barrier to all ecological processes leading to the loss of populations and species.

Recently, the territorial fragmentation process is having growing concern among European countries (Prillewitz, 1997). In fact, Europe as a whole has seen more habitat fragmentation than any other continent, having an increasing threat for its

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biodiversity heritage. According to the [Millennium Ecosystem Assessment \(2005\)](#), Europe has the highest level of habitats and ecosystems fragmentation. Specifically, between 1990 and 2006, the area of Europe covered by artificial surfaces increased by around 8% ([EEA, 2012](#)). This increasing proportion of the landscape used by humans has led to important decreases of natural surfaces. As sustained by [Geneletti \(2003\)](#), transportation infrastructures are blamed for highly contributing to the decrease in both the quantity and the quality of natural habitat. According to the European Environment Agency (EEA), roads, motorways, railways, intensive agriculture and urban developments are transforming European landscapes breaking up into ever smaller pieces, with potentially devastating consequences for flora and fauna across the continent ([EEA, 2011](#)). Furthermore, the renewable energy growth, in particular the bioenergy use by harnessing agro-forestry resources, became a further pressure factor owing to it is not still considered by land use planning ([de Santoli et al., 2014a](#)). The main result of this process is that in Europe, the majority of areas with high natural value (including those inserted in the Natura 2000 list), have become highly fragmented and isolated from one to another, determining serious consequences for the conservation of those species that use those areas.

In this contest, this paper presents one of the results of the multi-year collaboration in environment planning and management between the General Directorate for Nature and Sea Protection of the Italian Ministry for the Environment, Land and Sea, and Sapienza University of Rome.

The purpose of the project was to analyse impacts on biodiversity due to the human activities inside the Italian National Parks (INP<sub>s</sub>), in order to facilitate an environmentally sound management and planning of the natural protected areas. Specifically, after investigating habitat fragmentation due to urban settlements ([Astiaso Garcia et al., 2013a](#)) and environmental impacts related to buildings and facilities in natural protected areas ([Cumo et al., 2012](#); [Astiaso Garcia et al., 2012](#); [de Santoli et al., 2014b](#); [Astiaso Garcia et al., 2014](#)), the main aim of this paper was to investigate levels of natural habitat fragmentation due to the transportation infrastructures in the INP<sub>s</sub> through the use of an Infrastructural Fragmentation Index (IFI), considering the habitat fragmentation degree as a useful indicator for landscape and biodiversity protection and planning.

### Habitat fragmentation and the environmental impacts produced by transportation infrastructures

Habitat fragmentation is a process deriving from both natural or anthropogenic forces ([Blair et al., 2013](#)). It is commonly defined as the dynamic phenomena that generates a progressive decrease of natural environment areas increasing their isolation. [Heywood and Watson \(1995\)](#) define habitat fragmentation as the breaking up of extensive landscape features into disjointed, isolated or semi-isolated patches as a result of land use changes. For [Fahrig \(2003\)](#) it represents a landscape-scale process involving both habitat loss and the breaking apart of habitat. Generally, three main components of the habitat fragmentation process are identified ([Battisti and Romano, 2007](#)):

- reduction of the habitat fragments surface;
- increase of their isolation degree;
- reduction in quality/suitability of the residual fragments.

A first negative consequence of habitat fragmentation is the decrease in connectivity ([Burel and Baudry, 1999](#)). Generally, larger and connected ecosystems can better host and conserve local biodiversity compared to smaller and isolated ones ([Southerland, 1995](#)). Connectivity is a vital element of landscape structure and it plays an important role in ecological dynamics within and between habitats ([Bennett, 1990](#)), determining the degree to which the landscape facilitates or impedes the movement of organisms between patches ([Taylor et al., 1993](#)). For an exhaustive review on landscape connectivity see [Kindlmann and Burel \(2008\)](#).

As previously mentioned, the habitat fragmentation due to human pressures occurs mainly through the land consumption related to infrastructure works and/or building. The consequences for fauna and flora are so significant that reduce their survival chances. In particular, the loss of surfaces has significant ecological implications on a wide array of taxonomic groups, including birds, mammals, reptiles, amphibians, invertebrates and plants ([Fahrig, 2003](#); [Fischer and Lindenmayer, 2007](#); [Rosati et al., 2010](#)). Nonetheless, not all species have the same sensitivity to habitat and landscape fragmentation ([Aurambout et al., 2005](#)). As supported by [Lehmkuhl and Ruggiero \(1991\)](#), different species will be affected by different aspects of fragmentation. With regard to habitat fragmentation due to linear infrastructures, several studies focus on the analysis of the negative ecological effects produced by roads and other transportation infrastructures ([Andrews, 1990](#); [Forman and Alexander, 1998](#); [Fahrig and Rytwinski, 2009](#); [van der Ree et al., 2011](#); [Liu et al., 2011](#)). In fact, roads and railways represent new artificial elements that split the contiguous landscape units and interfere with the natural structure of the ecosystems, altering their ecological characteristics. For an exhaustive overview on this topic see [Iuell et al. \(2003\)](#). Here below the main negative ecological effects caused by transportation infrastructures on natural environments are summarized:

- *Edge effect*: It produces a transformation of the vegetation structure, the microclimate and the land cover in the fragments, which causes direct or indirect effects on the distribution and abundance of plant and animal species ([Laurance and Yensen, 1991](#); [Schonewald-Cox and Buechner, 1992](#));

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