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Viewpoints

More cool than tool: Equivoques, conceptual traps and weaknesses of ecological networks in environmental planning and conservation

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ABSTRACT

The paper critically examines the equivoques, conceptual traps and weaknesses of the recent 'ecological network' paradigm, invocated as a cool environmental planning tool to the aim to mitigate the effect of habitat fragmentation on biodiversity. We highlight as: (i) there is a semantic ambiguity deriving from the languages used in this interdisciplinary arena; (ii) these plans will be considered a true tool for biodiversity conservation when they will adopt a logic of problem solving and the standards requested in project cycle management (clear objectives, decision-making approach, appropriate monitoring and indicators, adaptive management); (iii) planners should follow a costs/benefits analysis comparing different scenarios and verifying that the 'connectivity' option effectively work better; (iv) each ecological network should be considered as a context-specific strategy where connectivity is only a simplified and schematic key of interpretation; (v) planners should carried out a local selection of fragmentation-sensitive targets that may not correspond with the species of conservation concern included in global or national red lists.

1. Introduction: connectivity as a paradigm shift

In the 1980s, no work on the conservation of threatened species could fail to incorporate the usage of 'population viability analysis' (PVA) and related basic and applied concepts (e.g. the SLOSS debate: the extinction vortex; Gilpin and Soulé, 1986) derived from the discipline of small population paradigm and management (Boyce, 1992; Durant, 2000). Actually, 'ecological connectivity' seems to have replaced PVA's and related concepts as the mainstream paradigm or 'key word' in conservation and landscape planning, especially in the developed world (Crooks and Sanjayan, 2006). Here, we refer to term 'connectivity' as a complex and non-linear phenomenon including many types of movement at species level (dispersion, dispersal, migration; Sheppe, 1965; Palomares et al., 2000; Bock et al., 2002; Mortelliti et al., 2007), and processes at higher ecological levels (Bennett, 1997; Van Vuren, 1999; Brooker et al., 1999).

The fact that habitat fragmentation represents one of the main threats to biodiversity at a continental, regional and landscape level (Davies et al., 2001; Haila, 2002; Fahrig, 1997; Fahrig, 2003; Lindenmayer and Fisher, 2006) has led to the conclusion that connectivity, as a concept, and ecological networks, as an operational tool, are a major answer to maintain healthy ecosystems and biodiversity (Linehan et al., 1995; Rosenberg et al., 1997; Bennett, 1998; Battisti, 2003; Boitani et al., 2003).

Ecological networks are defined as an interconnected system of habitats whose biodiversity needs to be safeguarded (Jongman, 1995). In this case the geometry of the network has a structure based on the recognition of core areas, buffer zones and corridors that allow the exchange of individuals in order to reduce the extinction risk of local populations. The ecological network concept has been used as a suitable basis for inserting biodiversity conservation into sustainable landscape development (Opdam et al., 2006). More in particular, ecological networks changed the conservation focus from rescuing isolated habitats to insuring overall ecological integrity and have been considered land use planning tools aimed to conserve structure and function of ecosystems, also providing present and future open space needs, and allow for economic growth and development (Linehan et al., 1995). Ecological network as a concept has therefore been included amongst the recent paradigms in conservation biology and landscape planning (sensu Salafsky et al., 2008) to contrast habitat fragmentation. Habitat fragmentation is a complex process that develops anthropogenic land use/cover patterns at different spatio-temporal scales. It may be disentangled in three main coarsencrease in their degradation (e.g. (i) increase of anthropogenic disturbances originating from the surrounding landscape matrix; ii) reduction in area size of habitat fragment, iii) increase of their isolation; Fahrig, 2003). The effects of this process are

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extremely varied, being target specific, where targets are plant and animal communities, species populations, and ecosystem processes. Moreover, historical and geographic contexts may produce further differences in biological (target) responses to habitat fragmentation (Battisti, 2003; Cristoffer and Peres, 2003; Brook and Bowman, 2004; see Swetnam et al., 1999 and the historical applied ecology approach).

However, since this complexity is due to different scales, targets, and contexts (see the "panchreston effect" in Lindenmayer and Fisher, 2007), it has been highlighted as an uncritical analysis of habitat fragmentation process and an automatic and dogmatic development of ecological network strategies may have futile results. Following the theoretical background available from the researches on the effects of habitat fragmentation, the ecological networks as a conservation tool should therefore take in account (see Huber et al., 2010): i) an increase of size of remnant habitat fragments; ii) a decrease in the level of their isolation (e.g., increasing connectivity); iii) a mitigation of the habitat degradation (e.g. acting on matrix disturbances) (Bennett, 1997; Ewers and Didham, 2006). In a project cycle logic (see Hockings et al., 2006), these strategies and measures should represent outputs that indirectly might act on target viability (e.g. increasing the density of target species/populations, species richness in communities, etc.), this last representing the true outcomes of conservation.

Despite their simple and persuasive logic, in this work we will highlight some equivoques, weaknesses, and conceptual traps that all too often continue to characterize the ecological network strategies. Therefore, we will define the following topics: (i) the problem of semantic ambiguity; (ii) the arena of ecological network planning (landscape planning or conservation biology?); (iii) the need of a decision-making approach with a costs/benefits analysis; (iv) the lack of an universality of 'connectivity' message; and (v) the selection of local fragmentation-sensitive species as indicators.

2. A semantic ambiguity

Considering that the ecological network planning is adopted from different professionals (urban and environmental planners, conservation biologists and practitioners, ecologists, politicians) having a variety of languages and jargons, communication could be affected by a semantic ambiguity, corresponding to the uncertainty arising from the fact that a word can have more than one meaning and it is not clear which meaning is intended (Regan et al., 2002; Battisti, 2011).

Different disciplines have different jargons and frameworks to ensure internal linguistic and conceptual rigor and, often, different targets (Campbell, 2005). In this sense, 'network' is the keyword largely used in our digital era and the 'network' paradigm is now included in many disciplines (from hard sciences, to organizational management areas and digital sciences, to biology, functional ecology and urban planning and others; e.g. Watts and Strogatz, 1998; Jeong et al., 2000; Opdam et al., 2006; Zhang et al., 2011), so inducing a semantic ambiguity.

Also in the landscape planning arena the word 'network' (and the consequent ecological network concept) has been equivocated, so that the 'net' metaphor emphasized only the measures focused to build networks among habitat patches through an increase of focus on nodes and corridors and forgetting the role of the interposed spaced between them (the landscape matrix).

Analogously, to other terms different meanings have been assigned inducing an ambiguity: among these the concept of corridors, continuity, connectivity and ecosystem (Bennett, 1997; Rykiel, 2001; Pickett and Cadenasso, 2002). For example, regarding the term 'connectivity', isolation affects movement but many ecological networks lack information on the type of isolation affecting the target populations: an isolation due to a diffused landscape matrix (e.g. intensive crop lands) acts differently to the isolation due to highways and roads (for individual carnivores, collisions with vehicles represent an important source of mortality during dispersion; Reed et al., 1996; Spellerberg, 1998; Van Vuren, 1999; Battisti et al., 2012). The first decreases connectivity due to isolation for distance, the second one act as a true barrier. The implications on the remnant isolated populations are very different but they are regularly confounded overall when 'connectivity' was used in a dogmatic and uncritical approach.

3. Ecological networks: landscape planning or conservation biology?

Due to the political appeal of two strong key words ('ecological' and 'networks'); the integrated ecological networks have been largely invocated as a cool tool in landscape and urban planning in order to create a system of 'green areas' or 'green infrastructures' using the connectivity paradigm (Little, 1990; Bueno et al., 1995; Gobster, 1995; Jongman, 1995; Cook, 2000; James et al., 2000; Crofts, 2004; Jongman and Pungetti, 2004; Beunen and Hagens, 2009; Hoctor et al., 2000; Gurrutxaga et al., 2010; Wickham et al., 2010; Rodríguez-Rodríguez, 2012; Pino and Marull, 2012; Jain et al., 2014; Lennon et al., 2015; De Montis et al., 2016).

Nevertheless, this tool is marginally considered in the arsenal of conservation (Boitani et al., 2007). For example, the term 'ecological network' has been excluded in a large number of reviews on connectivity conservation as a branch of conservation biology (Soulé and Orians, 2001; Crooks and Sanyajan, 2006; Lindenmayer and Fischer, 2006). As a consequence, a doubt arises that the ecological networks as a planning tool are only weakly embedded in conservation biology, mainly for a lacking of monitoring and adaptive management design testing its effectiveness, as requested in any conservation project cycle (Groves et al., 2002; Hockings et al., 2006).

Therefore, the use of ecological networks in landscape planning does not follow the basic criteria used in problem-solving strategies promoted by conservation biologists. In this sense, the ecological networks nowadays seem to exhibit more of a cool planning approach rather than a true tool for conservation strategies ("more cool than tool"). In the first case (landscape planning), ecological networks appear as politically-driven descriptive design that define deterministic corridors, buffer zones, stepping stones and core areas and, excluding limited examples (e.g. Bani et al., 2002; Jongman et al., 2011), without an appropriate scheme that include a set of goals, indicators, monitoring plans and adaptive management strategies (reviews in Bennett, 2004; Bennett and Mulongoy, 2006). To our knowledge, monitoring programmes testing the effectiveness of ecological network plans using a project cycle logic are totally lacking, at least in a large part of Europe (see examples in Filpa and Romano, 2003; Jongman and Pungetti, 2004).

In the case of conservation biology, ecological corridors should be considered as target-specific strategies characterized from: i) a definition of specific and objectives (declined for time span, space, targets, and hypothesized change in target attributes and parameters), ii) a rigorous monitoring programme of outputs and outcomes to evaluate the success, iii) an adaptive management processes (Margoluis and Salafsky, 1998; Miradi, 2008; Margoluis et al., 2009). Moreover, a conservation-based ecological network plan, should be correctly defined in terms of targets involved (at level of population/species, communities, ecosystems) and socio-historical constraints determining the local and context-specific habitat fragmentation (e.g. human-induced threats and their driving forces).

4. Prioritization and cost/benefits balance

The prioritization of actions in a strategy developed in a fragmented landscape should follow a decision-making approach, so assessing the costs/benefits balance and comparing alternative approaches (Magee, 1964; Clemen, 1996). For example, the use of scenario analysis has been suggested in planning and conservation strategies (Simberloff et al., 1992; Thompson et al., 2012). Nevertheless, although it has been utilized in a large number of sectors (land use planning: Roetter et al.,

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