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Integrating priority areas and ecological corridors into national network for conservation planning in China

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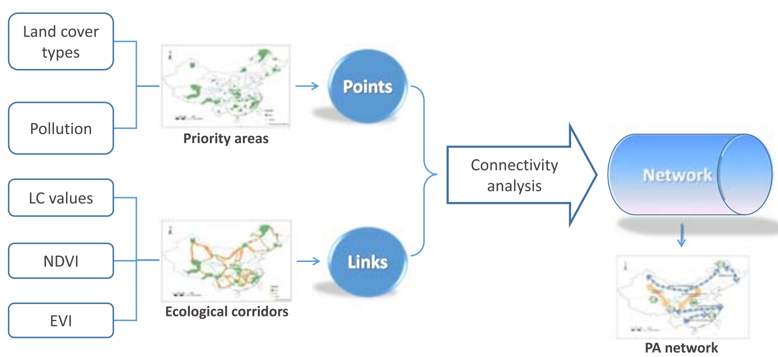
HIGHLIGHTS

- The method integrates priority areas and ecological corridors to the PA network.
- Spatial mismatch exists between nature reserves and priority areas.
- Patches with large areas, long boundaries contribute to high connectivity.
- Ecological network illuminates a strategy for strengthening PAs in China.

GRAPHICAL ABSTRACT



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ABSTRACT

Considering that urban expansion and increase of human activities represent important threats to biodiversity and ecological processes in short and long term, developing protected area (PA) network with high connectivity is considered as a valuable conservation strategy. However, conservation planning associated with the large-scale network in China involves important information loopholes about the land cover and landscape connectivity. In this paper, we made an integrative analysis for the identification of conservation priority areas and least-cost ecological corridors (ECs) in order to promote a more representative, connected and efficient ecological PA network for this country. First, we used Zonation, a spatial prioritization software, to achieve a hierarchical mask and selected the top priority conservation areas. Second, we identified optimal linkages between two patches as corridors based on least-cost path algorithm. Finally, we proposed a new framework of China's PA network composed of conservation priority and ECs in consideration of high connectivity between areas. We observed that priority areas identified here cover 12.9% of the region, distributed mainly in mountainous and plateau areas, and only reflect a spatial mismatch of 19% with the current China's nature reserves locations. From the perspective of conservation, our result provide the need to consider new PA categories, specially located in the south (e.g., the middle-lower Yangtze River area, Nanling and Min-Zhe-Gan Mountains) and north regions (e.g., Changbai Mountains), in order to construct an optimal and connected national network in China. This information allows us better opportunities to identify the relative high-quality patches and draft the best conservation plan for the China's biodiversity in the long-term run.

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1. Introduction

Protected areas (PAs) are regarded as one of main strategies for halting biodiversity loss resulted from land use change, habitat loss and fragmentation (Le Saout et al., 2013; Rodrigues et al., 2004; Thomas et al., 2012). The Aichi Biodiversity Targets accepted by the Convention on Biological Diversity (CBD; available in www.cbd.int/sp/targets/) proposed that global coverage of PAs should not be less than 17% of the total terrestrial surface by 2020. Well-designed PAs are essential for the conservation of both species and ecosystems (Bruner et al., 2001; Game et al., 2009), as well as, consequently, bringing benefit to society (Guerry et al., 2015). In fact, many authors showed that PAs carry out, in a medium and long term, a valuable role in developing reliable adaptation and mitigation strategies to conserve the biodiversity of focal ecosystems under future climate change scenarios (e.g., Ortega-Andrade et al., 2015; Prieto-Torres et al., 2016; Soares-Filho et al., 2010).

To effectively connect the key areas that may differ in shapes and sizes, and reduce the isolation of habitat fragments, both ecologists and conservation biologists recommended constructing ecological corridors (ECs; Peng et al., 2017). These corridors play an important role in providing routes and extended districts for the migratory species (Aars and Ims, 2008; Lynne et al., 2010); but at the same time they represent a valuable conservation tool promoting purify air pollutant, regulate climate and realize the movement of material, energy, and information in the ecosystem (Singh and Gokhale, 2015). Environmental protection organizations recognized the importance about the establishment of large-scale ECs for landscape connectivity, biodiversity restoration and, consequently, to maintain the ecological integrity of ecosystems (Bowers and Mcknight, 2012; Holland, 2012; Huang et al., 2008). Thus, in view of the scenarios mentioned above, some authors proposed an ecological network approach based on sustainability-related indicators into high-priority areas and their linkages (Théau et al., 2015).

An ecological network involves, usually, two parts during its development. One of them, named as "ecological points", represents the priority areas distributed spatially in areas with high biodiversity and conservation values (Nitu et al., 2014), while, the other (called "ecological links") is described as the narrow and linear (or near-linear) corridors that comprise the possible areas used directly by organisms to move from one patch to another (Beier and Noss, 1998). Hence this alternative conservation approach can be capable to maintain the protection challenges no matter the environmental and ecological (e.g., moves of species) changes at least in some extent. However, so as to maximize the efficiency of ecological network conservation, it is important to establish landscape connectivity among isolated biotope (Baranyi et al., 2011). This landscape connectivity (considered as the measure to describe the spatial connection and extension of areas) is very important because it ensures the possibility of dispersal and gene flow among populations of species, as well as other ecological functions of ecosystems (Haddad et al., 2003; Saura and Rubio, 2010; Tang et al., 2008). Maintaining or increasing connectivity denotes a better strategy to mitigate the adverse synergistic effects of habitat fragmentation and climate change (Prieto-Torres et al., 2016; Saura et al., 2011b).

Our case of study for ecological network construction is China, where a rapid economic development has produced a decrease in biodiversity and environmental degradation (Jia et al., 2011). The primary category within the China PA system involved the nature reserves (where anthropogenic activities are controlled and limited by the national laws to conserve nature), representing 80% of protected areas (Xu et al., 2017). Although these reserves can preserve some habitats and particular threatened species, it is important to objectively highlight that their current spatial delimitations are promoting the configuration of islands ecologically separated (Roedder et al., 2016; Zhang et al., 2016). Despite the increasing habitat fragmentation and global biodiversity crisis, the current application of ECs in China is limited only for local scale or in particular regions, without a global perspective for the landscape connectivity and ecological integrity (Dong et al., 2015; Kong et al., 2010). These cases mainly focused on urban greening (Yu et al., 2006). It represented an important problem and conservation gap for the country, especially if we considered that ecological network was changing from the micro to macroecology perspective to design efficient strategic planning (e.g., Ferretti and Pomarico, 2013; Samways and Pryke, 2016).

In this paper, we implemented an ecological network analysis for strengthening the PA system of China to identify and address the potential conservation gaps mentioned above. This methodological perspective allow us identify new potential conservation areas to promote the creation of a more representative, connected and efficient network for this country, maximizing the representation of biodiversity and improving the conservation of ecosystems in the medium and long term. This information is of great value because it can provide new and more accurate evidence that can guide current conservation decision-making processes.

2. Materials and methods

2.1. Environmental and spatial data

For our spatial analyses we used the information available in the land cover (from Global Land 180 Cover by National Mapping Organizations, http://www.iscgm.org/) and nature reserves (IUCN and UNEP-WCMC 2010; available at https://www.protectedplanet.net/) maps of China, as well as the Enhanced Vegetation Index (EVI) and Normalized Difference Vegetation Index (NDVI) from Atmosphere Archive & Distribution System (LAADS) Distributed Active Archive Center (DAAC, https://ladsweb.modaps.eosdis.nasa.gov/). In the first step, land cover types were classified into eight categories, including the broadleaf forest, coniferous forest, shrub, herbaceous plant, sparse vegetation, wetland, water body and urban area (Wang et al., 2009; Xiao et al., 2016). Then, we assessed the vegetation quality of the study area according to EVI and NDVI, which were obtained based on the data time series from January to December 2013, provided every 16 days at 500 m spatial resolution as a raster level-3 product. Finally, we downloaded the shapefiles for the 2158 China's nature reserves from World Database on Protected Areas (WDPA) provided by the United Nations Environment Programme (UNEP). All data were used in raster format with the same spatial resolution of NDVI maps (i.e., grid cell size corresponding to 500 m in each raster).

2.2. Conservation areas prioritization

We identified priority areas using the Zonation v4 software tool which is particularly well suited for large-scale high-resolution datasets (Moilanen et al., 2011). It starts from the entire landscape and then iteratively removes the least important site, considering distributions and weights of biodiversity features. Though using a set of species' distribution features could be considered as a better approach than biodiversity features based on ecosystem maps (e.g., Fajardo et al., 2014; Lessmann et al., 2014; Prieto-Torres and Rojas-Soto, 2016), we performed the analysis to define priority areas to protect by using the reclassified land cover map due to the fact that China involves a long species list and the individual biological information is difficult to obtain (e.g., Songer et al., 2012; Wan et al., 2017). In this sense, we considered the first seven established categories (see above) as important Chinese habitat types to protect (Wang et al., 2009; Xiao et al., 2016). For each of these habitats we assigned weights values (Table 1) according their priority and ecological importance (Liu et al., 1999; Shen et al., 2008). Contrarily, the remaining last one, namely urban area, was considered as the source of pollution that might cause future degradation of habitat quality; accordingly, we assigned negative weights (i.e. "penalization") to pixels covered by these areas.