Research article

Prioritizing conservation areas for coastal plant diversity under increasing urbanization

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ABSTRACT

Coastal urban expansion will continue to drive further biodiversity losses, if conservation targets for coastal ecosystems are not defined and met. Prioritizing areas for future protected area networks is thus an urgent task in such urbanization-threatened ecosystems. Our aim is to quantify past and future losses of coastal vegetation priority areas due to urbanization and assess the effectiveness of the existing protected area network for conservation.

We conduct a prioritization analysis, based on 82 coastal plants, including common and IUCN red list species, in a highly-urbanized but biotically diverse region, in South-Eastern France. We evaluate the role of protected areas, by taking into account both strict and multi-use areas. We assess the impact of past and future urbanization on high priority areas, by combining prioritization analyses and urbanization models.

We show that half of the highly diverse areas have already been lost due to urbanization. Remaining top priority areas are also among the most exposed to future urban expansion. The effectiveness of the existing protected area (PA) network is only partial. While strict PAs coincide well with top priority areas, they only represent less than one third of priority areas. The effectiveness of multi-use PAs, such as the Natura 2000 network, also remains limited.

Our approach highlights the impact of urbanization on plant conservation targets. By modelling urbanization, we manage to identify those areas where protection could be more efficient to limit further losses. We suggest to use our approach in the future to expand the PA network in order to achieve the 2020 Aichi biodiversity targets.

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1. Introduction

Urbanization is one of the main factors of long-lasting land transformation and a major threat to biodiversity worldwide (Grimm et al., 2008; McKinney, 2002; Seto et al., 2011). Coastal areas are particularly affected by both increasing urban population and mass tourism that lead to the rapid development of urbanized areas and consequently to losses of natural habitats (Airoldi and Beck, 2007; Bulleri and Chapman, 2010). Connecting land and sea, coastal habitats often stand out by a unique plant diversity and high specialisation within strong ecological gradients at small spatial scales (Médail and Quézel, 1997). Many coastal plants are adapted to stressful levels of salinity, drought and temperature (Baastrup-Spohr et al., 2015; Malcolm and Zedler, 1995) and are thus highly vulnerable to habitat decrease (Stefanaki et al., 2015). The conflict between human pressures and conservation of irreplaceable, vulnerable biodiversity makes prioritizing conservation actions within coastal zones particularly urgent.

The Mediterranean basin is a typical example, even though it covers only 2% of the Earth's land surface, it holds over 20% of the known vascular plant species. It harbours particularly high proportions (>50%) of endemic species (Greuter, 1994; Médail and Quézel, 1997). Therefore, Mediterranean coasts are recognized for their important diversity of habitats and species (Cox and

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Underwood, 2011). In parallel, the long human history in the Mediterranean has led to densely populated cities within narrow coastal fringes (UNPD, 2012). Nevertheless, we still know little of what has already been lost (but see Brown and McLachlan, 2006 for dune ecosystems) and whether current protected areas (PAs) are effective for conservation of coastal biodiversity against urbanization.

Adequately protecting the coastal diversity with appropriate conservation measures requires coordinating conservation efforts for the designation of new reserves (Cox and Underwood, 2011) and accounting for species with various rarity and vulnerability levels (Gauthier et al., 2013, 2010). The development of systematic conservation planning (Margules and Pressey, 2000) permits the identification of irreplaceable areas with regard to biodiversity and the optimization of conservation efforts so as to increase complementarity among reserves (Brooks et al., 2006; Cabeza and Moilanen, 2001). Systematic conservation planning also enables to take vulnerability into account and thus to react faster to potential human pressures (Pressey et al., 2007, 2004). To anticipate future losses of priority areas due to urbanization and to meet conservation targets, reserve planning should combine information from species distribution, prioritization and land-use modelling (Montesino Pouzols et al., 2014).

Plant species vary in habitat specificity, which interacts with threats due to human activities. For example, in dune habitats plant biodiversity has already largely been lost and most of the remaining species, though widespread, are threatened by extinction (Lavergne et al., 2004; Lhotte et al., 2014). Contrastingly, endemic species from rocky outcrops are rare and narrow-ranged, but their habitat is little amenable to deterioration, including to urbanization (Lavergne et al., 2005). These examples highlight why it is important to separate regressing and rare species. Therefore, we advocate the use of IUCN criteria documented in red list classifications to achieve this distinction (Noble et al., 2015). While these contrasted cases are not clearly separated in global assessments such as IUCN red lists, new criteria for prioritization have been proposed (Bacchetta et al., 2011; Gauthier et al., 2010; Schatz et al., 2014). Given the contrasting significance of rarity and decline for conservation, we decided to specifically focus on rare and declining species separately.

Here we propose 1) to quantify past, present and future losses of coastal habitats due to urbanization, based on the irreplaceability of their flora, 2) to assess the effectiveness of existing protected areas (PAs) for conservation of coastal plant diversity and to define the importance of strict compared to multi-use PAs (Brooks et al., 2006; Leroux et al., 2010; McDonald and Boucher, 2011), and 3) to identify non-protected high priority areas, that would optimally complement the existing network. We worked on the coast of the Provence-Alpes-Côtes d'Azur region in France, a densely populated and highly visited tourist destination. One quarter of the areas that were urbanized during the period 1990–2012 lie within the first 15 km from the coast, in Mediterranean habitats of an exceptionally rich plant diversity, including unique coastal dune and rocky habitats and two thirds of the plant species found in France (Médail and Verlaque, 1997).

We conducted several scenarios of conservation prioritization analyses, based on species distribution models. First, we prioritized areas based on all coastal plants, and then did a separate analysis for plants with conservation status according to IUCN, by separating further rare and declining plants. Secondly, we combined conservation priorities with a simple urbanization model to assess what has already been lost due to urbanization and what could be lost in the near future. We propose to extend protected areas to 17% of the coastal area in order to meet the 2020 Aichi biodiversity targets and to optimally prevent future plant diversity losses. Our results have interesting implications for conservation in the Mediterranean region and our approach is applicable to any type of ecosystem.

2. Material and methods

2.1. Study region and plant data

The analysis was conducted on the coastal zone of the Provence-Alpes-Côte d'Azur (PACA) region in France. We focussed on a 10-km band from sea, where urbanization mostly impacts coastal vegetation and challenges existing conservation plans. We accounted for all protected areas (PAs) situated within this coastal zone (Fig. 1) and separated them into two categories: 'strict' and 'multi-use' PAs, using the IUCN protected area categories (McDonald and Boucher, 2011). We considered protected areas as 'strict', when their conservation status effectively restricts human activities, including National Parks, National Nature Reserves, areas managed by the French Coastal Conservation Agency (Conservatoire du Littoral) and
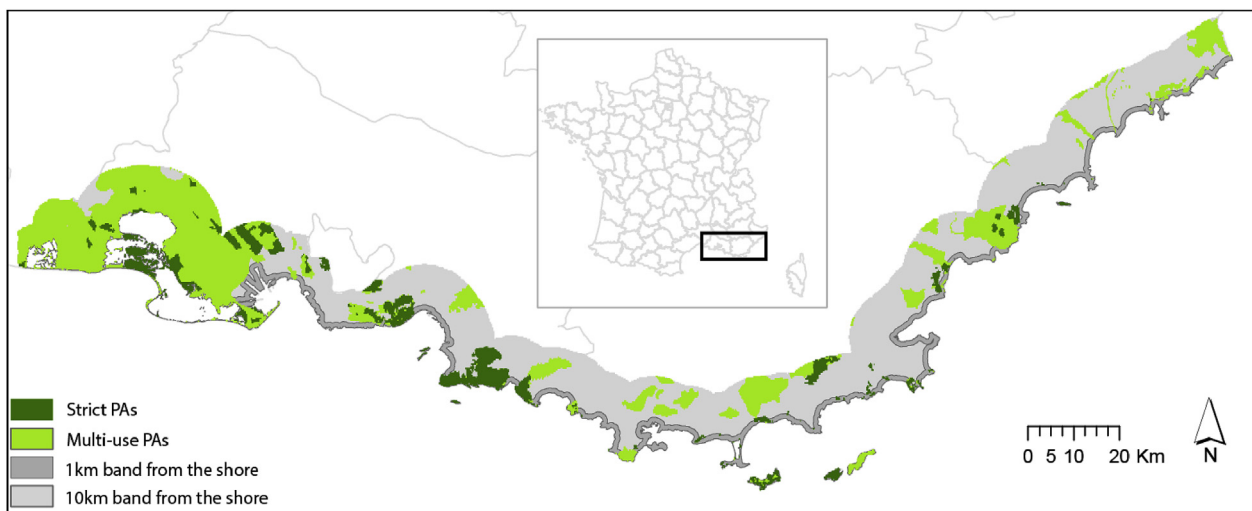

Fig. 1. Study region and existing strict and multi-use protected areas.