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Conservation planning to zone protected areas under optimal landscape management for bird conservation

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ABSTRACT

This study proposes a two-stage conservation planning approach. Firstly, the Land-Use Pattern Optimization-library is used to maximize the suitability of habitats for target species by optimizing configuration based on the current landscape. Secondly, the systematic conservation planning tool, Marxan is used to identify protected areas based on the estimated species distributions from the optimal landscape configuration. We compared our conservation plan for three target bird species from a highland farm with the conservation plan produced using Marxan alone. Our comparison showed the effectiveness of our approach by selecting a reserve network with higher habitat suitability, better connection, and smaller size after relatively minor landscape modification. The proposed approach advances previous reserve site selection algorithms by considering optimal landscape configuration and potential species distributions for a reserve network design. Our approach yields priority maps to guide the design of a reserve network as well as identify landscape management for conservation.

Software availability

Name: LUPOlib 1.0
Programming language: C/C++
Developer: Annelie Holzkämper
Availability: http://www.ufz.de/index.php?en=17779
Name: Marxan Optimized Version 2.43
Developer: Matt Watts
Hardware required: PC
Software required: X64 Windows OS
Availability: http://www.uq.edu.au/marxan/marxan-software

1. Introduction

The purpose of conservation planning is to identify cost-effective, representative and complementary biodiversity conservation areas for the protection or restoration of species or habitats (Margules and Pressey, 2000; Margules and Sarkar, 2007; Hermoso et al., 2013). Systematic conservation planning (SCP) uses quantitative and systematic approaches for design reserve networks that conserves species according to the conservation planning principles (Margules and Pressey, 2000; Margules and Sarkar, 2007; Klein et al., 2009). SCP has been applied to terrestrial (Smith et al., 2006; Zhang et al., 2012; Levin et al., 2013; Nackoney and Williams, 2013), marine (Smith et al., 2009; Delavenne et al., 2012; Levy and Ban, 2013), and freshwater ecosystems (Linke et al., 2012; Esselman et al., 2013). SCP principles have also been applied to the design of restoration priorities in degraded landscapes (Crossman and Bryan, 2006; Bryan and Crossman, 2008).

The last two decades have seen a large growth in quantitative systematic spatial conservation approaches and tools (Ball et al.,

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1364-8152/

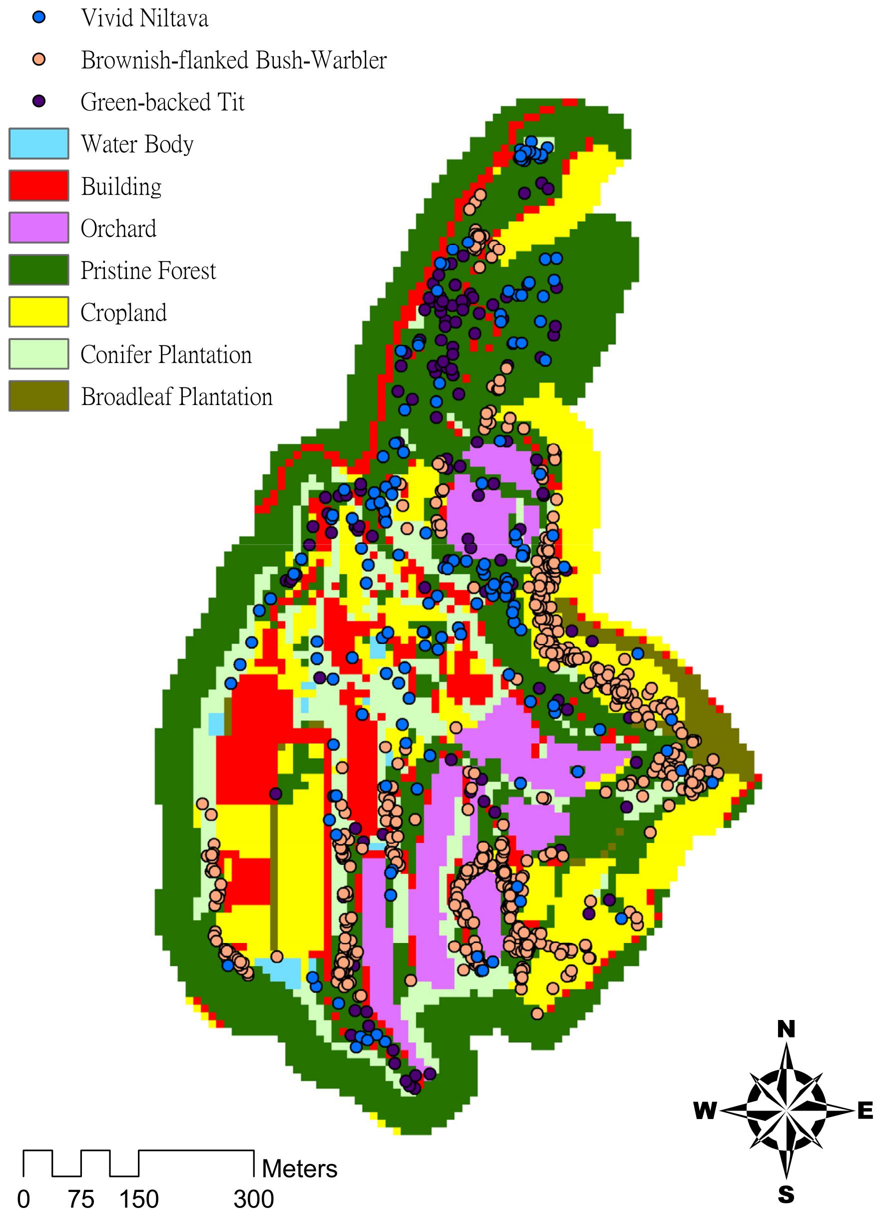

Fig. 1. Land-use of the Highland Experimental Farm, National Taiwan University, and distributions of each target species, the Vivid Niltava, Brownish-franked Bush-warbler, and Green-backed Tit. The Vivid Niltava was found mainly in the central forest, with more frequent anthropogenic disturbances; the Brownish-flanked Bush-warbler was found mainly in forest and cropland in the eastern part of the study area. The Green-backed Tit was found mainly in pristine forest in the northern part of the study area, which is less affected than other parts by human activity. The distributions of the first two species are strongly related to the volume of the foliage in the canopy while the last species favors shrubs (Lin et al., 2011).

2009). Marxan software (here after referred to as Marxan) (Ball and Possingham, 2000), Zonation (Moilanen, 2007; Lehtomäki and Moilanen, 2013), Consnet (Ciarleglio et al., 2009) and C-Plan (Pressey et al., 2009) all implement target-based planning as the primary planning method (Minin and Moilanen, 2012). Popular among these tools is the use of quick heuristic-based algorithms to perform spatial optimization to achieve conservation goals. Simulated annealing (SA) has been used to identify spatial prioritization for locating reserved planning units, as in Marxan (Ball et al., 2009). Marxan is now a widely used tool for performing spatial prioritization in SCP (Zielinski et al., 2006; Zhang et al., 2012; Levy and Ban, 2013) and to cost-effectively select protected areas that support conservation targets (Delavenne et al., 2012).

Most approaches to SCP are limited by their binary decision framework, except the approach described in Watts et al. (2009). Such a framework cannot simultaneously capture the full range of potential management nor conservation actions as part of SCP (Moilanen et al., 2009; Watts et al., 2009) and cannot consider spatial patterns within the selected areas despite land-use patterns being a major driver of ecosystem functions and services (Crossman et al., 2013; Labiosa et al., 2013). A genetic algorithm-based spatial optimization model, the Land-Use Pattern Optimization-library (LUPOlib) (Holzkämper et al., 2006; Holzkämper and Seppelt, 2007a,b) could be used in combination with existing reserve site selection algorithms to assess beforehand the spatial patterns of landscape elements for habitat suitability in protected areas. LUPOlib has been used to solve conservation planning-type problems, such as optimizing the trade-off between ecological and economic objectives and optimizing landscape management actions (Holzkämper and Seppelt, 2007b). We suggest that SCP could be enhanced by combining optimal landscape management with conservation planning of reserves. Current approaches to SCP