Abstract

At present, conservation planning softwares are dominating the field of spatial biodiversity conservation planning. The implementation of popular conservation planning algorithms typically produces arbitrary conservation designs, though, due to the lack of data contextualization for individual conservation features. The resulting conservation designs also suffer from a paucity of temporal analysis, often carried out with little thought for combatting unexpected biodiversity loss.

Here, we compare and contrast the benefits and constraints of two main approaches to conservation planning, the criteria-based Key Biodiversity Areas (KBA) approach and the complementarity Systematic Conservation Planning (SCP) approach, and prove that the implementation of a certain mathematical metric (*gamma irreplaceability*) significantly improves biodiversity retainment in biodiversity-relevant spatial conservation planning.

Criteria-based conservation approaches identify sites in significant need for conservation, but are often seen as redundant within a complementary national conservation plan. Complementarity approaches such as SCP, on the other hand, are able to minimize redundancy and maximize representation of a broad range of biodiversity features. Here, we review 200 papers that applied SCP using the Marxan conservation software, an algorithm that uses simulated annealing to return the lowest cost conservation design while meeting the minimum user-inputted requirements. When the user inputs their conservation problem into Marxan, they must associate targets for each individual conservation feature, often a percentage target of that feature's range or area of habitat. Of the 200 reviewed papers, we found that over 80% of the applications incorporated arbitrary target-setting methods, with 36% of the total studies using the same percentage target for every conservation feature at hand. Only 11.5% of applications used biodiversity element-specific targets. We use these findings to propose a robust framework for conservation planning that encompasses elements from both the KBA and SCP approaches that should be considered for global biodiversity conservation frameworks.

There is limited methodology when it comes to combating random site loss, or future unexpected biodiversity area loss, during field implementation of spatial conservation plans. Here we simulate random site loss using hexagonal-raster species distribution data in the British Isles, Madagascar, Poland, Australia, Central Africa, and Central America. For all of the regions, "dummy" conservation designs were developed using the Prioritizr R Package, similar to Marxan, with arbitrary targets of 10%, 25%, and 50% of species' ranges and areas of habitats respectively. Random site loss was simulated 100 times for each conservation target for each region, resulting in 3,600 iterations. We show that prioritizing the protection of cells with a higher *gamma irreplaceability* score first, rather than protecting the cells in the conservation area in a random order, yields a significant reduction in random site loss. At 99% confidence, our t-test reveals a significant reduction in random site loss when prioritizing the protection of sites based on *gamma irreplaceability* ($p < 0.1$), supported by a non-overlapping confidence interval [*c1* - *c2*] that does not include zero. We believe that these results emphasize the importance of incorporating *gamma irreplaceability* in future spatial biodiversity conservation frameworks.