21-Oct-2019

Dear Dr. Schuster:

Thank you very much for submitting your manuscript "Integer linear programming outperforms simulated annealing for solving conservation planning problems" # EAP19-0403 to Ecological Applications. The reviewers appreciated the work you have accomplished, but they raised substantial concerns about the paper. Based on the reviews, we will not be able to accept this manuscript for publication in the journal.

We are rejecting for several reasons. First, reviewer # 1 notes that your study makes many of the same points as an already published study: Beyer et al. (2016) also finds that ILP outperforms SA. Unlike Bayer et al. (2016) you use one set of observed data. However, this difference is not great enough to warrant publication. Second, reviewer # 2 found your spatial conservation prioritization program's objective problematic (see their review for details). Reviewer # 2 also worries that a reader would have the impression that ILP always finds the best solution irrespective of the taxa, location, extent, scale, etc., after reading your manuscript. Reviewer # 2 would have liked to see additional work on a more general validation of your results.

The reviews are copied below, and we hope they will help you should you decide to revise the manuscript for submission elsewhere. Thank you again for thinking of the Journals of the Ecological Society. We will look forward to further contributions from you and your colleagues.

Sincerely,

Dr. Erik Nelson

Subject Matter Editor, Ecological Applications

[enelson2@bowdoin.edu](mailto:enelson2@bowdoin.edu)

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Although your manuscript was not accepted for publication in Ecological Applications, we believe your manuscript is a strong candidate for potential publication in Ecosphere, a peer-reviewed, open-access, interdisciplinary journal providing rapid publication of high-quality research by the Ecological Society of America (ESA). Ecosphere has a similar standard for high-quality science as all of the ESA journals, but with a much quicker publication time, a broader scope, and fewer constraints on page lengths than the traditional journals.

I am willing to consider a version of your manuscript following major revision that addresses the concerns of the reviewers. You should also send a cover letter indicating your response to the review comments and the changes you have made in the manuscript. If you disagree with a reviewer's point, please explain why.

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Dr. Debra Peters

Editor-in-Chief, Ecosphere

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Reviewer(s)' Comments to Author:

Reviewer: 1

Comments to the Author

Overall impression:

In their article the authors compare the performance of two integer linear programming (ILP) solvers with a simmulated annealing (SA) solver for a real-world conservation planning problem. The results show that ILP outperforms SA. Overall, the article is well written. The topic is highly relevant for spatial conservation planning and fits the journal’s scope. There are a few comments stated below that should be clarified. Additionally, I would like to mention that the findings of this study are not entirely new. Beyer et al. (2016) – also cited in this study – already came to the same conclusion that ILP outperforms SA, also in a conservation planning context and using the same solvers (Marxan and Gurobi). The main difference I can see so far is that they used simmulated data and smaller problem sizes. Therefore, I suggest that the authors add more information to the manuscript about the novelty of their study compared to Beyer et al. (2016).

Comments:

~~Line 80: Check grammar.~~

~~Lines 82-88: A map would be nice and information about the land cover of the 20 % that are not mentioned in the text.~~

~~Lines 96-99: Why did you do that? For statistcal comparability?~~

~~Lines 128-129: For better understanding of the optimization problem and to make repeatability of the method easier, it would be helpful to give the problem formulation in a way like: min cost ; s.t. conservation value ≥ target. Additionally (but optionally), you could state the proper mathematical problem formulation in the Appendix for interested readers.~~

~~Lines 143-145: “Gurobi Optimization Inc. provides…” – I would erase this sentence since this piece of information is not relevant for the study.~~

~~Line 159: Why is there such a big gap between the second last (25) and the last (125) SPF you tested?~~

Lines 120 & 253-255: The formulation in lines 253-255 sounds like ILP algorithms outperform SA for all types of conservation planning problems. In line 120 you mention that you tested the algorithms for the minimum set problem which is one of the simpler problem formulations of spatial conservation prioritization problems. Do you think that ILP would also outperform SA for more complex problem formulations, e.g. dynamic problems, problems with more objectives, etc. given that they can be transformed into an ILP? The discussion could be improved by mentioning some limitations of using ILP instead of SA.

Figure S1: Why is there a solitary green point in the lower right corner of the plot? Did you run Marxan with 37128 planning units and 10 features only for a target value of 80 %?

Reviewer: 2

Comments to the Author

This manuscript attempts to compare the cost-effectiveness and processing times of SA versus ILP using both commercial and open-source algorithms. Although I believe this manuscript has quality, I have some major concerns:

Lines (77-80) “We found that ILP produced higher quality solutions potentially saving >$100 million (or 13%) for realistic conservation scenarios and that solutions were generated >1,000 times faster than using simulated annealing, opening up new possibilities for scenario generation. These findings also hold true problems aiming for spatially compact solutions.” This sentence should be at the beginning of the discussion of at the end. Instead, the author should include specific objectives or projections.

Study area - A map illustrating the study area would be helpful for the broad audience.

Biodiversity data - More details on biodiversity data are required. I could not understand the framework for the species distribution model and I cannot value a method that is still in revision (Rodewald et al. in revision).

Spatial conservation prioritization - The spatial conservation prioritization approach is confusing. The authors used 193,623 polygons for BC which were subsequently used as planning units. If the authors used them as unit, I assume that they calculated the incidence at each parcel. While I completely understand and support the use of cost in conservation analyses, I cannot understand why they use such small scale to use as planning using. The authors completely ignored spatial autocorrelation, since this is a spatial study, errors type I and II since they used species distribution modeling as the source of their biological dataset.

Another potential problem is the parcel area. Since this is not well explained in the methods, I believe planning units have different areas. Because the increase in the number of species with the area sampled is one of the oldest and most reported patterns in ecology, I wonder if the authors considered the area in their analysis and how.

The evaluation of the methods needs improvement. The authors only considered the cost and computational aspects, but they did not include probably one of the most important aspects – biological life. The authors should consider the use of species accumulation index (Rodrigues and Brooks 2007) to evaluate the efficiency of ILP and SA as a surrogate in representing Bird species. SAI compares the number of species represented at least once in the set of sites selected using ILP and SA, to an optimum value - the largest number of species that can be represented in the same number of sites and to a null solution.

The authors should also consider using complementarity-based Methods such as Zonation (Moilanen et al 2009, 2014). “Zonation is cutting edge software for spatial conservation prioritization and broad-scale spatial conservation planning. It identifies areas or landscapes that are important for retaining habitat quality and connectivity simultaneously for multiple biodiversity features (e.g. species, land cover types, ecosystem services, etc.), thus providing a quantitative method for enhancing the persistence of biodiversity in the long term. Zonation can also account for costs, thereby allowing cost-effective allocation of resources. Zonation can be used for traditional reserve or site selection, but it offers many other analyses for conservation”. Zonation has been used in many countries and hundreds of scientific publications.

Results- The results are limited to your study area and the taxa. The way it is, someone may have a wrong impression that ILP is the beast solution irrespective of the taxa, location, extent, scale, etc. To deserve general validity, the authors should use multiple taxa, extents, and geographical location.