ENVIRONMENTAL RESEARCH
LETTERS

LETTER • OPEN ACCESS

Economics and optics influence funding for ecological restoration in a nation-wide program

To cite this article: Jayden E Engert and Susan G W Laurance 2023 *Environ. Res. Lett.* **18** 054020

ENVIRONMENTAL RESEARCH
LETTERS

CrossMark

OPEN ACCESS

RECEIVED
21 August 2022

REVISED
11 April 2023

ACCEPTED FOR PUBLICATION
18 April 2023

PUBLISHED
5 May 2023

LETTER

Economics and optics influence funding for ecological restoration in a nation-wide program

Jayden E Engert* **and Susan G W Laurance**

Centre for Tropical Environmental and Sustainability Science, College of Science and Engineering, James Cook University, Cairns, Queensland 4878, Australia

* Author to whom any correspondence should be addressed.

E-mail: jayden.engert@my.jcu.edu.au

Keywords: Australia, biodiversity loss, ecosystem restoration, large-scale restoration, restoration policy, threatened species, tree planting

Supplementary material for this article is available online

Abstract

Australia is a world leader in habitat loss and species extinction, and for many species, ecological restoration will be necessary for continued persistence. Between 2014 and 2018, the Australian federal government allocated a substantial portion of funding for threatened species recovery to a nation-wide ecological restoration program called '20 Million Trees Land-care Program', which included a competitive grant round. By comparing successful and unsuccessful grant applications, we were able to identify factors associated with restoration funding allocation. We then assessed the Program's ability to provide benefits to threatened species by analyzing the overlap between restoration projects and threatened species habitat. We found that funding allocation under the 20 Million Trees Program was primarily driven by 'value for money' factors, specifically 'cost per tree' and number of trees planted. Additionally, projects were more likely to be funded if they mentioned threatened species in the description, but less likely to be funded if they actually overlapped with areas of high threatened species richness. Of the 1960 threatened species assessed, we found that only 9 received funding for restoration projects covering more than 1% of their range. Conversely, we found that utilizing alternative project selection schemes, such as alternative 'value for money' metrics or spatial planning methods, could have delivered better outcomes for some of the threatened species most impacted by habitat loss. Our results show that inopportune selection criteria for awarding of funding for ecological restoration can significantly reduce the benefits delivered by programs.

1. Introduction

Loss and degradation of habitat is a key threat to the majority of the world's terrestrial plant and animal species (Brooks *et al* 2002, Rodrigues *et al* 2006), and ecological restoration is gaining attention as method of mitigating the impacts (IUCN 2020). Australia is a world leader for biodiversity loss and extinctions (Groombridge *et al* 2002, Woinarski *et al* 2015, Waldron *et al* 2017), and for the majority of Australia's threatened species ecological restoration is necessary for long-term persistence (Maxwell *et al* 2019, Ward *et al* 2022a). Recognizing the need for ecological restoration across the continent, a number of governmental and non-governmental land-care schemes have been established including the Federal Government's '20 Million Trees Land-care Program' (DAWE 2021a).

The Australian Government's 20 Million Trees Program was established in 2014 with the stated aim of planting 20 million trees by 2020. The programs goals were 'to re-establish green corridors, urban forests and threatened ecological communities' (CoA 2014). Restoration projects were funded under the Program through competitive grant rounds, procurement from large-scale service providers, and non-competitive discretionary grants (DAWE 2021a). While the procurement projects received the largest portion of funding under the Program, the competitive grants scheme delivered the most individual projects and covered the greatest geographic extent (DAWE 2021a). Importantly, funding for restoration projects was redirected from the threatened species recovery program, despite the 20 Million Trees Program not explicitly aimed at conserving threatened species (Ritchie *et al* 2017). A subsequent review of funding allocation under the Program by the Australian National Audit Office found weaknesses in procedures, whereby stated assessment methods were not adhered to and eligibility assessments not conducted in a transparent manner (ANAO 2016).

Restoration planning studies, conducted at various spatial scales, have been used to identify priority areas for investment (Etter *et al* 2020, Strassburg *et al* 2020) and methods to overcome barriers in restoration planning (Brancalion *et al* 2019b, Zeng *et al* 2020). However, final decisions about awarding of funding and selection of sites are predominantly made by governments susceptible to electoral influence (Shogren *et al* 1999, Restani and Marzluff 2002) or companies susceptible to public perceptions (Löfqvist and Ghazoul 2019). Hence, decisions may be shaped to maximize political gains for the funding group rather than the ecological outcomes (Restani and Marzluff 2002). Restoration funding may also be influenced by economic considerations, such as cost per area (Brancalion *et al* 2017, Martin *et al* 2021), and political considerations, such as presence of charismatic fauna (Czech *et al* 1998, Martin-Lopez *et al* 2009). The influence of economic or political considerations in funding allocation may result in diminished outcomes for nature (Brancalion *et al* 2017, Colleony *et al* 2017), hence, understanding the drivers of funding allocation may improve our ability to counter decisions that lead to suboptimal delivery of restoration programs.

Here, we analyze the allocation of funding for various tree planting activities, henceforth referred to as 'restoration', under a multi-million-dollar nationwide land-care program, through which funds were awarded via competitive grant rounds. We attempt to identify factors that influence funding allocation in this program, and the potential impacts of these factors for threatened species habitat in Australia. Specifically, we identify influential correlates of grant success under the 20 Million Trees Land-care Program and determine which threatened species had funded projects within their habitat range and which did not. Finally, we compare the potential restoration benefits for threatened species of the Program against benefits delivered under alternative project selection schemes.

2. Methods

2.1. Restoration project information

The competitive grant rounds component of the 20 Million Trees Land-care Program spent >AU$13 million in order to plant 3 million trees to revegetate ~8000 ha across Australia (DAWE 2021a). We assessed the potential benefits of this Program for threatened species by examining the project outlines for all 169 successful (funded) and 698 unsuccessful (unfunded) applications. Project outlines were brief and included the project title and unique application identifier, natural resource management region, State, total funding requested (AU$, excluding GST), number of trees growing to over two meters height to be planted, cost per tree (AU$) calculated as the amount of funding requested per tree to be planted, and a project summary. Project summaries did not follow a specified format, but provided various information on the project location, area to be restored, number of non-tree plants to be planted, threatened species benefited by the project, use of weed removal or other site preparation, and community group involvement (table 1).

We geo-referenced the restoration projects based on information provided in their summaries to evaluate the potential benefits to species of national environmental significance (threatened species) (Australian Government 2021a). Of 867 projects, 206 were geo-referenced to within 1 km of their expected location. We were able to geo-reference a further 623 projects to within 10 km of their expected location, leaving 38 projects that we were not able to geo-reference with any degree of precision (figure 1). Of the projects that we were not able to georeferenced, only five were funded. By geo-referencing restoration projects, we were able to obtain additional information, including likely vegetation type, maximum potential biomass, threatened species richness, and federal electorate.

2.2. Threatened species

We obtained habitat range maps for Australia's federally listed threatened fauna and flora species from the Species of National Environmental Significance database (Australian Government 2021a). This database represented the most up-to-date data for these species at time of publication. In total this database contained range maps for 2137 species (724 fauna species and 1347 flora species). We clipped the threatened species range maps to include only the Australian landmass (including Tasmania and large islands), leaving 1960 species.

To assess the importance of ecological restoration for the persistence of threatened species, we calculated the percentage of each species habitat range that had been cleared or transformed to date, and hence was restorable, using both 'may occur' and 'likely to occur' range maps (supplementary methods). While modelled environmental or geographic extent maps ('may occur' range) may overestimate a species' true distribution, many of Australia's threatened species have lost significant areas of pre-European habitat (Ward *et al* 2022b) and hence current modelled habitat maps

Table 1. Full list of model terms included in the gbm, including information from project outlines.

Model term	Description	Data reference
FundReq	Amount of funding requested in grant application ($AU).	20 Million Trees Land-care Program Successful and Unsuccessful Grant Applications
Trees	Number of trees reaching over 2 m height.	
Stems	Total number of plants (trees and non-trees).	
TreeCost	Funding requested ($AU) per tree.	
StemCost	Funding requested ($AU) per plant.	
Area	Area of restoration project taken directly from project description or estimated based on number of trees and planting density.	
SnesPA	Presence or absence of species of national environmental significance in the project description.	
SnesDesc	Number of species of national environmental significance listed in the project description.	
Community	Binary variable indicating if community group involvement is mentioned in the project summary.	
Weeding	Binary variable indicating if weed removal is mentioned in the project summary.	
Works	Binary variable indicating if other site preparation (i.e. fencing, earth works) are mentioned in the project summary.	
TotBiom	Total potential biomass of restored area based on project area and maximum potential biomass of project site.	Roxburgh *et al* (2017)
TreeBiom	Potential biomass of restored area adjusted for number of trees to identify plantings in high-biomass vegetation types.	
SnesGIS	Number of species of national environmental significance whose 'likely to occur' range intersected the project location.	Australian Government (2021a)
Population Density	Human population density within specified neighborhood distances of each project (1 km, 10 km, 20 km, 50 km, 100 km).	Tatem (2017)
Electorate	The name of the Federal Electorate in which the project is most likely to occur.	AEC (2021a)
Party	The political party currently in power in the Federal Electorate in which the project is most likely to occur.	AEC (2021b)
Status	The stability of political control of the Federal Electorate, summarized as 'safe', 'marginal', or 'swing'.	

('likely to occur' range) often substantially underestimated a species' full historic distribution.

We identified restoration project applications that overlapped current threatened species habitat using information from the species 'likely to occur' habitat. We buffered these habitat polygons by 10 km to account for uncertainty in restoration project locations and to account for species' ability to disperse into newly restored habitat. We then identified projects that may benefit threatened species by intersecting project locations with these buffered polygons in ArcMap 10.8. While tree planting projects may not provide any tangible benefits for threatened species, for the sake of the analyses included here we assume that they will.

2.3. Restored area

The area to be planted (henceforth referred to as restored) was provided for only 30% of the applications (255 projects). For these projects, we identified the broad vegetation type to be restored (savannah, shrubland, woodland, open forest, or closed forest), and the tree planting density (number of trees divided by planted area). We were then able to calculate, for each vegetation type, the quartile values for tree planting density (Supplementary Material). We then used these values, along with the number of trees in the grant application, to estimate restored area for the projects for which area was not provided ($n = 622$). We also used these values to calculate an estimated area cost of restoration for different bioregions and vegetation types (Australian Government 2021b) for use in optimal site selection modelling (Supplementary Material).

Finally, as there is substantial variation in the area covered by species' ranges, we calculated the area benefits of restoration projects as the percentage of a species range that was potentially restored (area restored by the project divided by species total range area) for each threatened species whose range it

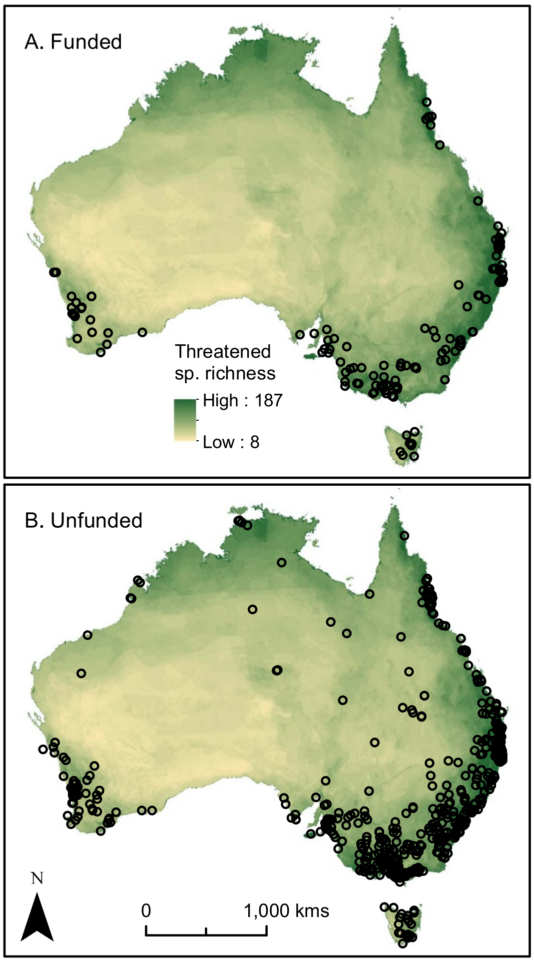

Figure 1. Locations of restoration projects outlined in (a) successful (funded) and (b) unsuccessful (unfunded) grant applications from the 20 Million Trees Land-care Program. The richness of species of national environmental significance (SNES) is illustrated by color intensity for both fauna and flora.

Table 2. Alternative metrics to assess project 'value for money'.

Alternative	Description
Area cost	Funds requested for the project, divided by area to be restored (in hectares).
Biodiversity cost	Funds requested for the project, divided by the area of threatened species habitat provided. The area of threatened species habitat was calculated as the area of the project (in hectares) multiplied by the number of threatened species whose range intersect the project.
Benefits cost	Funds requested for the project, divided by the area benefits for threatened species. Area benefits are outlined under the 'Restored area' header.

overlapped. We therefore summed, for each project, the percentage of each threatened species range that was potentially restored by said project and termed this the 'total area benefits' of the project.

2.4. Predicting successful applications

As we were unable to acquire detailed information on scoring criteria or project ranks used in decision-making, we identified a list of potential variables based on grant application guidelines and hypothesized criteria used to determine suitable projects. We initially started with a list of 18 potential covariates of grant success including information obtained from project outlines and geo-referenced project locations (table 1).

To identify the determinants of successful grant applications, we used gradient boosted machines (gbm). Gradient boosted machines are an extension of decision tree algorithms that fit new trees on weighted versions of the original dataset in order to improve classification. As grant application success was not determined by any mathematical functions, we were primarily concerned with identifying which covariates were influential and the direction of the relationship. Gradient boosted machines are ideal for this classification as they can accommodate complex non-linear responses and are robust to multicollinearity and covariance structures (Elith *et al* 2008). Gradient boosted machines were fit using a Bernoulli distribution (figure 2), and ten-fold cross validation was utilized to identify the optimal number of trees and the final model was selected as the model with the highest area under the curve (AUC) value. We conducted modelling using the package 'gbm' (Greenwell *et al* 2020) in R (R Core Team 2017). We generated partial differential plots demonstrating the marginal relationship between covariates and the predicted response using the package 'pdp' (Greenwell 2017).

2.5. Alternative project selection schemes

As the 20 Million Trees program received government funding, 'value for money', and specifically 'cost per tree', was considered an important criteria for assessing projects (CoA 2014). To assess the effect of this criteria on the scheme's ability to deliver benefits for threatened species we compared the realized outcomes with those achieved (1) when ignoring the influence of 'value for money' in assessing projects ('no cost'), (2) when assessing 'value for money' using alternative criteria (table 2), and (3) when funding restoration purely to maximize threatened species benefits. We assessed the benefits of projects selected under each scheme by (1) calculating the total area benefits of the selected projects, and (2) assessing the area benefits for individual threatened species.

To remove the influence of 'value for money' from project assessments, we predicted the probability of a project being funded (using the gradient boosted machine model outlined previously) while holding 'cost per tree' at its average value for all projects to negate the influence of this term. Similarly, to assess the schemes' ability to deliver benefits for threatened species using alternative 'value for money' criteria, we predicted probability of a project being funded when the 'cost per tree' term was replaced by an alternative cost term (table 2). Each alternative cost term was rescaled to match the value distribution of the 'cost per tree' term using a Box-Cox transformation. After predicting new probabilities of funding under the aforementioned alternatives, each project was ranked and the 164 projects with highest probabilities were assumed to be funded (matching the number of funded projects included in modelling).

Finally, to assess the Programs ability to deliver maximum benefits to threatened species, we developed an optimized site selection model against which to compare. We formulated a site selection problem using the 'prioritizr' package (Hanson *et al* 2021) in R, which selected 164 sites from areas that overlapped restoration project locations from the grant applications list (both funded and unfunded). The site selection model included a manual relative target for each species, which was calculated as half of the species range that was 'restorable', and was optimized using a minimum shortfall objective function which aims to minimize the unmet representation target for each species. Use of the manual relative targets ensured that the site selection model favored species which had experienced the greatest historical habitat loss (detailed methods in Supplementary Material).

3. Results

From our assessment of project summaries, the most influential factors driving success in grant funding were cost per tree, neighborhood population density, and number of trees (figure 2(a)). Projects were more likely to be funded when the cost per tree was low (<AU$5), with projects having a cost per tree >AU$10 almost never being funded (figure 2(c)). Additionally, projects planting more trees and with higher neighborhood population density were more likely to be funded (figure 2(d)). Site-level biomass had no influence on application success, and applications with intermediate values for tree-level biomass were most likely to be successful, suggesting that carbon sequestration potential had little influence on funding allocation (Supplementary Material). Our grant application success model achieved high predictive power, with an AUC of 0.955 (figure 2(b)).

Grant applications were also substantially more likely to be funded when they included the names of threatened species in the project summaries (figure 2(e)). Despite this, projects that were located in areas of high threatened species richness were less likely to be funded (figure 2(f)), and many of Australia's threatened species did not benefit from restoration projects within their 'likely to occur' habitat areas (figure 3(a)). Funded restoration projects occurred within the habitat of 769 threatened species, while 1302 species received no habitat restoration under this program. Of the species for which no funding was allocated, an additional 399 could have received funding if different projects were selected (Supplementary Material).

Even when only considering species that did receive project funding within their range, the restored areas were typically only a fraction of a percent of their modelled range and only nine species benefited from projects covering more than 1% their range (figure 3(a)). We also show that many projects capable of delivering more substantial total area benefits were not funded, with a large portion of these projects having a very low chance of receiving funds under the allocation scheme utilized (figure 3(b)).

All alternative project selection schemes delivered greater total area benefits for threatened species than the implemented 'cost per tree' selection (figure 4(i)). Of these alternatives, the 'benefit cost' scheme and the prioritizr model delivered the greatest outcomes, with an increase in area benefits of 54.76% and 171.55% respectively. While the prioritizr model may not be a fair comparison to the original Program as it ignored all selection criteria implemented in the scheme, the 'benefit cost' scheme provides an example of what the Program could have achieved if using a 'value for money' term more relevant for assessing biodiversity and conservation values of projects. Notably, even simply ignoring the influence of 'value for money' resulted in an increase in total area benefits.

The alternative project selection schemes also resulted in notable changes in the locations of funding allocation (figure 4(ii)). The area cost, biodiversity cost, and benefits costs schemes all increased the number of projects funded in the south and southwest of mainland Australia. Conversely, the prioritizr model largely decreased the number of projects funded in the south of the country and increased the number of projects funded in the northern areas of the country. Disparities between the location of funded projects between, for example, the benefits cost scheme and prioritizr model are likely due to other selection criteria, such as population density, which were not included in the prioritizr model.

Finally, all alternative selection schemes resulted in more species having funded restoration projects covering more than 0.1% or 1% of their ranges, particularly those species which had greater percentages of their ranges that were 'restorable' (figure 4(iii)). Similarly, all alternative selection schemes except for the biodiversity cost scheme resulted in substantially more species needing restoration across more than half of their range receiving some amount of restoration. The prioritizr model made the largest improvement in terms of number of species having some amount of their habitat restored.

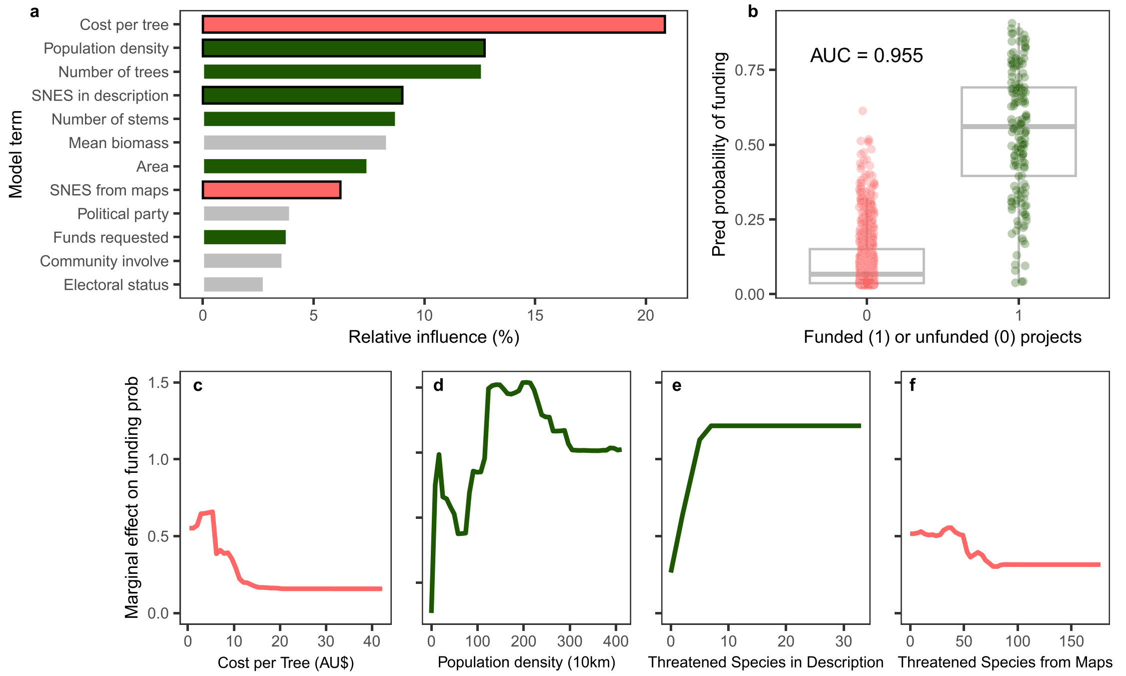

Figure 2. Factors associated with grant application success in the 20 Million Trees Land-care Program. (a) Relative influence of the covariates included in the final model. Red bars indicate covariates with a negative relationship to the response variable, green bars indicate a positive relationship, and gray bars indicate a more complex relationship. (b) Model accuracy demonstrated by predicted probability and AUC score. (c)–(f) Partial dependence plots of the two most influential covariates as well as the two covariates related to project value for threatened species.

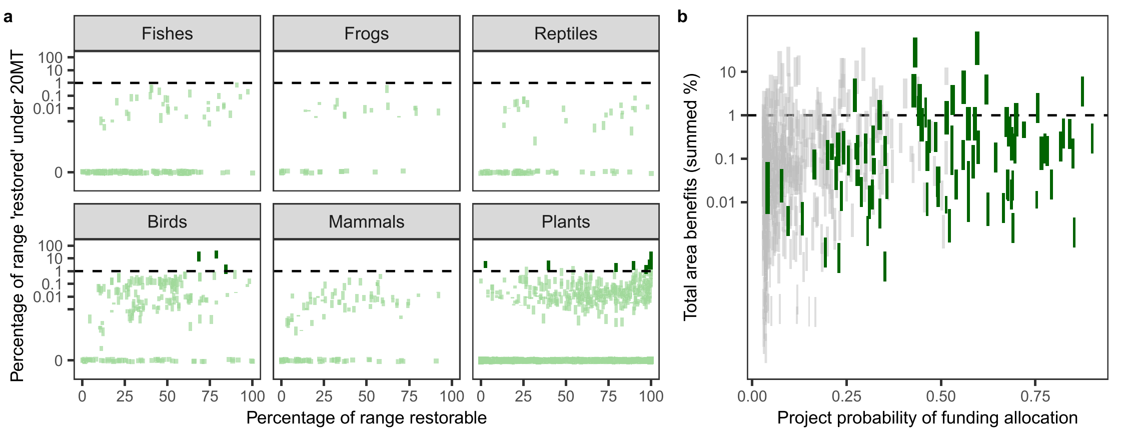

Figure 3. Restored area benefits for threatened species of projects funded and unfunded under the 20 Million Trees Program. (a) Percentage of threatened species habitat area potentially 'restored' under the 20 Million Trees Program. (b) Area benefits for threatened species potentially delivered by restoration projects against the projects' chance of receiving funding under the 20 Million Trees Program. Bars in (a) and (b) indicate the interquartile range of values. In (a) dark bars indicate species for which the median value for restored range was more than 1% of the species total range. In (b) green bars indicate funded projects while gray bars indicate unfunded projects, total area benefits refers to the sum of the percentages of each species range potentially restored for each project.

4. Discussion

Our examination of the restoration projects funded under the 20 Million Trees Landcare Program competitive grants round found potentially significant biases in the funding allocation that we consider diminished its benefits for Australia's threatened fauna and flora species. Overall, we found that economic considerations such as 'cost per tree' and potential in-kind contributions were the strongest factors determining funding allocation, while carbon and biodiversity values had little or negative influence on project funding, contrary to the stated objectives of the Program. For example, we found that while mentioning threatened species in project descriptions improved chances of funding, funded projects actually contributed to negligible or no expansion of habitat area for threatened species. Similarly, projects in areas with high carbon sequestration potential were not more likely to be funded than those in

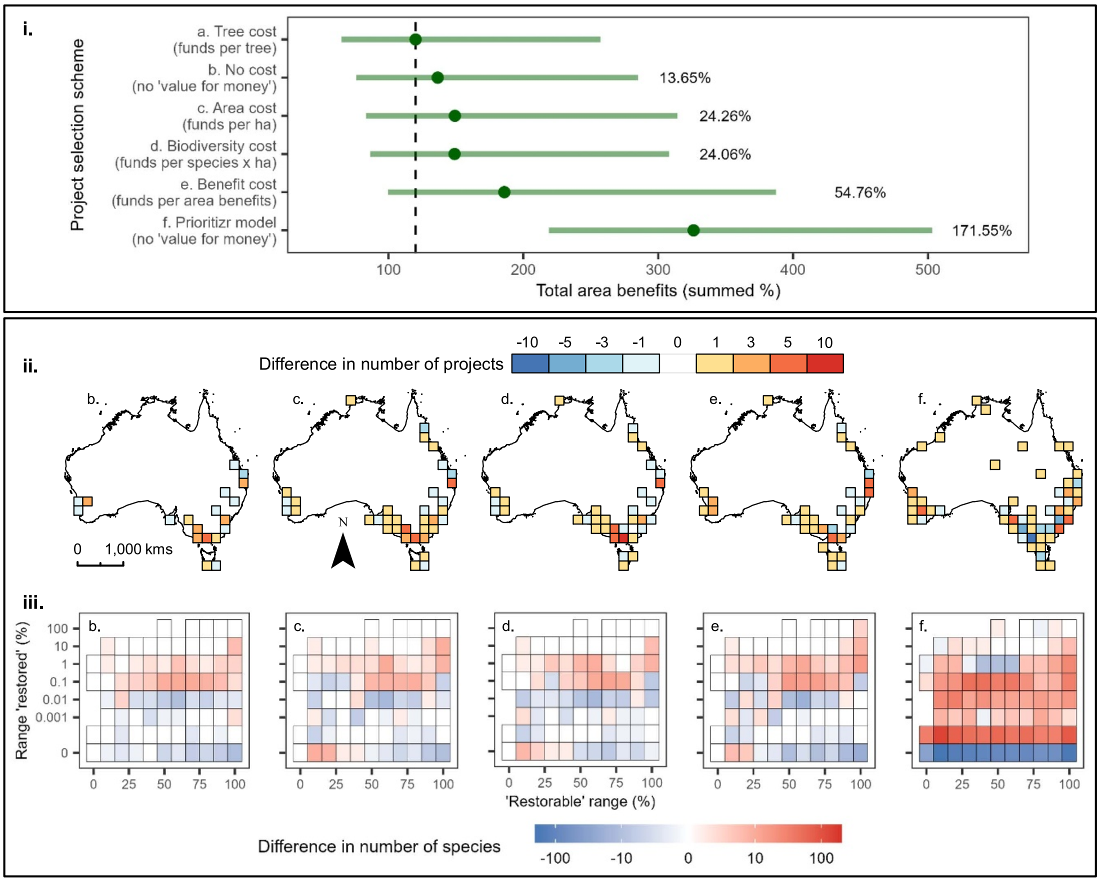

Figure 4. Difference in total area benefits (i) locations (ii), and area benefits for threatened species (iii) of projects selected for funding under various selection schemes when compared to the 'tree cost' scheme. Letters in each row (rows i, ii, and iii) correspond to the same selection scheme in all other rows. In row (ii), positive values indicate areas in which more projects are funded when using a selection scheme other than the 'Tree cost' selection scheme. In row (iii), positive values indicate classes in which there are more species when using a selection scheme other than the 'Tree cost' selection scheme.

areas with low to intermediate potential. Our results show that alternative methods of selecting projects, including using alternative 'value for money' metrics, could have delivered substantially better outcomes for threatened species.

Our results suggest that use of simple project selection criteria amenable to public reporting may have undermined the outcomes of the 20 Million Trees Program. Firstly, seeking to maximize the number of trees planted by using tree cost to evaluate project 'value for money' resulted in lower threatened species benefits than achieved using similar metrics specifically targeted to biodiversity. Secondly, the apparent reliance on threatened species list from project summaries, rather than range maps, resulted in funding being directed to a small number of well-known species and away from projects occurring in areas of high threatened species richness. While the reliance on project summaries may be due to paucity of species distributional data (at the time of development of grant guidelines), we suggest that the low number of well-known species listed relative to the total number of threatened species in Australia (Australian Government 2018) may be due to biases towards charismatic species. Additionally, the lack of correlation between number of species in project summaries and threatened species richness in project areas (supplementary results) may lend further credence to our suggestion that project selection was shaped by charismatic species, as is common across environmental funding schemes (Czech *et al* 1998, Walsh *et al* 2013, Bellon 2019).

Our results suggest that funding for ecological restoration was preferentially allocated to more populated areas of Australia despite less-developed areas potentially delivering greater benefits to threatened species. This decision may reflect the requirement for projects to attract in-kind contributions in the forms of financial support and volunteer labor (CoA 2014). However, alternative project selection schemes, including the prioritization model we employed suggest that allocating funds to less populated areas could deliver greater benefits for threatened species. Similarly, previous work suggests that restoration of habitat within densely populated areas may have diminished conservation values, as these areas typically have higher levels of disturbance (Chazdon 2003), and are less likely to be connected to large areas of remnant habitat, meaning restoration could create isolated parks rather than high value habitat (Crouzeilles *et al* 2016, Hale and Swearer 2017). Therefore, as suggested by Collard *et al* (2020), program requirements for in-kind contributions and 'value for money' are likely to substantially diminish the ecological value of restoration programs by affecting the spatial allocation of funding.

The importance of 'value for money' outlined in the grant guidelines (CoA 2014) was reiterated by our model results. While decision criteria stipulated 'value for money' should not be weighted higher than biodiversity values in decision making, our model suggests that these factors explained over half of the probability of a project being funded. This result, supported by the findings of a government audit (ANAO 2016), and the use of 'cost per tree' as the value metric, had significant negative impacts on the delivery of potential benefits for threatened species. Allowing 'cost per tree' or similar metrics to drive funding allocation for restoration programs may lead to perverse outcomes. For example, more diverse and structurally complex vegetation communities such as closed forests and wetlands can be more expensive to restore (Maggini *et al* 2013, Mappin *et al* 2021), despite their substantial values for biodiversity (Australian Government 2018, IPBES 2019), climate regulation (Yu *et al* 2010, McAlpine *et al* 2018), and ecological service maintenance (Fu *et al* 2013, Sheil 2018). Additionally, we, along with Collard *et al* (2020), suggest that the limited funding periods and low project costs—often significantly lower than those quoted by restoration practitioners (Maggini *et al* 2013, Collard *et al* 2020)—required from these projects may lead to proponents reducing costly site maintenance activities less attractive to volunteers (Galabuzi *et al* 2014, Palma and Laurance 2015, Collard *et al* 2020, Van Oosterzee *et al* 2020). However, site maintenance activities can be important determinants of restoration success (Suganuma *et al* 2018, Shackleford *et al* 2021, Mounsey *et al* 2022).

While we were unable to access in-depth information on decision criteria or ranking schemes used in the 20 Million Trees Landcare Program, our funding success model based on outlined Program objectives achieved high predictive power. Therefore, it is likely to be informative about decision-making processes, and may be more useful than designed ranking criteria if final decisions were not in-line with department recommendations (ANAO 2016). For example, while reducing greenhouse gas emissions was outlined as a key Program objective (CoA 2014), our model suggests that carbon sequestration potential of projects had little influence on decision making. Conversely, some identified predictors may be representative of final decisions rather than the underlying motivations for said decisions. For example, it is more likely that projects were selected when threatened species richness was low due to perceived differences in restoration success of ecosystems rather than an effort to minimize biodiversity values of the Program. In order to improve clarity and confidence in funding allocation decisions, we recommend greater transparency around both decision-making criteria and implementation of ranking schemes. Additionally, while our analysis of the benefits of the Program for threatened species was based on restored area, restoration targeted towards ecological connectivity can deliver larger benefits than implied by area measures (Laurance and Laurance 1999). However, for many species habitat loss to-date has been extensive and substantial habitat restored will be required to ensure future persistence (Ward *et al* 2022b).

5. Conclusions

Our results indicate that 'value for money' concerns such as tree cost were the principal drivers of funding allocation decisions in a nation-wide ecological restoration program. This resulted in allocation of funding primarily to cheap projects in populated areas, and diminished returns for Australia's threatened fauna and flora. We demonstrate that use of alternative 'value for money' metrics or project selection methods, such as spatial planning methods focused on conservation priorities, could have produced substantially larger area benefits for threatened species at the same cost. Collectively, our results show that inappropriate selection criteria can significantly reduce the benefits delivered by programs. In order to improve clarity and confidence in the allocation of funding under large restoration programs, we recommend greater transparency in both the design of project ranking criteria and the methods used to implement said criteria. Additionally, we recommend that economic considerations be given less import in decision making, and that 'value for money' calculations are made with respect to benefits for biodiversity, rather than simply by the number of trees or the area potentially restored.

Data availability statement

The data that support the findings of this study are available upon reasonable request from the authors.

Acknowledgments

We thank E Carmichael, J Seabright, and E Engert for assistance in geo-referencing project locations. We thank N Vogado for providing comments on the manuscript.

ORCID iD

Jayden E Engert https://orcid.org/0000-0002-5558-2058

References

AEC 2021a Federal electoral boundary GIS data for free download *[National]* (available at: https://aec.gov.au/Electorates/gis/gis_datadownload.htm)

AEC 2021b 2019 federal election downloads and statistics (available at: www.aec.gov.au/elections/federal_elections/2019/downloads.htm)

ANAO 2016 Award of funding under the 20 Million Trees Programme *ANAO Report No.4 2016–17*

Australian Government 2018 EPBC Act list of threatened species (available at: www.environment.gov.au/cgi-bin/sprat/public/publicthreatenedlist.pl?wanted=fauna)

Australian Government 2021a Species of national environmental significance (SNES) (available at: www.environment.gov.au/science/databases-maps/snes)

Australian Government 2021b National vegetation information system (NVIS). Bioregional assessments programme (available at: www.environment.gov.au/land/native-vegetation/national-vegetation-information-system)

Bellon A M 2019 Does animal charisma influence conservation funding for vertebrate species under the US Endangered Species Act? *Environ. Econ. Policy Stud.* **21** 399–411

Brancalion P H S *et al* 2019b Global restoration opportunities in tropical rainforest landscapes *Sci. Adv.* **5** eaav3223

Brancalion P H S, Meli P, Tymus J R C, Lenti F E B, Benini R M, Silva A P M, Isernhagen I and Holl K D 2019a What makes ecosystem restoration expensive? A systematic cost assessment of projects in Brazil *Biol. Conserv.* **240** 108274

Brancalion P H, Lamb D, Ceccon E, Boucher D, Herbohn J, Strassburg B and Edwards D P 2017 Using markets to leverage investment in forest and landscape restoration in the tropics *For. Policy Econ.* **85** 103–13

Brooks T M *et al* 2002 Habitat loss and extinction in the hotspots of biodiversity *Biol. Conserv.* **16** 909–23

Chazdon R L 2003 Tropical forest recovery: legacies of human impact and natural disturbances *Perspect. Plant Ecol. Evol. Syst.* **6** 51–71

CoA 2014 *20 Million Trees Programme Grant Guidelines—Round One 2014–15* (Commonwealth of Australia)

Collard S J, O'Connor P J, Prowse T A, Gregg D and Bond A J 2020 Objectives versus realities: spatial, temporal, financial and social deficiencies in Australia's public revegetation investment model *Ecol. Manage. Restor.* **21** 35–41

Colleony A, Clayton S, Couvet D, Saint Jalme M and Prévot A C 2017 Human preferences for species conservation: animal charisma trumps endangered status *Biol. Conserv.* **206** 263–9

Crouzeilles R, Curran M, Ferreira M S, Lindenmayer D B, Grelle C E and Rey Benayas J M 2016 A global meta-analysis on the ecological drivers of forest restoration success *Nat. Commun.* **7** 11666

Czech B, Krausman P R and Borkhataria R 1998 Social construction, political power and the allocation of benefits to endangered species *Biol. Conserv.* **5** 1103–12

DAWE 2021a 20 Million Trees Program review (Canberra: Department of Agriculture, Water and the Environment) CC BY 4.0

DAWE 2021b Emissions reduction fund (Canberra: Department of Agriculture, Water and the Environment)

Elith J, Leathwick J R and Hastie T 2008 A working guide to boosted regression trees *J. Anim. Ecol.* **77** 802–13

Etter A, Andrade A, Nelson C R, Cortés J and Saavedra K 2020 Assessing restoration priorities for high-risk ecosystems: an application of the IUCN Red List of Ecosystems *Land Use Policy* **99** 104874

Fu B, Wang Y K, Xu P and Yan K 2013 Mapping the flood mitigation services of ecosystems—a case study in the Upper Yangtze River Basin *Ecol. Eng.* **52** 238–46

Galabuzi C, Eilu G, Mulugo L, Kakudidi E, Tabuti J R S and Sibelet N 2014 Strategies for empowering the local people to participate in forest restoration *Agrofor. Syst.* **88** 719–34

Greenwell B M 2017 pdp: an R package for constructing partial dependence plots *R J.* **9** 421–36

Greenwell B, Boehmke B and Cunningham J & Developers 2020 gbm: generalized boosted regression models *R package version 2.1.8* (available at: https://CRAN.R-project.org/package=gbm)

Groombridge B, Jenkins M D and Jenkins M 2002 *World Atlas of Biodiversity: Earth's Living Resources in the 21st Century* (Berkeley, CA: University of California Press)

Hale R and Swearer S E 2017 When good animals love bad restored habitats: how maladaptive habitat selection can constrain restoration *J. Appl. Ecol.* **54** 1478–86

Hanson J O, Schuster R, Morrell N, Strimas-Mackey M, Edwards B P M, Watts M E, Arcese P, Bennett J and Possingham H P 2021 Prioritizr: systematic conservation prioritization in R *R package version 7.1.1.1* (available at: https://github.com/prioritizr/prioritizr)

IPBES 2019 *Global Assessment Report on Biodiversity and Ecosystem Services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services* ed E S Brondizio *et al* (Bonn: IPBES secretariat) p 1148

IUCN 2020 *Bonn Challenge: Impact and potential of forest landscape restoration*

Laurance S G W and Laurance W F 1999 Tropical wildlife corridors: use of linear rainforest remnants by arboreal mammals *Biol. Conserv.* **91** 231–9

Löfqvist S and Ghazoul J 2019 Private funding is essential to leverage forest and landscape restoration at global scales *Nat. Ecol. Evol.* **3** 1612–5

Maggini R, Kujala H, Taylor M, Lee J, Possingham H, Wintle B and Fuller R 2013 *Protecting and restoring habitat to help Australia's threatened species adapt to climate change* (Gold Coast: National Climate Change Adaptation Research Facility) p 54

Mappin B, Ward A, Hughes L, Watson J E M, Cosier P and Possingham H P 2021 The costs and benefits of restoring a continent's terrestrial ecosystems *J. Appl. Ecol.* **59** 408–19

Martin M, Woodbury D J, Doroski D A, Nagele E, Storace M, Cook-Patton S C, Pasternack R and Ashton M S 2021 People plant trees for utility more often than for biodiversity or carbon *Biol. Conserv.* **261** 109224

Martín-López B, Montes C, Ramírez L and Benayas J 2009 What drives policy decision-making related to species conservation? *Biol. Conserv.* **142** 1370–80

Maxwell S L, Reside A, Trezise J, McAlpine C A and Watson J E 2019 Retention and restoration priorities for climate adaptation in a multi-use landscape *Glob. Ecol. Conserv.* **18** e00649

McAlpine C A, Johnson A, Salazar A, Syktus J, Wilson K, Meijaard E, Seabrook L, Dargusch P, Nordin H and Sheil D 2018 Forest loss and Borneo's climate *Environ. Res. Lett.* **13** 044009

Mounsey C M, Stevens J C, Renton M, Dixon K W and Miller B P 2022 The influence of environmental drivers and restoration intervention methods on postmine restoration trajectories *Restor. Ecol.* **30** e13503

Palma A C and Laurance S G W 2015 A review of the use of direct seeding and seedling plantings in restoration: what do we know and where should we go? *Appl. Veg. Sci.* **18** 561–8

R Core Team 2017 *R: A Language and Environment for Statistical Computing* (Vienna: R Foundation for Statistical Computing) (available at: www.R-project.org/)

Restani M and Marzluff J M 2002 Funding extinction? Biological needs and political realities in the allocation of resources to endangered species recovery: an existing priority system, which should guide the fish and wildlife service in endangered species recovery, is ineffective, and current spending patterns decrease long-term viability of island species *BioScience* **52** 169–77

Ritchie E, Nimmo D, Driscoll D, Heard G, Watson J, Evans M C and Doherty T 2017 Australia's species need an independent champion *The Conversation* **12** 2021

Rodrigues A S L, Pilgrim J D, Lamoreux J F, Hoffman M and Brooks T M 2006 The value of the IUCN Red List for conservation *TREE* **21** 71–76

Roxburgh S, Karunaratne S and Paul K 2017 *A Revised Above-ground Maximum Biomass Layer for Australia's National Carbon Accounting System* (Canberra: CSIRO Land & Water)

Shackelford N, Paterno G B, Winkler D E and Suding K L 2021 Drivers of seedling establishment success in dryland restoration efforts *Nat. Ecol. Evol.* **5** 1283–90

Sheil D 2018 Forests, atmospheric water and an uncertain future: the new biology of the global water cycle *For. Ecosyst.* **5** 19

Shogren J F *et al* 1999 Why economics matters for endangered species protection *Biol. Conserv.* **13** 1257–61

Strassburg B B N, Iribarrem A, Beyer H L and Visconti P 2020 Global priority areas for ecosystem restoration *Nature* **586** 724–9

Suganuma M S, Torezan J M D and Durigan G 2018 Environment and landscape rather than planting design are the drivers of success in long-term restoration of riparian Atlantic forest *Appl. Veg. Sci.* **21** 76–84

Tatem A J 2017 WorldPop, open data for spatial demography *Sci. Data* **4** 1–4

Van Oosterzee P, Liu H and Preece N D 2020 Cost benefits of forest restoration in a tropical grazing landscape: Thiaki rainforest restoration project *Glob. Environ. Change* **63** 102105

Waldron A, Miller D, Redding D, Mooers A, Kuhn T S, Nibbelink N, Roberts J T, Tobias J A and Gittleman J L 2017 Reductions in global biodiversity loss predicted from conservation spending *Nature* **551** 364–7

Walsh J, Watson J, Bottrill M, Joseph L and Possingham H 2013 Trends and biases in the listing and recovery planning for threatened species: an Australian case study *Oryx* **47** 134–43

Ward M *et al* 2022a Restoring habitat for fire-impacted species' across degraded Australian landscapes *Environ. Res. Lett.* **17** 084036

Ward M *et al* 2022b Creating past habitat maps to quantify local extirpation of Australian threatened birds *Environ. Res. Lett.* **17** 024032

Woinarski J C Z, Burbidge A A and Harrison P L 2015 Ongoing unraveling of a continental fauna: decline and extinction of Australian mammals since European settlement *Proc. Natl Acad. Sci. USA* **112** 4531–40

Yu Z, Loisel J, Brosseau D P, Beilman D W and Hunt S J 2010 Global peatland dynamics since the last glacial maximum *Geophys. Res. Lett.* **37** L13402

Zeng Y, Sarira T V, Carrasco L R, Chong K Y, Fries D A, Lee J S H, Taillardat P, Worthington T A, Zhang Y and Pin Koh L 2020 Economic and social constraints on reforestation for climate mitigation in Southeast Asia *Nat. Clim. Change* **10** 842–4