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Assessing the impact of referred actions on protected matters under Australia's national environmental legislation

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Abstract

Australia's national environmental legislation, the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) has been criticized for failing to mitigate the national extinction crisis. Under the EPBC Act, projects anticipated to have a significant impact on protected matters must be referred to the Australian Government for assessment. Actions deemed unlikely to have a significant impact are granted permission to proceed, while actions expected to have a significant impact must undergo further assessment. We spatially analyzed potential habitat loss deemed either significant or non-significant in Queensland and New South Wales for threatened species, migratory species, and threatened ecological communities between 2000 and 2015. Impact scores were developed to quantify and compare the value of woody vegetation cleared under each referral determination. We found no statistically significant difference between median impact scores for vegetation removed under significant and non-significant determinations. Over half (63%) of all scored losses occurred under actions deemed non-significant, with certain species disproportionately impacted. The tiger quoll (*Dasyurus maculatus maculatus*) and grey-headed flying-fox (*Pteropus poliocephalus*) lost 82% and 72% of their total referred potential habitat under non-significant actions, respectively. Our results indicate that the application of the EPBC Act is failing to adequately conserve the protected matters of this investigation.

KEYWORDS

biodiversity conservation, controlled action, decision-making, effectiveness, environmental policy, EPBC Act, habitat loss, referral, significant impact, threatened species

1 | INTRODUCTION

Extinction threatens 25% of global biodiversity (IPBES, 2019), and losses are expected to accelerate in the absence of immediate action (Leclère et al., 2020; Pimiento et al., 2020; Tilman et al., 2017). Current efforts by the international community are failing to halt wildlife extinction, demonstrating the need for improved national strategies (Hirsch et al., 2020; WWF, 2020). As a substantial contributor to the decline, Australia has lost at least

100 endemic species since 1788 (Woinarski et al., 2019). Although native flora and fauna face many threatening processes, the cumulative impacts of habitat loss, degradation, and fragmentation present the greatest threat to Australian wildlife (Allek et al., 2018; Evans et al., 2011; Ward et al., 2021). In particular, Queensland and New South Wales (NSW) have sustained high-clearing rates leading to the classification of Eastern Australia as a global deforestation hotspot (Taylor, 2015). Habitat loss in the region has been linked to declines in species such as the black-throated finch (*Poephila cincta cincta*) and koala (*Phascolarctos cinereus*) (Queensland Government, 2017).

When properly crafted and implemented, legislation has significant potential for widespread conservation gains, including the mitigation of habitat loss (Trouwborst et al., 2017; Van Dyke & Lamb, 2020). The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is the national environmental law for Australia (Australian Government, 1999) and protects Matters of National Environmental Significance (MNES; see Appendix S1). The EPBC Act requires proponents (individuals or organizations) of development projects to submit a "referral" to the Australian Government if an "action" is likely to have a "significant impact" on MNES. Threatened species, migratory species, and threatened ecological communities are considered MNES. Therefore, projects likely to have an impact that is "important, notable or of consequence, having regard to its context or intensity" on these listed species or communities must be referred for consideration (Australian Government, 2013a). Following submission, the Australian Government will deem a referral as either "action is clearly unacceptable", "controlled action" (CA), or "not a controlled action" (NCA). "Action is clearly unacceptable" determinations prohibit the project, CA determinations require further assessment, and

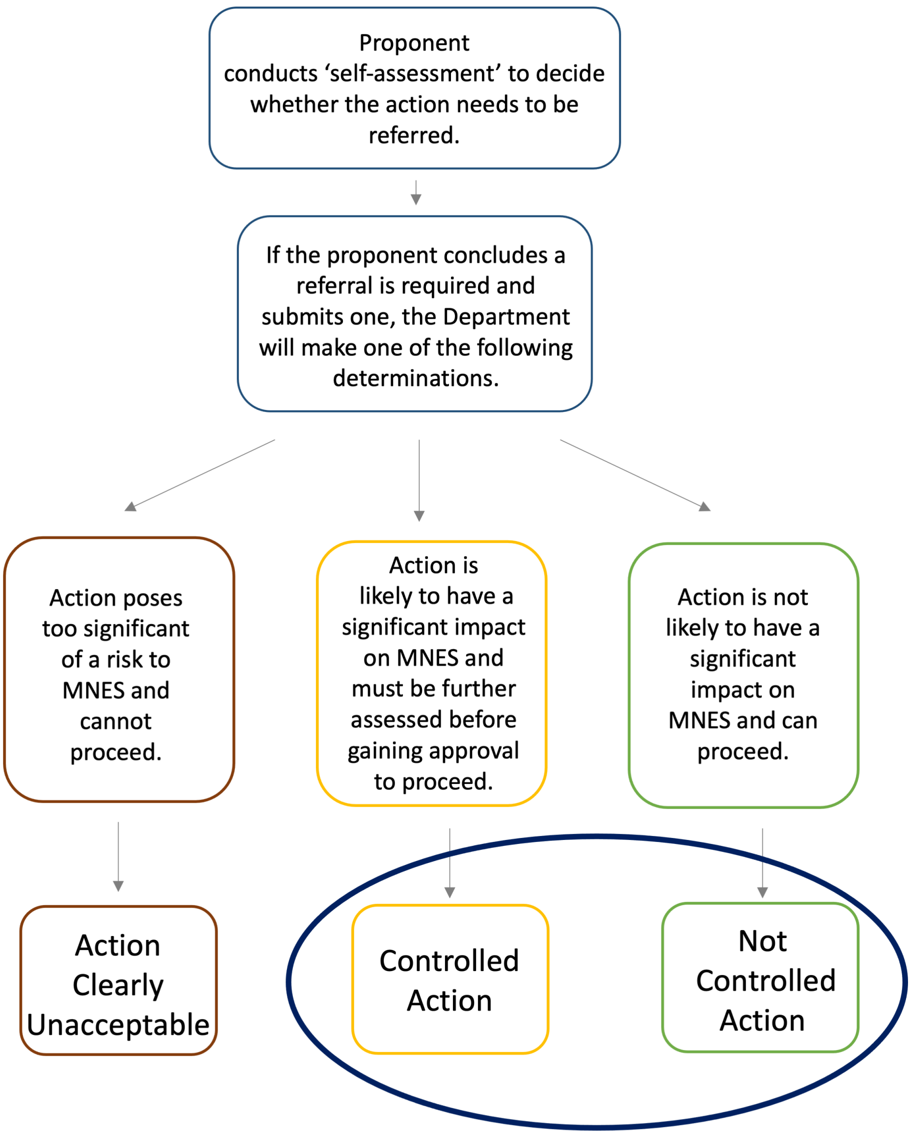

FIGURE 1 Referral process beginning with self-assessment by the proponent (based on Australian Government, 2013a). The consequences of "controlled action" and "not controlled action" determinations (highlighted in the blue oval) are the focus of this study. Note that "not controlled action" also includes "not controlled action-particular manner" determinations in this analysis

NCA determinations allow the project to proceed as stated in the referral documentation or sometimes in a "particular manner" as specified by the Australian Government (Figure 1).

The EPBC Act has been routinely criticized for its inability to curb Australian biodiversity loss. Inadequacies pertaining to species listing (Shumway & Seabrook, 2015; Walsh et al., 2013), lack of climate change considerations (Hoeppner & Hughes, 2019) and ineffectiveness in relation to species recovery (Ashman et al., 2021) have been examined. Exposing major compliance shortcomings, a recent investigation found that 93% (7.1 million ha) of the potential habitat cleared for threatened species, migratory, and threatened ecological communities was not referred for assessment, as required by the EPBC Act (Ward et al., 2019). Although this work revealed that most habitat destruction goes unreferred, the characteristics of the 7% of loss submitted to the Australian Government for assessment have not yet been analyzed. Considering a recent independent review of the EPBC Act presented concerns surrounding inconsistencies in the decision-making process (Samuel, 2020), it is crucial we examine specific areas where the EPBC Act and its administration may be failing.

The aim of this study is to examine the relationship between remotely sensed land clearing data and the two types of referral determinations (NCA and CA) in relation to threatened habitats. Since "action is clearly unacceptable" determinations do not permit clearing, only the CA and NCA referrals are investigated. Using government-published maps of woody vegetation loss, our objective is to quantify and compare the associations of CA and NCA referral determinations with potential habitat loss for terrestrial threatened species, migratory species, and threatened ecological communities. To better capture the value of the potential habitat cleared, we apply an impact index, as area alone is not entirely reflective of an action's true impact. For example, 50 ha of land providing habitat for four species with small ranges is viewed as more valuable than 100 ha of land providing habitat to one species with a large range. Consequently, our impact index considers both the number of species impacted and the proportion of their available ranges destroyed by a given project. If the national legislation were effectively protecting MNES, we hypothesize that referrals deemed NCAs would have less overlap with clearing events within the mapped distributions of MNES, and therefore have smaller impact scores when compared to CA referrals. This analysis will illustrate to what extent the referred clearing of woody vegetation that provides potential habitat for protected matters occurs without rigorous assessment under the EPBC Act.

2 | METHODS

Geospatial data delineating woody vegetation loss, referral footprints, the distributions of threatened species, threatened ecological communities, and migratory species were intersected in ArcGIS 10.6. The analysis was restricted to Queensland and New South Wales as high-resolution Statewide Landcover and Trees Survey data was only available for these regions (SLATS; NSW Government, 2020; Queensland Government, 2018). The output of this spatial analysis allowed us to approximate the woody vegetation loss providing potential habitat under CA and NCA referrals between 2000 and 2015. An impact index was then applied to these cleared areas to quantify the value of the woody vegetation lost under each referral determination.

2.1 | Woody vegetation clearing data

As the basis for mapping habitat destruction, we used spatial data of woody vegetation loss (not including natural losses or fire scars) published by the Queensland and NSW state governments using the same SLATS methodology (NSW Government, 2020; Queensland Government, 2018). Rasters showing woody vegetation loss in NSW over the periods of 2000–2002, 2002–2004, 2004–2006, and then annually until August 2016–2017 were combined into a single raster. For Queensland, a similar raster combined SLATS clearing data from 2000–2001 to July 2017–2018.

Both rasters had pixels with 30-m resolutions and contained numeric values that combined the year and purpose of clearings (see Appendix S1 for categories). We excluded clearings prior to the enactment of the EPBC Act. Rasters were filtered to only include pixels that were also mapped as forested in 2000 using the Australian Government's *National Forest and Sparse Woody Vegetation* cover spatial layers for that year (Australian Government, 2018a). To preclude areas already developed prior to 2000, we obtained land use spatial data from the Australian Bureau of Agricultural and Resource Economics and Sciences (Jodie Mewitt, personal communication) which represented uses such as mines, plantations, commercial forest timbers, and residential areas in 2000. Bodies of water, such as lakes and rivers were also excluded. For pixels cleared more than once within the study timeframe, only the year of the first event was used in the analysis to avoid including repeat clearings of young regrowth. Finally, since we are only focused on intentional clearings referred to the EPBC Act, we excluded natural causes of vegetation loss such as wildfires and extreme weather events as recorded in the original published SLATS sources.

2.2 | EPBC referral data

The spatial distributions of referral footprints were obtained from the Australian Government records database (Australian Government, 2018b). Information regarding the industry, year of submission, and determination (NCA or CA) were included for each referral. The version we used contained 6373 referrals across Australia from 2000 to 2020. The dataset was reduced to only include referrals within the jurisdictions of Queensland and NSW. Referrals submitted after July 2015 in NSW and June 2016 in Queensland were omitted from the analysis to allow 2 years for the impacts of any referral-related clearings to show on satellite data. Therefore, the study period fully covers 2000–2015, along with the first 6 months of 2016 for Queensland. Referrals deemed "action clearly unacceptable" were not included in the study as any related clearing would not have been approved by the Australian Government. In addition, referrals with no expected land-clearing activities were removed, such as those submitted for the aerial baiting of wild dogs. Regarding CA determinations, only those with an "approval decision" status were retained since approval is required before land clearing can occur. Consequently, lapsed or withdrawn referrals were discarded. After refinement, 1755 referrals remained. NCA and NCA-particular manner referrals were grouped together, as both ultimately approve the action without further assessment beyond the initial decision of the regulator.

2.3 | Threatened species, migratory species, and threatened ecological community distribution data

Potential habitat loss for nationally recognized threatened species, threatened ecological communities, and migratory species is the focus of this investigation. They will collectively be referred to as MNES throughout the study. We used 100-m resolution distribution maps for 1883 listed threatened and migratory species which displays areas where they are "known to occur" and "likely to occur" (Australian Government, 2016). "Known to occur" describes locations of preferred habitat for species that are within a reasonable ecological distance from recorded sightings, while "likely to occur" outlines habitat that is predicted to be suitable for species and is within appropriate distances from "known to occur" ranges. These maps delineate ranges where suitable habitat is "known" or "likely" to occur and does not necessarily mean the habitat is occupied. Consequently, we refer to these areas as "potential habitat". The role of the referral process is to ensure that surveys are done prior to action approval to determine if the "known" or "likely" mapped habitats are genuine. Distributions of 84 threatened ecological communities were also obtained at a 100-m gridded resolution. However, in addition to areas where these communities are "known to occur" and "likely to occur", the dataset includes areas where they "may occur". For the purposes of our analysis, we removed these "may occur" distributions due to the increased uncertainty of their actual presence on-the-ground. Communities lacking dominant woody vegetation, such as caves and alpine regions beyond the tree line were removed from the analysis (Australian Government, 2020a). Finally, vulnerable communities were removed since they are not considered MNES under the EPBC Act (Australian Government, 2013a).

2.4 | Referred clearing of potential habitat

We intersected referral footprints and clearing datasets to generate a referral-clearings output. This allowed us to identify areas of land cleared under NCA and CA referral determinations between 2000 and 2015. In an attempt to ensure clearing events were direct consequences of submitted referrals, we removed any associations of clearing events with referrals that did not match with respect to either time or purpose. Clearing events that occurred in years prior to referral submission were omitted. However, as the Queensland clearing datasets are based on the financial year, clearings within the first 6 months of the calendar year that were related to referrals submitted in the first half of that same calendar year may have been unintentionally excluded from the analysis. As there is no way of determining in which calendar year the Queensland clearings occurred, there was no way to correct this. Regarding the purpose of clearings, both the industry submitting the referral and the cause of clearing as reported by SLATS were assigned to four comparable categories: agriculture, infrastructure, mining, and urban development (see Appendix S1 for more detail). We removed clearing events where the reasons for woody vegetation loss as stated by SLATS did not match the referral submission. For example, agricultural-related clearing that intersected with a mining referral would have been eliminated from the analysis.

Spatially overlapping referral footprints with identical purposes confounded efforts to associate individual clearing events with a singular referral. Attributing these ambiguous clearing events to the correct referral requires laborious study of referral documentation and satellite

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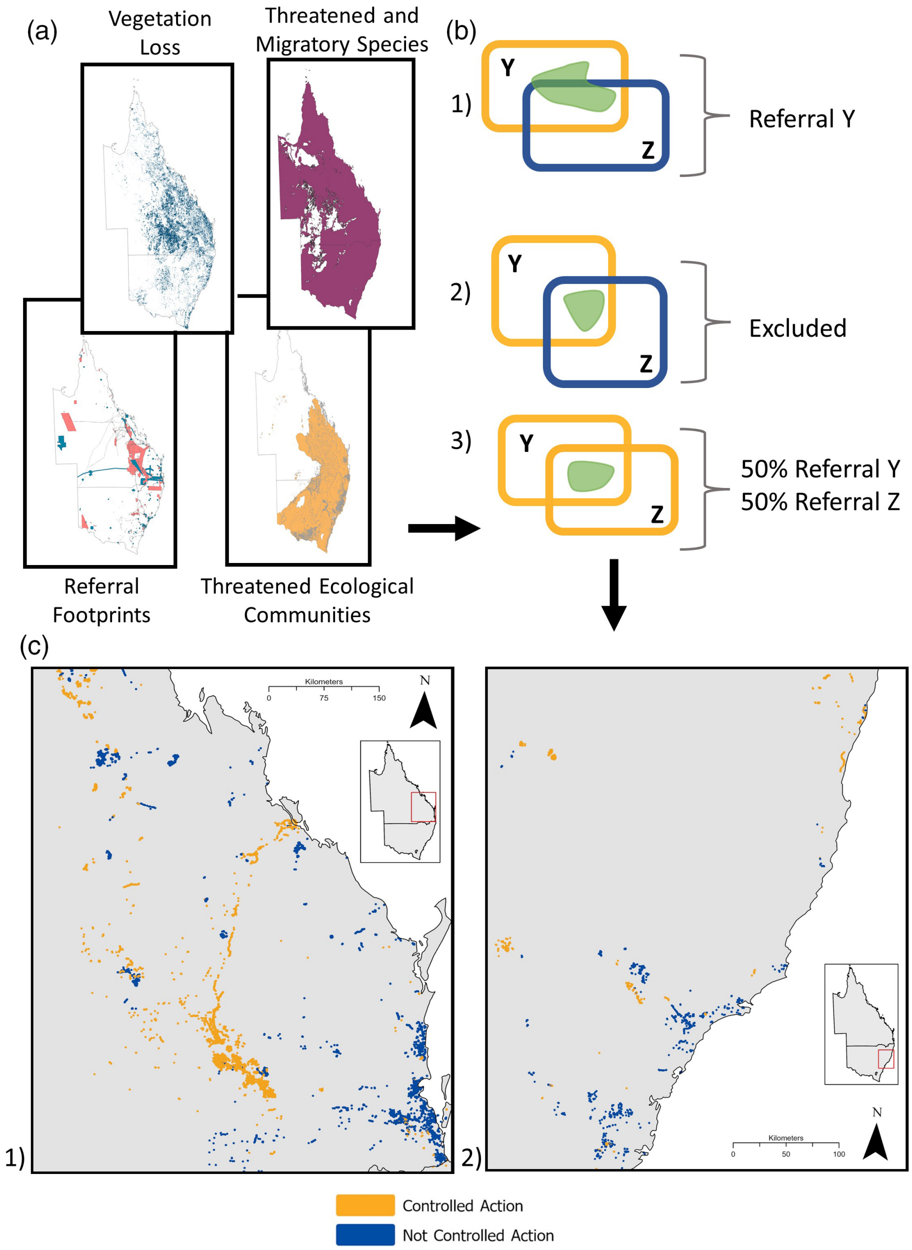

FIGURE 2 (a) Visual depiction of the spatial data intersected to determine threatened species, migratory species, and threatened ecological community potential habitat loss. (b) Shows how "ambiguous" clearing events (green) that overlapped with more than one referral were assigned, where the orange and blue rectangles represent opposing referral determinations. (c) Final output of potential habitat loss for MNES in (1) Queensland and (2) NSW under CA (orange) and NCA (blue) referral determinations. CA, controlled action; MNES, Matters of National Environmental Significance; NCA, not a controlled action; NSW, New South Wales

data. Instead, we applied three measures to ensure analyzed clearings were counted only once and associated with the correct referral determination. First, clearing events were attributed to the referral with the largest spatial overlap. For example, if 15 ha of a 20-ha clearing event was associated with *Referral Z*, while the entire 20 ha of the same clearing was also associated with overlapping *Referral Y*, the clearing was attributed to *Referral Y*. Any intersection with *Referral Z* was removed from the dataset. Second, if a clearing event intersected two or more referrals with opposing (NCA and CA) determinations, the clearing was entirely removed from the analysis. This was done to avoid any chance of attributing clearing events to incorrect referral determinations and resulted in a 15% loss of MNES-related clearing data. Third, clearing events that intersected two or more referrals with the same purpose and determinations (NCA-NCA or CA-CA) were evenly split by area among the overlapping referrals. For example, if a 30-ha clearing event intersected three CA referrals of the correct timing and purpose, 10 ha of CA clearing would be attributed to each of the three overlapping referrals (Figure 2b). Approximately 29% of the MNES-related clearings were split among referrals using this method.

To determine the area of potential threatened habitat cleared under referrals, we separately intersected the referral-clearings output with the species and community spatial distributions (Figure 2a). Only MNES listed under the EPBC Act at the time of the decision-making process are taken into consideration by the Federal Government

(Australian Government, 2013b). Therefore, we removed clearings if the MNES was listed in the years following referral submission. For example, only referrals from 2012 to 2015 that impacted vegetation within the mapped koala distribution were retained since koalas were listed in 2012. For MNES that were listed in the same year as the submitted referral, the specific MNES listing date (Australian Government, 2020b) and referral decision date (Australian Government, 2021) were retrieved, compared, and removed accordingly.

2.5 | Impact index to quantify the value of cleared land for MNES

We applied a dimensionless impact index to quantify the conservation importance of clearings associated with either NCA or CA determinations. First, the proportion of potential habitat removed under each clearing event (c) within the mapped distribution for MNES (i) was calculated:

$$P_{ci} = \left(\frac{X_{ci}}{Y_i}\right) \times 10^3 \quad (1)$$

where X_{ci} is the area (ha) of potential habitat cleared in a clearing event (c) for a given MNES (i) and Y_i is the total area (ha) of the mapped distribution where MNES (i) is "known" or "likely" to occur (Australian Government, 2016). Note, a multiplier of 10^3 was incorporated for the ease of reporting results and thus reflects the proportion of impacted potential habitat expressed as parts per thousand (P_{ci}).

Next, we summed the proportions of impacted potential habitat (P_{ci}) across all clearing events (c) and across all MNES (i) within a given referral, producing an impact score for each referral (Z_r):

$$Z_r = \sum_{c=1}^{m} \sum_{i=1}^{n} P_{ci} \quad (2)$$

where n is the total number of MNES with mapped distributions intersecting clearing events within a referral and m is the number of clearing events pertaining to the MNES in question. Note, this index quantifies the conservation value of the cleared woody vegetation. Although the units are proportions by area (expressed as parts per thousand), their sum after considering the multiple impacted MNES can no longer be considered a simple proportion. Rather it must be seen solely as an index of impact and when applied, produces a score representing the "*weighted* potential habitat" cleared. This contrasts with the simple area (ha) of woody vegetation cleared in the absence of the index.

The proportions of potential habitat cleared (P_{ci}) were also summed across all clearing events, for all referrals, to provide the "overall proportion of potential habitat" (H_i) impacted for a given MNES (i) during our study period (again expressed as parts per thousand):

$$H_i = \sum_{c=1}^{b} P_{ci} \quad (3)$$

where b is the total number of clearing events that overlap all referrals and involve MNES (i) over the study period. When H_i is reported for an individual species or community, it will be referred to as the "overall proportion of potential habitat". Similar to above (Equation (2)), when these proportions are summed across multiple MNES to compare impacts under various categories, such as the impacts experienced by different threat categories, these outputs will again be referred to as index scores and represent the "*weighted* potential habitat" cleared.

2.6 | Sensitivity analysis

Clearing events that intersected two or more referrals of different determinations (NCA and CA) were excluded from the analysis, consequently omitting 15% of the available MNES-related clearing data. To explore how the removed data impacted results, a sensitivity analysis was conducted. We retained and attributed these ambiguous clearing events to the CA referrals in question. Although it is highly unlikely all ambiguous clearings were the result of CA referrals, this extreme assumption provided a means of conservatively assessing the role of NCA referrals without excluding any available clearing data. A second sensitivity analysis was also conducted to explore the impacts of splitting clearing events equally over overlapping referral footprints of the same determination. To do this, we compared the median impact scores under CA and NCA actions using the 71% of clearing data that was not split.

2.7 | Matched pairs comparison

Important details in the referral documentation offer specific context for each action and are crucial in shaping the decision-maker's determination. Such information is not adequately captured in the foregoing spatial analysis, where the only evidence that an observed clearing was caused by the proposed action for a given referral is the coincidence in space, time, and purpose. Despite this coincidence, it is possible the observed clearing was not causatively related to the action specified in the referral. We reviewed the referral documentation to better understand the relationship between the observed spatial relationships and the information submitted to the decision-maker. Using unique identifiers, referral documents were retrieved using the online portal (Australian Government, 2021). Four matched pairs were established for comparison where one referral was a CA and the other was NCA. The pairs were selected to be near one another (within a 50 km radius) so that mostly the same species were impacted. Pairs were also within 2 years of each other and submitted by the same industry.

3 | RESULTS

3.1 | Overall MNES habitat impacts

Of the woody vegetation loss referred to the Australian Government for assessment in Queensland and NSW between 2000 and 2015, about 19,430 ha of potential habitat for MNES was cleared (Figure 2c). Approximately 10,941 ha of woody vegetation providing potential habitat for one or more threatened species was cleared under CA referrals (that is 57% of the total area referred to the Australian Government) and 8176 ha (43%) under NCA referrals. Migratory species lost 10,943 ha (57%) of potential habitat under CA referrals and 8206 ha (43%) under NCA referrals. Threatened ecological communities experienced the least amount of clearing with 2051 ha (85%) removed under CA referrals and 370 ha (15%) under NCA referrals. As migratory species and threatened species habitats often overlap, the sum of the individual MNES components is larger than the stated area of land cleared.

Application of the impact index, which involved summing the proportions of potential habitat loss across MNES, resulted in a score of 58.1 for threatened species under CA referrals (that is 38% of the total threatened species impact score) and 96.7 (62%) under NCA referrals. The impact score for migratory species was also smaller under CA referrals at 0.5 (20%) compared to 2.0 (80%) under NCA referrals. Threatened ecological communities scored 1.7 (40%) under CA referrals and 2.5 (60%) under NCA referrals. Therefore, when considering the summed proportions of cleared potential habitat under the EPBC Act for the MNES of this study, NCA referrals were responsible for 63% of the weighted potential habitat loss and CA referrals for 37%.

3.2 | Relationship between referral determinations and MNES impacts

Referral-specific impact scores (Z_r) represented the summed proportions of potential habitat loss across all

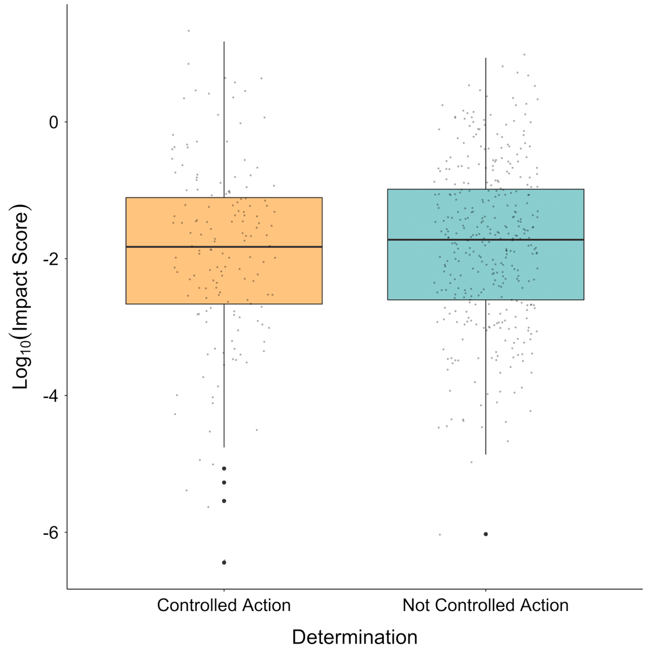

FIGURE 3 Impact scores of the 517 referrals (CA = 153, NCA = 364) intersecting with potential habitat loss in Queensland and NSW between 2000 and 2015. These impact scores are the summed proportions of potential habitat loss for all threatened species, threatened ecological communities and migratory species under each referral. (Wilcoxon rank sum test, $W = 26{,}704$, $n = 517$, $p = .46$, 95% confidence interval: −0.0043 to 0.0015). CA, controlled action; NCA, not a controlled action; NSW, New South Wales

impacted MNES for each referral (Equation (2)). We compared impact scores of the two determinations (Figure 3) using a Wilcoxon rank sum test which found no statistically significant difference between the median impact scores for potential habitats cleared under CA determinations (Median = 0.015, n = 153) and NCA determinations (Median = 0.019, n = 364), W = 26,704, n = 517, p = .46, 95% confidence interval: −0.0043 to 0.0015.

3.3 | Specific impacts on MNES

In the first 15 years of enactment, 306 threatened species, 13 threatened ecological communities, and 60 migratory species experienced potential habitat loss under referred actions. Among the threatened and migratory species to lose the greatest absolute area of potential habitat was the fork-tailed swift (*Apus pacificus*) at 19,149 ha, the red goshawk (*Erythrotriorchis radiatus*) at 15,689 ha, and the Australian painted snipe (*Rostratula australis*) at 13,304 ha. In comparing the overall proportions of land cleared under the two referral determinations, certain species were found to have lost most of their potential

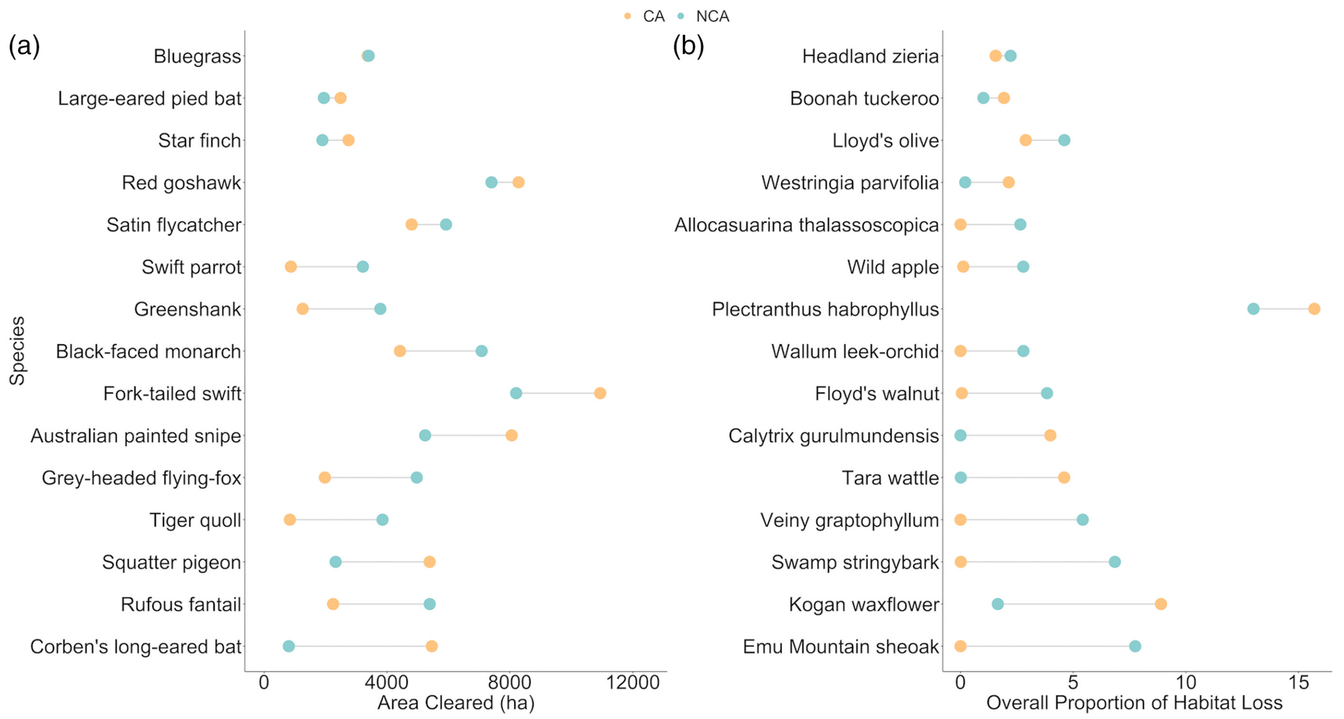

FIGURE 4 (a) The total areas of potential habitat cleared under each referral determination for the 15 species with the greatest absolute areas cleared. (b) The proportions of the overall potential habitat cleared under each referral determination for the 15 species with the greatest overall proportions cleared. For example, Corben's long-eared bat (*Nyctophilus corbeni*) lost 5460 ha of potential habitat under CA referrals and 806 ha under NCA referrals, whereas Emu Mountain sheoak lost 0% of its nationally mapped habitat under CA referrals and 0.77% under NCA referrals (as a reminder, the overall proportion of habitat loss incorporates the 10^3 multiplier). CA, controlled action; NCA, not a controlled action

habitat under NCA referrals. For example, 82% (3856 ha) of the referred potential habitat loss for the tiger quoll (*Dasyurus maculatus maculatus*) occurred under NCA referrals (Figure 4a).

Since species with large ranges are more likely to lose a greater absolute area of potential habitat, we determined the overall proportion of potential habitat cleared for each MNES. The following three plant species were most impacted (along with their associated impact scores): *Plectranthus habrophyllus* (28.7), kogan waxflower (*Philotheca sporadica*) (10.6), and Emu Mountain sheoak (*Allocasuarina emuina*) (7.8; Figure 4b; note these proportions are expressed as parts per thousand). Interestingly, all referred potential habitat loss for Emu Mountain sheoak and veiny graptophyllum (*Graptophyllum reticulatum*) occurred under NCA referrals despite their listings as endangered species.

3.4 | Trends in referral determinations

There were 207 infrastructural referrals (NCA = 148, CA = 59); 129 mining referrals (NCA = 63, CA = 66); 170 urban development referrals (NCA = 145, CA = 25), and 11 agricultural referrals (NCA = 9, CA = 2) remaining after spatial intersections. The urban development sector had a greater cumulative impact under NCA referrals (61.1, representing 74% of the total urban impact score) than CAs. The agricultural sector (3.1, 98% of the total agricultural impact score) and infrastructure sector (33.0, 54% of the total infrastructure impact score) also lost more weighted potential habitat under NCA referrals. Only the mining sector had a greater cumulative impact under CA referrals (10.8, 73% of the total mining impact score) (Figure 5a).

More weighted potential habitat, that is habitat that considers the number of species and their impacted range, was cleared under NCA referrals compared to CAs for all three threat statuses (Figure 5b). Vulnerable species with the greatest overall proportion of potential habitat loss under NCA determinations included Lloyd's olive (*Notelaea lloydii*; 4.6) and Wallum leek-orchid (*Prasophyllum walluml*; 2.8). Endangered species most impacted were *Plectranthus habrophyllus* (13.0) and Emu Mountain Sheoak (7.8). The critically endangered ecological community "Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest" was disproportionately impacted by NCA clearings (1.5) when compared to the CA clearings (0.5).

FIGURE 5 Impact scores were summed across all clearing events to show the overall impacts of referral determinations on (a) threatened species, migratory species, and ecological communities for each industry, (b) threatened species and ecological communities when considering threat category (excluding migratory species), and (c) for threatened species, migratory species, and ecological communities in areas where habitat is "known" or "likely" occur

Regarding the possible presence of threatened species in cleared areas, the most weighted potential habitat loss occurred in areas where species are "likely to occur". In regions where threatened species are "known to occur", more weighted potential habitat was lost under NCA referrals (79% of the total "known" impact score) compared to CA referrals (Figure 5c). To explore specific species impacted by habitat clearing under NCA referrals in "known to occur" areas, we identified the top 15 species to lose the greatest proportion of habitat (expressed as parts per thousand) in these regions. The three most impacted species and the associated areas cleared in these regions were the Oriental cuckoo (*Cuculus optatus*) with 1427 ha, the spectacled monarch (*Symposiachrus trivirgatus*) with 2015 ha, and grey-headed flying-fox (*Pteropus poliocephalus*) with 3800 ha of "known to occur" potential habitat cleared under NCA referrals (Figure 6).

3.5 | Sensitivity analysis

By assigning all land clearing events that overlapped referrals of differing determinations to CA referrals, we retained 36,671 ha of potential habitat loss that was excluded from the primary analysis and an additional 27 CA referrals. Applying the impact index to this alternate dataset provided an impact score of 100 (50%) for clearings performed under CA referrals and 101 (50%) for NCA referrals. Compared to our primary results where these conflicting clearings were omitted, CA clearing accounted for 13% more of the weighted potential habitat loss. As no significant difference was detected between the median impact scores for referrals of opposing determinations, our main finding was not impacted (Wilcoxon rank sum test, NCA Median = 0.019, CA Median = 0.025, $n = 544$, $W = 33{,}807$, $p = .54$, 95% confidence interval: −0.0015 to 0.0050). The general trends observed in referral determinations largely remained the same compared to our original findings except that the cumulative impacts of CA referrals were greater than NCAs for projects completed by the infrastructural sector, in areas where species were "known to occur", and for vulnerable species. In the second sensitivity analysis where we excluded all clearing events that overlapped multiple referrals, retaining 71% of original MNES clearing data, no significant difference was detected between the median impact scores under CA and NCA referrals (Wilcoxon rank sum test, CA Median = 0.016, NCA Median = 0.019, $n = 392$, $W = 16{,}677$, $p = .53$, 95% confidence interval: −0.0056 to 0.0022). As well, no differences

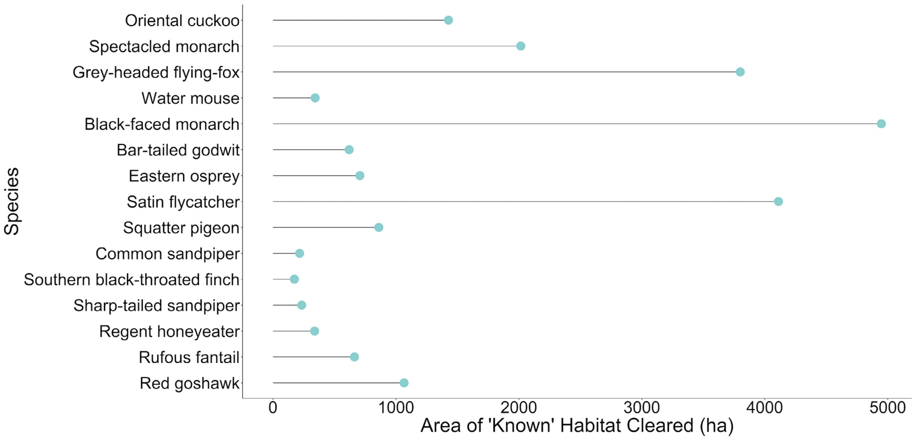

FIGURE 6 The 15 threatened and migratory species with the highest overall proportion of potential habitat loss under NCA referrals in areas where they are "known to occur" (where at least a cumulative 100 ha had been cleared between 2000 and 2015). Species with the greatest proportion of "known to occur" loss are listed from top to bottom and are displayed with the associated absolute area cleared during the study period. NCA, not a controlled action

in referral trends were observed compared to the primary findings (see Appendix S1).

3.6 | Matched pairs comparison

We provide four examples reflective of the encountered matched pair scenarios. Some followed expectations where the impacts on MNES anticipated in the CA referral documentation were undoubtedly greater than its paired NCA referral (S6.1; see Appendix S1 for example case studies). We observed cases where the details provided in the documentation may have been important in the decision-making process. For example, in one pair, the scale of impact was similar. However, the quality of habitat was described as more valuable at the CA site, potentially explaining the CA referral determination (S6.2). Reflective on our spatial output, we also encountered scenarios where the expected impact of an NCA referral on threatened species habitat appeared to be greater than its corresponding CA referral (S6.3). Few cases were found where the decision-maker restricted the scale of impact for a CA referral to be less than that originally intended by the proponent, and when encountered the scale of impact was marginally reduced (S6.2). We also came across scenarios where either CA or NCA referrals completed only small fractions of the intended project (or none at all) within the timeframe of our study as detected by the satellite clearing data (S6.2 and S6.4).

4 | DISCUSSION

Between 2000 and 2015 in Queensland and NSW, 63% of weighted potential habitat loss was cleared under NCA referrals and 37% under CA referrals. This means over half of the weighted potential habitat loss (after considering the number of species and their overall mapped ranges impacted) that overlapped with referral footprints submitted to the Australian Government was approved on the basis of referral documentation and not subject to further scrutiny under the EPBC Act. Furthermore, our findings show no statistically significant difference between median impact scores for CA and NCA determinations. Therefore, our expectation that CA referrals would, on average, have greater impact scores than those deemed NCAs was not substantiated.

Three reasons may explain why the clearing of potential habitat is deemed by the regulator as non-significant and thus NCA. First, the vague terminology of "significant impact" and ambiguity of significant impact criteria may allow different regulators to apply subjective decisions without regard to objectively measured impact (Samuel, 2020). For example, significant actions include those "likely to lead to a long-term decrease in the size of a population" (Australian Government, 2013a). However, without clear species-specific thresholds, determining which actions are likely to lead to such a decrease remains abstract. Second, proponents may intentionally minimize the impacts an action is likely to have in a referral in hopes of avoiding the cumbersome environmental assessment process. For example, during our examination of the referral documentation for the matched pairs comparison, proponents frequently described habitat to be impacted as "degraded". The Australian Government, however, does not appear to have access to reliable data sources to critically examine such claims and is overly dependent on the honesty of proponents and their hired consultants (Samuel, 2020). Again, this may result in an action being deemed NCA when not appropriate. Third, due to a lack of transparency in the decision-making process, there are increasing perceptions that social and economic factors may be given more weight than environmental factors when determining the overall impacts of an action (Samuel, 2020). If this were to be the case, more referrals could be "waved through" as NCAs to conciliate industries.

Regardless of the reasoning, poor administration of the EPBC Act appears to be preventing adequate protection of Australia's threatened biodiversity. Integrating the knowledge that only 7% of all potential habitat cleared in Australia is referred to the Australian Government for consideration (Ward et al., 2019) with our findings that 59% of the referred MNES area is removed under CA determinations, means possibly as little as 4% of land providing potential habitat in Queensland and NSW undergoes thorough assessment under the EPBC Act where mitigations and offsets can be applied to reduce net impacts to non-significant levels. This value would be even less than 4% if the number of species and the proportion of their impacted ranges were considered. Notably, the degree of protection received may depend on the type of MNES. For example, over half of the species impacted by clearings of "known" potential habitat were migratory species (Figure 6). Considering we controlled for their often-associated large distributions using the impact index, this finding stands out given the number of migratory species (60) in our study was much less than the assessed threatened species (306). Similar to the treatment of vulnerable species (Simmonds et al., 2020), migratory species may not be receiving adequate consideration under the EPBC Act and warrants further investigation. For some threatened species, the relationship between NCA determinations and potential habitat loss aligned with our hypothesis that less impact would be observed on MNES under NCAs. For example, the recently delisted Kogan waxflower (Australian Government, 2020c) lost most of its weighted potential habitat under CA referrals (Figure 4b). However, for other species such as the vulnerable grey-headed flying-fox or endangered tiger quoll, most of the referred area providing potential habitat was cleared under NCAs (Figure 4a).

Out of the 19,430 ha of land cleared that provided potential habitat within the referral footprints, 41% was deemed non-significant. However, this same area accounted for 63% of the total weighed potential habitat loss under NCA determinations. This greater loss under NCAs after applying the index highlights the importance of considering both the number of species impacted and the proportion of their ranges. The cumulative impacts on species beyond the area of woody vegetation removed should also be taken into consideration during the decision-making process. Failure of the EPBC Act to consider cumulative impacts across projects is another widely criticized aspect of the legislation (Dales, 2011; Grech et al., 2016; Whitehead et al., 2017). Cumulative impacts are of particular concern in the urban development sector. Of all referrals submitted by the urban sector, 85% were deemed non-significant despite accounting for 74% of the overall weighted potential habitat cleared which considerably impacted certain species. For example, the urban development sector cleared the greatest area of potential regent honeyeater (*Anthochaera phrygia*) habitat, of which 99% (2209 ha) occurred under NCA referrals—mostly small lots of land with a median area of 3 ha. Our findings also identified the regent honeyeater to be among the most impacted species by clearings of "known to occur" habitat (Figure 6). Since the enactment of the EPBC Act, the regent honeyeater has been uplisted to critically endangered with habitat loss from residential and commercial developments recognized as a high-priority threat (Crates, Ingwersen, et al., 2021). It is now estimated that less than 400 individuals persist in the wild (Garnett et al., 2011), and depleting population numbers are beginning to interfere with fundamental behavioral characteristics (Crates, Langmore, et al., 2021). Urban sprawl is expected to intensify in the next 20 years (Clark & Johnston, 2016; Coleman, 2016) and many threatened species inhabit these urban areas, relying on remnant patches of vegetation for survival (Ives et al., 2016), making it is crucial the assessment process properly examines these referrals.

The number of threatened species listed under the EPBC Act has increased by an average of 8% over the past 5 years (Cresswell et al., 2021). These listed species require environmental legislation that is effective to prevent further extinctions. As our findings identify an area where the EPBC Act and its administration appear to be failing, we offer the following suggestions for improvement. First, we support calls for improved databases, including improved habitat mapping and monitoring of species populations (Samuel, 2020). Such information will enable decision-makers to better verify information received in a referral, as comprehensive information is fundamental to proper decision-making (Beunen, 2006). Second, we recommend the establishment of a database that spatially tracks former approvals so cumulative impacts can be considered in the decision-making process. Third, approvals given as a result of NCA determinations should not be indefinite. At present, no expiry exists for NCA determinations, meaning habitat clearing may occur decades after approval. To account for dynamic changes in the environment, actions taken under NCA referrals should be required to occur within a set timeframe from approval as new species may be listed or listed species may be uplisted over time. Finally, definitions for "significant impact" must be developed to reduce the ambiguity that enables regulators to be subjective (Murray et al., 2018; Samuel, 2020; Simmonds et al., 2020; Ward et al., 2019). Specifically, quantitative thresholds should exist for habitat destruction for each protected matter similar to those for koalas—although results from our case studies highlight the importance of their consistent application (Australian Government, 2014). Definitive thresholds also promote compliance, as it prevents developers from incorrectly claiming their action is not significant by exploiting existing ambiguities. Quantitative thresholds and standardized survey methods established by a scientific committee with current ecological knowledge can also better assist ecological consultants, as concerns have been expressed surrounding the lack of professional standards binding such consultants (Dyer & Simmonds, 2021; Samuel, 2020).

This analysis is subject to under and over-estimation errors as it is based solely on spatial data which is not confirmed on the ground except in the pairwise case studies. Clearing is only attributed to a given referral if it is coincident in space, time, and purpose, however, coincidence does not ensure causality. The clearing observed may not in reality have been relevant to the referral. We also split ambiguous clearing events among overlapping referrals so as not to lose data (Figure 2b). For these reasons, we may have incorrectly over or underinflated the area cleared under a given referral. Conversely, we filtered out clearing events where location, time, and purpose did not match, rather than interrogating each individual referral. In doing so, we may have discarded real connections between clearing events and referrals, understating the real impact. For example, if the purpose of a clearing event as stated by SLATS was incorrect and consequently did not match the purpose of an overlapping referral when it should have. Finally, clearing under a given referral may not have yet taken place as it will, or has happened after the timeframe of this analysis. This fact also means that for some referrals, the actual impact has been underestimated.

An accumulation of such individual referral errors could alter the median clearing calculated for each referral determination, ultimately impacting our finding that no significant difference exists between the median value of habitat cleared under CA and NCA referrals, but only if NCA and CA referrals are biased in some way toward under or over-estimation errors. We have no reason to believe that such bias exists. For total confidence in assigning clearing events to referrals, one would have to undertake the onerous task of manually matching clearing events and referrals, reading each referral and digitizing their published maps (if available). To provide more confidence in our findings though, when ambiguous clearing events were retained as CA clearings in the sensitivity analysis, the main conclusions pertaining to urban development-related clearings and overall determination impacts did not change. The results from our second sensitivity analysis using the unsplit data also showed no significant difference between CA and NCA impacts (see Appendix S1).

Our study quantifies the potential habitat areas where MNES are "known or likely" to occur as mapped by the Australian Government. We cannot be certain species or communities occupy all mapped areas and acknowledge that the ground-truthed information included in submitted referrals may contradict the potential habitat distribution maps provided by the government. For example, our results indicated substantial clearing occurred for the fork-tailed swift, however, this species is almost exclusively aerial and therefore any habitat loss is unlikely to have a significant impact (Australian Government, 2022). Again, such scenarios would result in an error of overestimation of the impact. Conversely, it may be that government maps of potential habitat fail to include actual occupied habitat that was cleared under some of these referrals, resulting in an underestimation of impact. We also recognize that when examining the aggregate clearings experienced for MNES, clearings may have been included that were technically considered non-significant as per the national guidelines. For example, projects for pipelines often have elongated but narrow impacts on vegetation and therefore may not be deemed likely of a significant impact on MNES. For this reason, the matched pairs were used to provide further insight into referral-specific details and compare the observed spatial impact with the information examined by the decision-maker. Another potential concern with our findings was if the decision-makers systematically reduced the impact threshold as a consequence of a CA determination. This could potentially explain the lack of significant difference between the two determinations. However, as previously mentioned, few cases could be found where the impacts of CA referrals were curtailed and when found the scale of impact was not substantially reduced.

Examination of the referral documentation did highlight an issue of proponents only developing a fraction of the proposed area or not executing the project at all. This may happen for a variety of reasons, including actions requiring multiple years for completion or funding issues interfering with project commencement. Where present, these scenarios cause a disconnect between the observed spatial impact and information provided to the decision-maker. Although incomplete projects were found to occur under both CA and NCA determinations, we realize these incomplete actions may have also influenced our final conclusions as an impact underestimation error as discussed above.

Overall, inconsistencies in the decision-making process are evident at both the spatial and referral documentation levels. The role of transparent thresholds, clear definitions, detailed spatial information, and connected databases are paramount in reducing the subjectivity of determinations. Across the globe, environmental laws need to be both properly crafted and implemented to effectively curb the present biodiversity crisis. With Australian wildlife rapidly declining, it is clear that changes need to be made to the keystone piece of environmental legislation. Here, we identified a specific aspect of the legislation and its administration that requires improvement. The EPBC Act and its regulators must refine the criteria and decision-making processes surrounding referral determinations to properly protect threatened Australian habitats.

AUTHOR CONTRIBUTIONS

Martin F. J. Taylor conceived the concept and prepared vegetation datasets. Natalya M. Maitz performed the spatial analysis, interpreted results, and wrote the manuscript. All authors offered continuous input on the general project direction and final manuscript comments.

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CONFLICT OF INTEREST

Hugh P. Possingham is on the Board of Directors for BirdLife Australia, Chair of the Terrestrial Environmental Research Network, and Chair of the Environment Institute, Adelaide University.

DATA AVAILABILITY STATEMENT

Outputs from the spatial analysis are available at https://doi.org/10.48610/6c8fee3.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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