Resilient Landscapes

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QUT

Methods for identifying areas important to biodiversity

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Acknowledgement of Country

We acknowledge the Traditional Owners of Country throughout Australia and their continuing connection to and stewardship of land, sea and community. We pay our respects to them and their cultures and to their Ancestors, Elders and future leaders.

Our Indigenous research partnerships are a valued and respected component of National Environmental Science Program research.

Areas important for biodiversity are a priority for protection. Image: dudlajzov/Adobe Stock.

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Executive summary

In December 2022, the Australian Government joined 195 other nations in signing on to the Kunming-Montreal Global Biodiversity Framework (GBF) at the 15th meeting of the Conference of the Parties (COP 15) of the Convention on Biological Diversity. The Kunming-Montreal GBF aims to halt and reverse the decline in biodiversity globally by 2030, and it sets 4 goals and 23 associated targets to meet this overarching aim. Protected and conserved areas are seen as central to this, and the GBF includes a commitment in its Target 3 to protect and conserve 30% of land and sea areas by 2030, otherwise known as the '30-by-30' target.

Target 3 reads 'Ensure and enable that by 2030 at least 30 per cent of terrestrial and inland water areas, and of marine and coastal areas, especially areas of particular importance for biodiversity and ecosystem functions and services, are effectively conserved and managed through ecologically representative, well-connected and equitably governed systems of protected areas and other effective area-based conservation measures …'. This captures many principles related to the design and implementation of protected and conserved areas. The GBF defines 'areas of particular importance for biodiversity and ecosystem functions and services as 'areas particularly important for biodiversity include areas high in species richness or threatened species, threatened biomes and habitats, areas with particularly important habitats and areas that are important for the continued provision of ecosystem functions and services'. There are several methods of identifying and defining important areas, and these are the focus of this project.

The scope of this project was to:

- identify and review the possible mapping methods to identify areas important for biodiversity,
- review existing state, territory, and NGO approaches, and assess their alignment to global requirements,
- summarise how these approaches can be used to ensure that protected and conserved areas in Australia are representative of our diverse landscapes and seascapes.

For this project, 'methods' refers to systematic and scientific approaches used to identify specific geographic regions or sites that are important for biodiversity. These methods typically analyse various ecological and biological factors, including species distribution data, habitat characteristics and conservation priorities, to pinpoint areas suitable for conservation efforts to protect and sustain biodiversity.

There are various internationally recognised methods for identifying areas important for biodiversity. In Australia, many methods are used by jurisdictions and non-government organisations (NGOs), including land conservancies, to identify and define areas important for biodiversity. We evaluated the available methods that could be used to identify, in a nationally consistent way, areas that are important for biodiversity.

On the basis of our analysis, we recommend irreplaceability (both as a stand-alone method commonly used by governments and conservation NGOs, and as Criterion E of the Key Biodiversity Area [KBA] method) as an appropriate nationally consistent approach for Australia.

Review of international methods to identify areas important for biodiversity

We identified and reviewed relevant internationally recognised methods for identifying areas important for biodiversity specific to terrestrial environments (WWF 2017): KBAs, biodiversity hotspots and criteria-based methods, including Outstanding Universal Value (OUV) and Ramsar sites. We note that the KBA method was designed as a combination of 2 distinct methods (site-based assessments using threshold criteria and systematic conservation planning using measures of irreplaceability) (IUCN 2016; Smith et al. 2019). Irreplaceability is different to the other methods reviewed in that the irreplaceability of areas (or 'sites') is calculated as the likelihood that a given site will need to be protected to ensure the achievement of regional conservation targets (Ferrier et al. 2000). Conservation targets might be set based on the assessed adequacy needs for specific ecosystems or species or in response to political targets; however, for KBA Criterion E (Irreplaceability through quantitative analysis), there is specific guidance on setting targets in relation to site-based attributes as defined through the threshold-based KBA Criteria A–D (KBA Standards and Appeals Committee 2019). We therefore assessed KBA overall and KBA Criterion E (irreplaceability) both individually and as a single method.

We conducted a desktop review of these methods against the following criteria to judge their overall performance and determine their suitability for use in a nationally consistent way in Australia (Table 1).

- fit-for-purpose – is the approach feasible, compatible and responsive?
- inclusiveness – can the approach identify areas with diverse genetic, species and ecosystem representation?
- persistence – does the approach consider conditions necessary for the long-term survival of species and other elements of biodiversity?
- uniqueness – can this approach identify locations with rare and distinctive species or ecosystems?

Based on our desktop assessment, we identified 3 methods that performed well overall across the criteria – KBA Criteria A-D, KBA Criterion E (irreplaceability), and OUV.

Table 1. Summary of the assessment of the Key Biodiversity Area methods, biodiversity hotspots method, Outstanding Universal Value method and Ramsar method.

✓	The approach performs this function well.
–	The approach somewhat does this.
×	The approach does not do this.

Method	Fit-for-purpose	Inclusive-ness	Persistence	Uniqueness	Overall assessment	Comment
Key Biodiversity Area (KBA) Criteria A–D	–	✓	–	✓	✓	The data required to conduct comprehensive application of the site-based threshold criteria across all species exists only in part and would likely require significant investment in expert elicitation or site assessments to conduct at the national scale. The criteria are not as flexible as Criterion E in considering other aspects of site design and interfacing with broader national policy principles (e.g. comprehensive, adequate, representative [CAR] and climate refugia aspects).
KBA Criterion E (irreplaceability)	✓	✓	✓	✓	✓	Criterion E – irreplaceability – is calculated with available decision support tools, but targets must reflect guidance given in the KBA criteria to ensure that species features and thresholds are met. The type of data that can be used include existing vegetation, habitat and threatened species (e.g. Species of National Environmental Significance) data (DCCEEW n.d.). Criterion E is efficient, flexible and interfaces well with broader national policy principles (e.g. CAR and climate-refugia considerations where data is available).
KBA overall	–	✓	–	✓	✓	The overall KBA method rating reflects the ratings of Criteria A-D noting that for those criteria the data required exists only in part. However, if sites are evaluated against KBA Criterion E greater flexibility exists and this data exists now for use.
Biodiversity hotspots	✓	–	×	✓	–	Biodiversity hotspots are considered effective based on our fit-for-purpose criterion. However, the method is based on strict rules and data requirements, reducing its flexibility. The approach considers certain inclusiveness elements, such as species richness and endemism. The approach indirectly accounts for genetic diversity, but it does not account for ecological processes. The approach does not address our persistence criteria.
Outstanding Universal Value (OUV)	–	✓	–	✓	✓	The OUV method ranks well for feasibility, suitability and compatibility with global frameworks. It is moderately efficient, flexible to different data types, and scalable but it lacks responsiveness due to the detailed nature of conservation assessment processes. This method is not a dedicated tool for biodiversity assessment, but it can indirectly contribute to the identification of areas with outstanding samples of genetic, species and ecosystem diversity and benefits from a comparative assessment approach. The method would most likely need to be paired with another or used in conjunction with spatially explicit tools to comprehensively assess important areas for biodiversity. The OUV method performs strongly in relation to our criteria of assessing uniqueness.
Ramsar	–	–	–	✓	–	The Ramsar method aligns well with the uniqueness criterion. However, its focus on wetland conservation limits its ability to comprehensively address broader aspects such as ecological integrity, species' persistence, threats and climate resilience. Additional criteria and methods may be necessary for a more comprehensive assessment beyond wetlands.

Alignment of methods to global requirements and state and territory approaches

We further assessed the reviewed methods and considered their alignment to approaches used by Australian states and territories. This assessment was informed by policy documents, interviews and a workshop. As part of the assessment of currently used methods in jurisdictions, we also considered and recorded the use of priority Threat Management approaches. This is an internationally recognised method and one that we discovered was frequently applied by jurisdictions in Australia.

In Australia, NGOs invest in private protected areas. To capture the methods used by NGOs to identify areas important for biodiversity, we lastly used a questionnaire to survey NGOs to complement the jurisdictional data.

Based on this, we categorised methods currently used by Australian jurisdictions and NGOs according to the international methods (Table 2).

Nearly all Australian jurisdictions and NGOs use irreplaceability mapping through existing tools or in-house decision-support tools based on the mathematical formulations and principles of irreplaceability (Table 2). Similarly, nearly all jurisdictions and NGOs use hotspot maps.

Table 2. Summary of methods currently employed by Australian jurisdictions and non-government organisations. An 'x' indicates that they align with that international method. We have bolded entries for Irreplaceability (Key Biodiversity Area Criterion E) to visually emphasise that most jurisdictions and non-government organisations use this method.

	Method name	Key Biodiversity Area (KBA) Criteria A–D	Irreplaceability (KBA Criterion E)	Priority threat management sites	Outstanding Universal Value/ Ramsar	Biodiversity Hotspots	Others (specific to non-government organisations)
Jurisdictions							
Queensland	Regional ecosystem and priority species mapping		**X**			X	
Australian Capital Territory	High priority zones				X	X	
Victoria	Strategic Management Prospects	X	**X**	X		X	
New South Wales	National Parks approach		**X**	X	X		
	Saving Our Species		**X**	X			
	Areas of Outstanding Biodiversity Value	X	**X**				
Tasmania	Conservation Information System	X	**X**			X	
South Australia	Landscape Assessment Framework (LAF) and Conservation Action Planning (CAP), New conservation planning and priority setting method	X	**X**	X	X	X	
Northern Territory	Sites of Conservation Significance	X	**X**		X	X	
Western Australia	Identifying new areas for the reserve network	X			X	X	
Non-government organisations							
In aggregate (n=6)	Methods used include: • the Interim Biogeographic Regionalisation for Australia framework for prioritising under-represented bioregions • irreplaceability mapping using software such as Zonation and Marxan • criteria-based mapping methods such as Key Biodiversity Area • species hotspot approaches.	3 of 6	**5 of 6**	1 of 6	3 of 6	2 of 6	IUCN Red List Species and Ecosystems; principles based on CAR (comprehensive, adequate and representative)

We invited all state and territory representatives to a workshop for further discussion and interpretation of the variety of methods applied across jurisdictions and their benefits and challenges. Key similarities in jurisdictions were discussed and validated.

This analysis of methods used by Australian jurisdictions and NGOs showed that:

- Significant effort is already invested in identifying areas important for biodiversity.
- Many well-developed methods are already used to identify important areas for biodiversity.
- Methods currently employed (and areas identified using them) are comparable, given they share a methodological basis (in particular, employing the principle of irreplaceability) and, typically, similar underlying data.
- While the methods, and often underlying data, are well aligned, there remain some differences in application that result in anomalies in mapped areas, particularly at jurisdictional boundaries. A data harmonisation approach was discussed in the workshop to smooth these anomalies.

Figure 1 shows Australian areas important for biodiversity currently identified using international (e.g. World Heritage Areas) and national (Threatened Species Priority Places) methods.

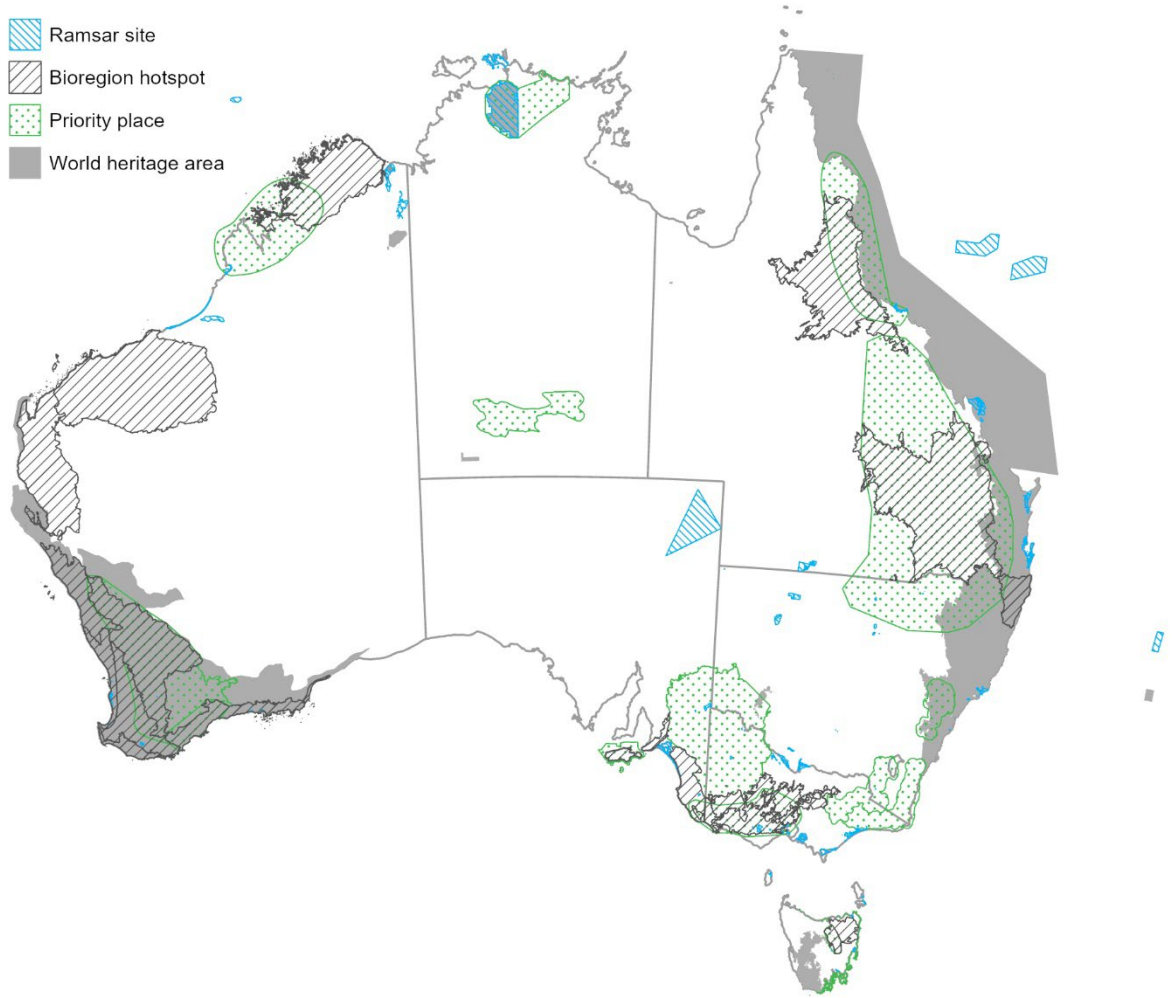

Figure 1. Australian areas important for biodiversity that are currently mapped using national and international methods.

Figure 2 shows the areas identified as important at the jurisdictional level using methods used by Western Australia, the Northern Territory, New South Wales and Victoria. While Queensland and the Australian Capital Territory have well-developed methods for identifying areas, the mapped areas important for biodiversity are not public and thus are omitted from Figure 2. Tasmania and South Australia have documented methods for mapping areas important for biodiversity but have not yet implemented these to create mapped outputs. Figure 2 reflects this, with the absence of mapped areas within these jurisdictions. Section 3.3 contains more detailed state and territory maps.

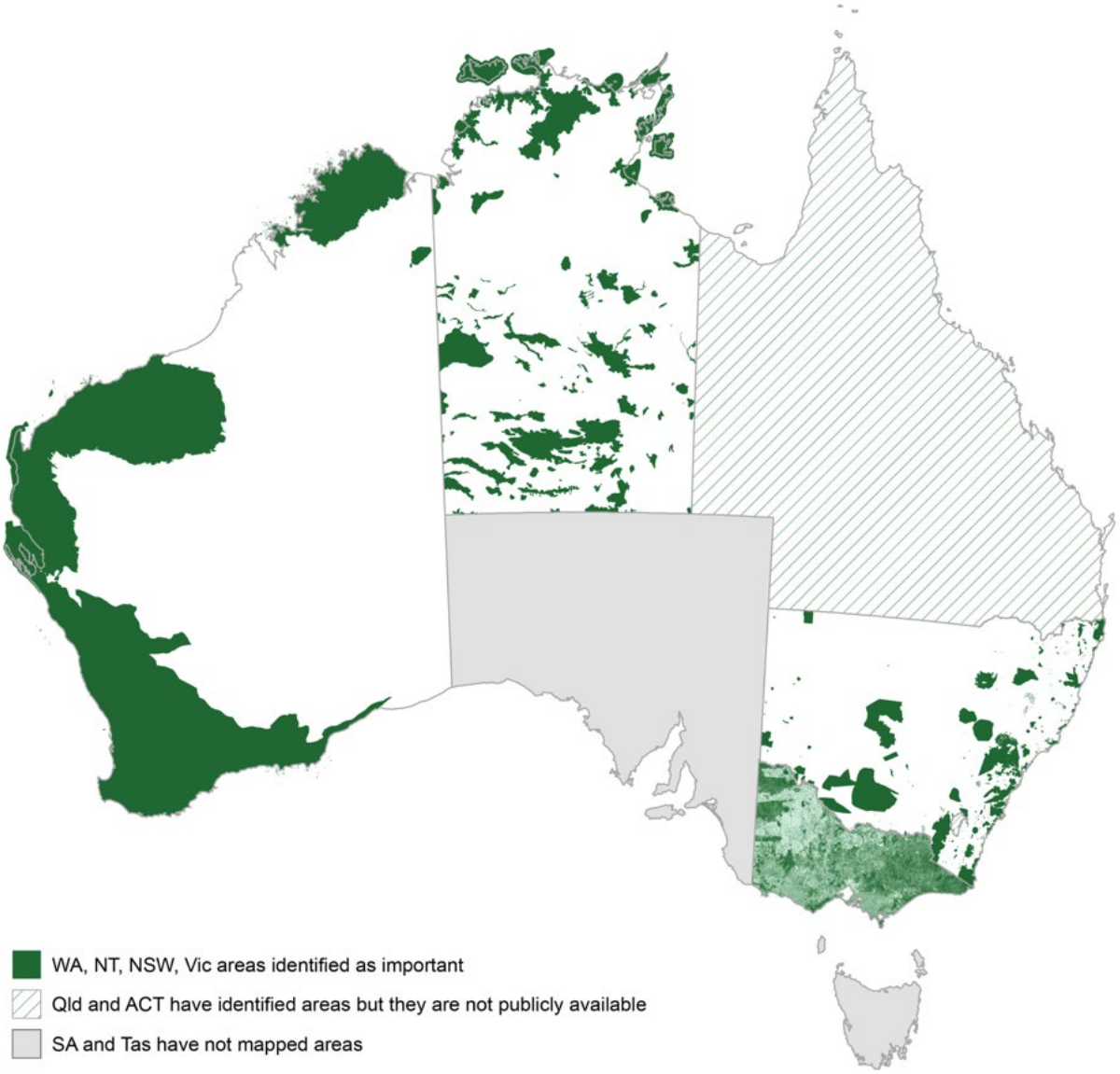

Figure 2. Areas identified as important by Western Australia, the Northern Territory, New South Wales and Victoria.

Recommended international method

On the basis of our analysis, we recommend irreplaceability (both as a stand-alone method commonly used by governments and conservation NGOs, and as Criterion E of the Key Biodiversity Area [KBA] method) as an appropriate nationally consistent approach for Australia.

Importantly, the method most commonly used by Australian jurisdictions and NGOs is irreplaceability mapping, which corresponds to Criterion E used to define KBAs. One way to implement the recommended method would therefore be to capitalize on this by using irreplaceability mapping as a starting principle for identifying important areas for biodiversity at a national scale. A national scale irreplaceability map to identify important areas for biodiversity can be used as a single product or used to interface with jurisdiction level maps of important areas for biodiversity. If used alongside jurisdiction level maps, harmonisation of

jurisdiction level maps of areas important for biodiversity may also be required, particularly to account for discrepancies at state borders.

The methods used by jurisdictions are based on contemporary science, collaboration and jurisdictional priorities, and they use the best available data for that state or territory. Jurisdictional maps made from these methods are a valuable resource that should inform any national method. However, jurisdictions currently use different underlying data (often reflecting higher resolution maps of biodiversity than available at national scales). This necessitates the integration and smoothing (or 'harmonisation') of areas identified across jurisdictional boundaries to rectify any artificial hard edges and fill gaps (e.g. the border between Victoria and New South Wales shows where choices of data, targets and representation of areas guided by irreplaceability mapping have resulted in continuity issues at the border [see Figure 3]). To achieve harmonisation, attention should be given to ensuring that any national method is collaboratively compared against jurisdiction level maps.

Figure 3. An example of how the different methods used by jurisdictions can result in continuity issues along borders.

One approach to such a data harmonisation is shown in Figure 4 and further discussed here. A national map produced using national datasets would be the starting point to identify areas of high irreplaceability.

Data harmonisation, using irreplaceability to guide the process, could then enable the creation of a national map of areas important for biodiversity that matches and respects those currently delineated by each state and territory (Appendix 1). This would require cross-checking any national product against existing areas already mapped by jurisdictions. For example, this could involve comparing any national map of areas of high irreplaceability to those mapped by jurisdictions to confirm whether the areas correlate with each other. Any differences may need further investigation and, where necessary, adjustment to achieve harmonisation in a national approach.

This approach could then be workshopped to correct any border discrepancies and to help jurisdictions consider any gaps in their current maps. Our workshop participants agreed that states and territories with shared borders could work collaboratively on a shared set of priorities to overcome inconsistencies in the national map with centralised support – for example, access to appropriate national datasets.

During our workshop with state and territory representatives for this project, some participants strongly advocated for a harmonised method that could potentially address national and global biodiversity targets. Participants saw this as a practical option, because each jurisdiction needs to meet their own state policy and legislative requirements. Employing a harmonised method at a national scale after correcting jurisdictional border discrepancies would ensure that areas reflect underlying biodiversity, rather than human-created jurisdictions.

This will help ensure the applicability of any national method, allow jurisdictions to keep meeting their state policy and legislative requirements, and prevent unnecessary duplication of effort (or ‘reinvention of the wheel’).

We note that new data regularly becomes available (e.g. threatened species location and range data). Therefore, a necessary aspect of implementing a nationally consistent method will be regular and iterative updates to mapped areas.

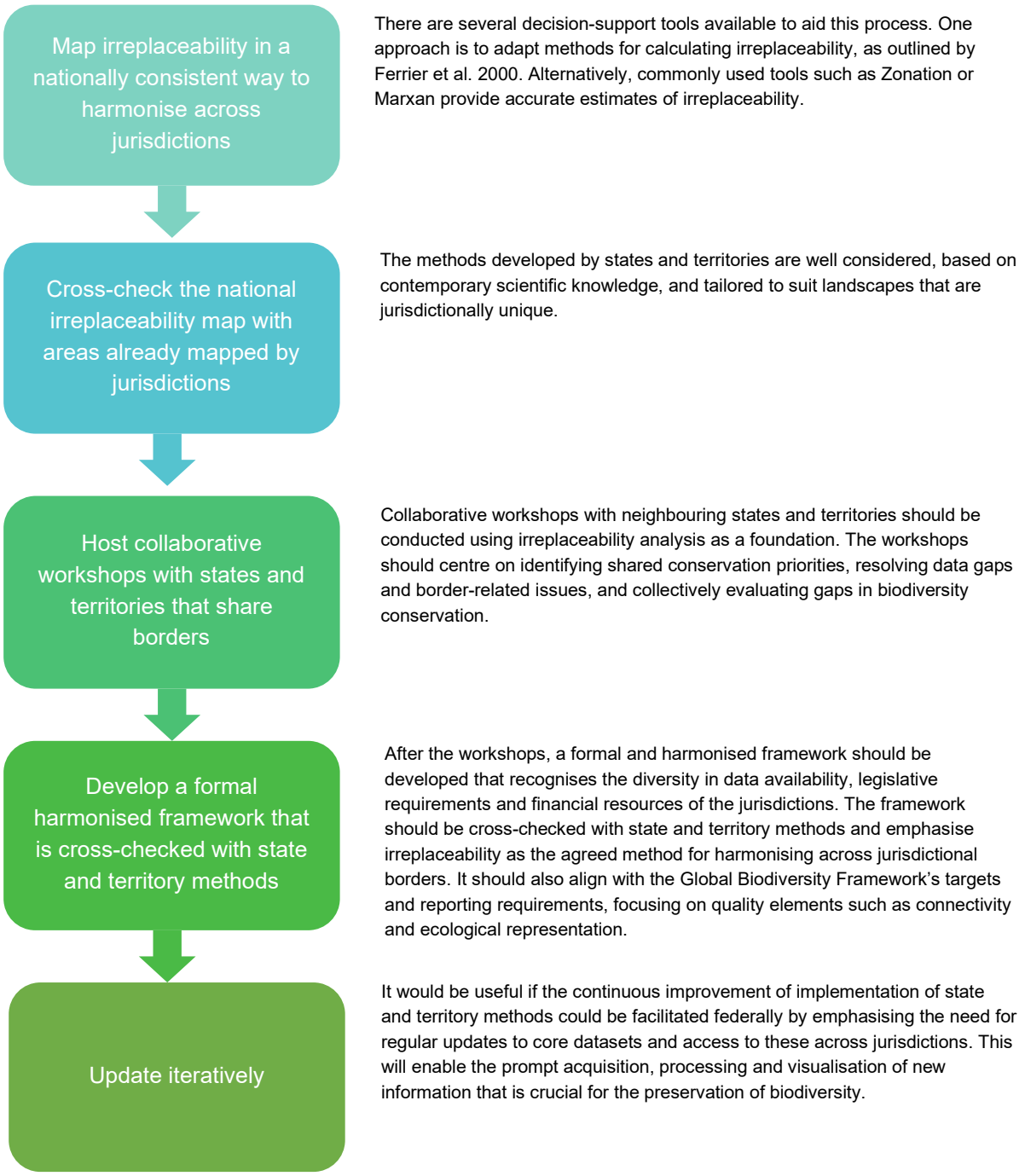

Figure 4. A flow chart of the potential future steps, some of which are beyond the life of this project.

See section 4.2 for further details on the information in Figure 4.

How the recommended approach can be used to ensure that protected and conserved areas in Australia are ecologically representative

We note that the 30-by-30 target seeks that at least 30% of land and sea, 'especially areas of particular importance for biodiversity and ecosystem functions and services, are effectively conserved and managed through ecologically representative, well-connected and equitably governed systems of protected areas and other effective area-based conservation measures …'. This target emphasises protecting and conservation areas important for biodiversity while also addressing aspects of reserve design and management including ecological representation and connectivity. While the focus of this report is on methods appropriate for identifying areas important for biodiversity, we also captured the extent to which those methods might encompass or be complementary to considerations of representativeness and connectivity. Our recommended approach of KBA Criterion E (irreplaceability mapping) was judged to perform well across all evaluation criteria and could be applied to consider relevant design principles such as ecological representativeness and connectivity.

1. Background and project scope

Much of Australia's unique biodiversity is under threat, and the health of our ecosystems continues to deteriorate. Habitat loss, changes in fire regimes and water flows, introduction of feral plants and species, and pollution all impact our natural systems. This has resulted in many of Australia's native plants, animals and ecosystems being nationally listed as threatened.

Protected and conserved areas are crucial in addressing the global decline of biodiversity (Kearney et al. 2018; 2022), and Australia has made national and international commitments to achieve protected and conserved area targets. Areas that are important for biodiversity are central to these targets. Areas of particular importance for biodiversity are defined by the GBF (Target 3 guidance notes) as 'Areas particularly important for biodiversity include areas high in species richness or threatened species, threatened biomes and habitats, areas with particularly important habitats and areas that are important for the continued provision of ecosystem functions and services'. Identifying and defining these areas is an important first step in conserving them, and therefore available mapping methods are the focus of this project.

The scope of this project was to:

- conduct a review of the possible mapping methods, including their pros and cons regarding alignment to global requirements, and approaches used by Australian jurisdictions and non-government organisations (NGOs)
- summarise how these approaches can be used to ensure that protected and conserved areas in Australia are representative of our diverse landscapes and seascapes.

We investigated the national policies and methods available for identifying areas important for biodiversity, including those used by Australian jurisdictions and NGOs. We then determined a possible way to identify, in a nationally consistent way, areas important for biodiversity.

1.1 National and international commitments

COP15 Nations adopt 23 Targets for 2030.

In 2018, parties to the Convention on Biological Diversity (CBD) began development negotiations for the Global Biodiversity Framework (GBF) to guide worldwide actions to preserve and protect nature. The GBF replaces the CBD's *Strategic plan for biodiversity 2011–2020* and its Aichi Targets, and thus development negotiations in the 4 years leading up to the GBF declaration included specific re-negotiations of targets, in particular the area-based measure targets.

In December 2022, the Australian Government joined 195 other nations in signing on to the final Kunming-Montreal GBF at the 15th meeting of the Conference of the Parties (COP 15) of the CBD (CBD 2022a). The Kunming-Montreal GBF aims to halt and reverse the decline in biodiversity globally by 2030, and it sets 4 goals and 23 associated targets to meet this overarching aim. Protected and conserved areas are seen as central to this, and Target 3 of the GBF is to protect and conserve 30% of land and sea areas across the globe by 2030 – also known as the '30-by-30' target.

Target 3 reads 'Ensure and enable that by 2030 at least 30 per cent of terrestrial and inland water areas, and of marine and coastal areas, especially areas of particular importance for biodiversity and ecosystem functions and services, are effectively conserved and managed through ecologically representative, well-connected and equitably governed systems of protected areas and other effective area-based conservation measures …'. This captures many principles related to the design and implementation of protected and conserved areas.

The emphasis on ‘areas of particular importance for biodiversity’ is specifically relevant to this project.

This target aims to expand protected areas and other area-based conservation measures (OECMs) to preserve habitats, populations, and vital ecosystem services for humans (CBD 2022a). It is worth noting that within this target, protected and conserved areas will be measured against indicators, including the extent to which they protect areas important for biodiversity and are ecologically representative. With this in mind, we summarise both the global indicators that will be used to track progress against these target sub-components as well as alignment of these components to national policies and methods already in use within Australia.

1.1.1 International indicators

To track progress against the Kunming-Montreal GBF targets, a set of headline, component and complementary indicators have been developed for each target. Table 2-1 provides a list of indicators proposed by the Kunming-Montreal GBF monitoring framework to track the progress against Target 3 – the 30-by-30 target (CBD 2022b). ‘Protected area coverage of key biodiversity areas’ is the nominated component indicator that will be used to monitor the progress made at the international level towards safeguarding areas important for biodiversity (CBD 2022b). Additional complementary indicators include ‘Status of key biodiversity areas’, ‘Extent to which protected areas and other effective area-based conservation measures cover key biodiversity areas that are important for migratory species’ and the ‘Ramsar Management Effectiveness Tracking Tool’.

Table 1-1. Headline Indicators for the 30-by-30 target and proposed component and complementary indicators listed in the Global Biodiversity Framework (CBD 2022b).

Headline indicator	Component indicators	Complementary indicators
• Coverage of protected areas and other effective area-based conservation measures	• Protected area coverage of key biodiversity areas • Protected Area Management Effectiveness • ProtConn • Protected Area Connectedness Index • Red List of Ecosystems • Connectivity Indicator • The number of protected areas that have completed a site-level assessment of governance and equity • Species Protection Index	• Protected area downgrading, downsizing and degazettement • Status of key biodiversity areas • IUCN Green List of Protected and Conserved Areas • Number of hectares of UNESCO designated sites (natural and mixed World Heritage sites and Biosphere Reserves) • Protected area and other effective area-based conservation measures management effectiveness indicator • Protected Area Isolation Index • Protected Areas Network metric • Extent to which protected areas and other effective area-based conservation measures cover key biodiversity areas that are important for migratory species • Coverage of protected areas and other effective area-based conservation measures and traditional territories (by governance type) • Ramsar Management Effectiveness Tracking Tool • Percentage of biosphere reserves that have a positive conservation outcome and effective management • Extent of Indigenous peoples and local communities' lands that have some form of recognition • Species Protection Index • Number of countries implementing national legislation, policies or other measures regarding free, prior and informed consent related to conservation • Red List of Ecosystems

1.2 Relevant national policies

Australia is committed to meeting the international targets. National strategies that are relevant to and guide actions to meet international targets are detailed below.

1.2.1 The National Reserve System

Currently, more than 22% of Australia is protected in the National Reserve System (NRS). While Australia has not historically mapped areas important for biodiversity as a core component of the NRS system, it has been a leader in policies and methods for designing and implementing reserve systems that are ecologically representative. *Australia's strategy for the National Reserve System 2009–2030* (NRMMC 2009) was designed to implement obligations under the CBD. The NRS encompasses public, Indigenous and private protected areas, and it is underpinned by the objective to be comprehensive, adequate and representative (CAR).

Specifically, CAR means:

- comprehensive: the inclusion in the NRS of examples of regional-scale ecosystems in each bioregion
- adequate: the inclusion of sufficient levels of each ecosystem within the protected area network to provide ecological viability and to maintain the integrity of populations, species and communities
- representative: the inclusion of areas at a finer scale, to encompass the variability of habitat within ecosystems.

The Australian Government uses a bioregional approach to plan, prioritise and track progress for the NRS to meet its CAR objectives. Australia's landscapes have been divided into 85 biogeographic regions identified by distinctive climate, geology, landforms, vegetation and fauna. Regionalisations on a national scale are useful for addressing biodiversity loss and ensuring that the NRS meets CAR principles. Progress in building a CAR reserve network is tracked at a bioregional level to identify which regions have met targets and which are under-represented in the network – and, thus, where finite resources should be directed (Thackway and Cresswell 1997). Data that informs the NRS is collected from state and territory governments and stored on the Collaborative Australian Protected Areas Database (2022) (Figure 2-1).

The NRS strategy articulates targets of progressing comprehensiveness, protecting threatened species and ecosystems, and protecting critical sites for climate change resilience, and seeks to track these for each bioregion of the Interim Biogeographic Regionalisation for Australia (IBRA); however, there may be variation in timing and application of these targets, especially where a bioregion has highly fragmented landscapes that are less accessible or appropriate for reserve acquisition and protection. Therefore, the primary indicator of progress for investing in and creating a CAR reserve network is the proportion of IBRA bioregion protected (i.e. progressing representativeness).

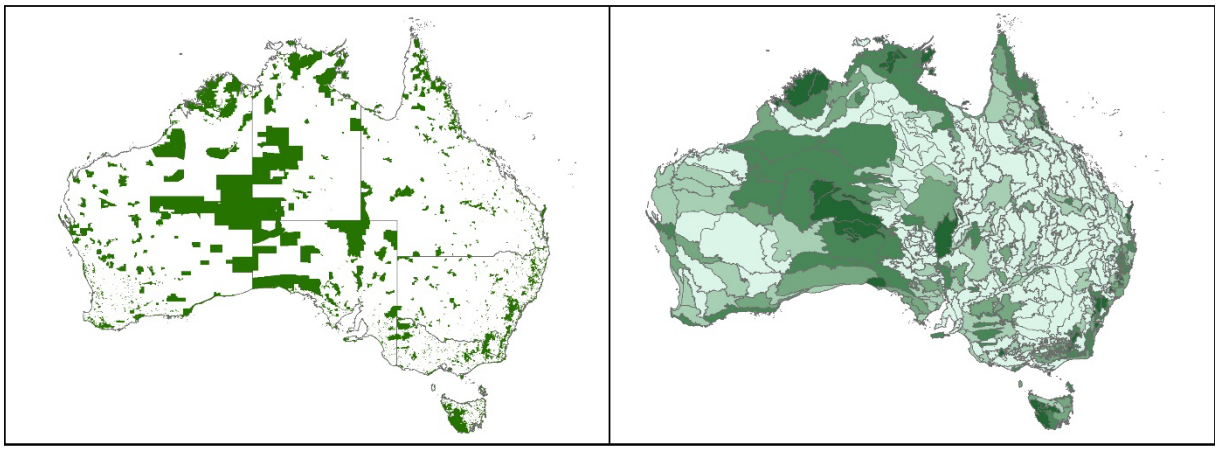

Figure 1-1. Australia's protected areas (left; from the Collaborative Australian Protected Areas Database 2022) and levels of protection at a bioregional level (right; bioregional data).

1.2.2 Other relevant strategies

Other relevant Commonwealth strategies that consider areas important for biodiversity in different ways include the *Nature positive plan* (DCCEEW 2022a) and the *Threatened species action plan 2022–2032* (DCCEEW 2022b).

1.2.2.1 Nature positive plan 2022

The *Nature positive plan: better for the environment, better for business* was created in response to the *Independent review of the EPBC Act – final report* (Samuel 2020). The fundamental principles of the plan are to prevent further extinction, streamline sustainable development and restore public accountability through an independent Environmental Protection Authority. One key commitment underpinning the strategy is the development of regional plans. The plans will include mapping values on at least three tiers such as high, moderate and low environmental value, or at a more granular level (such as percentages or heatmaps). The approach is being trialled in partnership with state and territory governments. These pilot regional plans intend to identify areas that meet biodiversity objectives, including the 30-by-30 target.

1.2.2.2 *Threatened species action plan 2022–2032*

The *Threatened species action plan 2022–2032* outlines an approach focused on species and ecosystems. These species were identified through applied prioritisation principles including risk of extinction, multiple benefits and uniqueness. One of the key objectives of the plan is Objective 4, that at least 30% of Australia's land mass is protected and conserved by 2032, which is consistent with the intent of Target 3 in the Kunming-Montreal GBF.

Priority places are a significant component of the plan. Twenty sites were selected to ensure a balance between the diversity of threatened species and ecological species, and representativeness of Australia's widely varied species, landscapes and seascapes.

2. Methodology

There are various internationally recognised methods for identifying areas important for biodiversity. In Australia, many methods are used by jurisdictions and NGOs, including land conservancies, to identify and define areas important for biodiversity.

For this project, 'methods' refers to systematic and scientific approaches used to identify specific geographic regions or sites that are important for biodiversity. These methods typically analyse various ecological and biological factors, including species distribution data, habitat characteristics and conservation priorities, to pinpoint areas deserving of conservation efforts to protect and sustain biodiversity.

We assessed the available methods that could be used to identify, at a national scale, areas that are important for biodiversity.

We evaluated each method against a set of criteria. These criteria encompassed key attributes essential for a method that could be used in a nationally consistent way to identify areas important for biodiversity.

2.1 Review of international methods to identify areas important for biodiversity

We first examined the literature and identified methods that are well defined and accepted by the international community for identifying areas important for biodiversity specific to terrestrial environments. We compared the list of identified methods from our literature search to the list of methods identified by WWF (WWF 2017). As our list of methods (KBA, Hotspots, OUV, Ramsar) matched we considered this to be a comprehensive set of internationally accepted methods and used these as the basis for further review and focus. Based on this list of methods we then reviewed existing recognised areas important for biodiversity in Australia and identified which method had been employed to identify the areas. This enabled us to understand the extent to which Australia is currently using particular internationally recognised methods.

We then conducted a desktop review of the international and Australian jurisdictional methods against the following criteria to judge their overall performance and determine their suitability for use in a nationally consistent way in Australia:

- fit-for-purpose – is the approach feasible, compatible and responsive?
- inclusiveness – can the approach identify areas with diverse genetic, species and ecosystem representation?
- persistence – does the approach consider conditions necessary for the long-term survival of species and other elements of biodiversity?
- uniqueness – can this approach identify locations with rare and distinctive species or ecosystems?

Appendix 1 lists the full list of defined criteria.

For our review of individual methods we note that the Key Biodiversity Area (KBA) method was designed as a combination of 2 distinct methods (site-based assessments using threshold criteria and systematic conservation planning (SCP) using measures of irreplaceability) (IUCN 2016; Smith et al. 2019). Irreplaceability is different to the other methods reviewed in that the irreplaceability of areas (or 'sites') is calculated as the likelihood that a given site will need to be protected to ensure the achievement of regional conservation targets (Ferrier et al. 2000). Conservation targets might be set based on the assessed adequacy needs for specific ecosystems or species or in response to political targets; however, for KBA Criterion E (Irreplaceability through quantitative analysis), there is specific guidance on targets to be set to equate to analogous site-based attributes as the threshold-based Criteria A–D (KBA Standards and Appeals Committee 2019). We therefore assessed KBA overall and KBA Criterion E (irreplaceability) both individually and as a single method.

2.2 Identifying methods currently employed in Australia

We further assessed the reviewed methods, considering their alignment to approaches used in Australia.

2.2.1 Identifying methods used by state and territory governments

Through a combination of desktop analysis and interviews with government representatives, we identified the methods utilised in each jurisdiction to prioritise areas for biodiversity conservation (see Appendix 2). The analysis of these methods was based on the criteria outlined in section 2.1, which helped us evaluate their overall utility. This assessment was informed by policy documents, interviews and a workshop. As part of the assessment of currently used methods in jurisdictions, we also considered and recorded the use of Priority Threat Management approaches. This is an internationally recognised method (Carwardine et al. 2019) and one that we discovered was frequently applied by jurisdictions in Australia.

We then invited all state and territory representatives to a workshop for further discussion and interpretation of the variety of methods applied across jurisdictions and their benefits and challenges. Key similarities in jurisdictions were discussed and validated. Section 3.3 describes these results.

2.2.2 Identifying methods used by non-government organisations

In Australia, NGOs play a crucial role in identifying and preserving areas that are important for biodiversity. To document their efforts, we modified the interview questions posed to states and territories into a questionnaire and sent it to various NGOs across the country. Section 4.4 contains more details on this.

3. Results

3.1 Summary of methods currently employed in Australia

Our desktop analysis identified several widely used international methods for identifying areas important for biodiversity which included: KBAs, biodiversity hotspots, and criteria-based methods including sites of Outstanding Universal Value (OUV) (World Heritage areas) and Ramsar sites.

At a national level areas already recognised as important for biodiversity have been identified with KBA, hotspot, and OUV methods. Figure 3-1 shows recognised areas important for biodiversity currently identified using internationally and nationally recognised methods.

Figure 3-1. Nationally recognized areas important for Biodiversity

Table 3-1 lists the internationally recognised methods that emerged from our analysis, with ways they are used and Australian examples. Figure 3-2 shows these areas mapped by method.

Table 3-1. The internationally recognised methods reviewed, example global schemes that employ the method, and Australian examples within jurisdictions.

Methods under review	Schemes	Australian examples
Key Biodiversity Areas	Important Bird Areas, Alliance for Zero Extinction, Important Plant Areas	Areas of Outstanding Biodiversity Value
Biodiversity hotspots (threatened species and ecological communities)	Conservation International Hotspots and endemic bird areas	*Threatened species action plan 2022–2032* – threatened species priority places
Internationally recognised criteria-based methods for identifying Outstanding Universal Values	World Heritage and Ramsar	National Heritage List

Figure 3-2 shows areas derived from hotspots, criteria-based OUV methods, Ramsar sites and priority places in Australia as examples of how some of these methods have been used nationally and internationally to identify areas important for biodiversity.

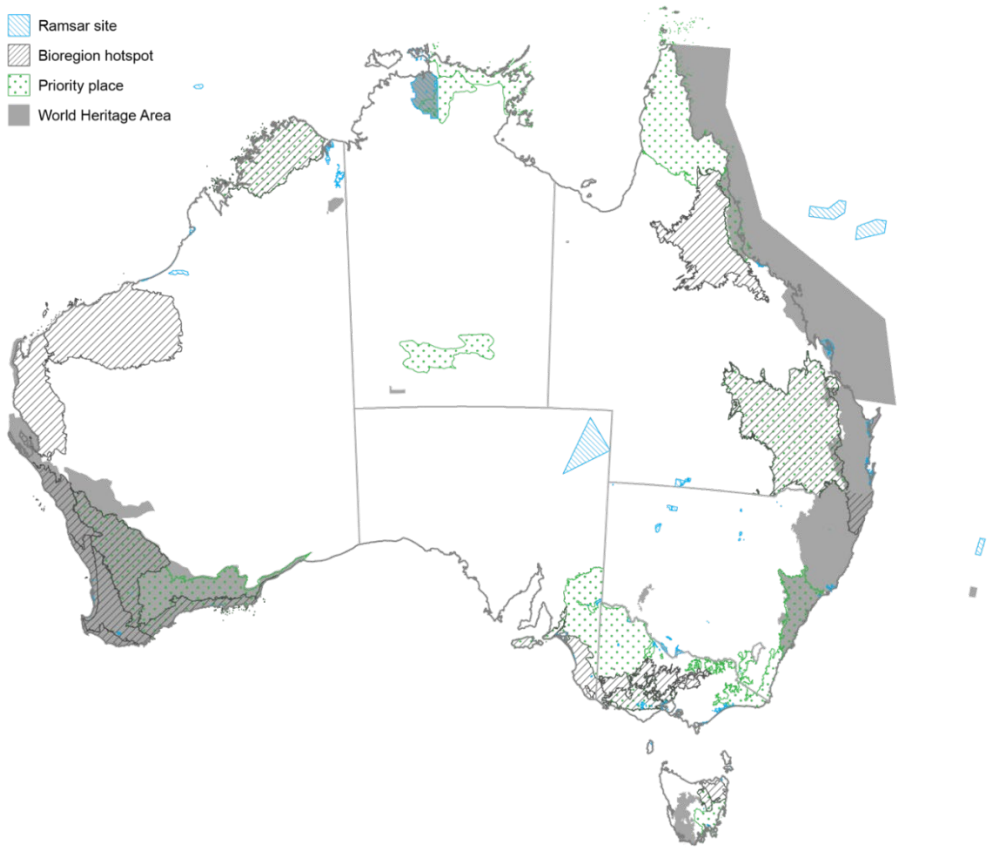

Figure 3-2. National and international methods used to derive the map of Australian areas important for biodiversity.

3.2 Internationally recognised methods and their assessment against criteria

When assessing the methods based on alignment to our criteria, three of these methods performed well overall across the criteria – KBA Criteria A-D, KBA Criterion E, and OUV (Table 3-2).

Table 3-4, Table 3-6, Table 3-8 and Table 3-10 outline the assessments carried out on each individual method. These assessments were performed using the project criteria described in Appendix 1. An overall score was assigned for each criterion. To further support the analysis, a strengths, weaknesses, opportunities, and threats (SWOT) analysis was performed for each method, and the results are presented in Table 3-5, Table 3-7, Table 3-9 and Table 3-11.

We assessed if the methods were fit-for-purpose based on their current adoption and application within Australia. To achieve this, we categorised methods currently used by Australian jurisdictions and NGOs according to the international methods (See Section 3.3).

The following sections in this report provide a detailed summary of the methods and their strengths and limitations.

Table 3-2. Summary of the assessment of the Key Biodiversity Area methods, biodiversity hotspots method, Outstanding Universal Value method and Ramsar method.

✓	The approach performs this function well.
—	The approach somewhat does this.
✕	The approach does not do this.

Method	Fit-for-purpose	Inclusiveness	Persistence	Uniqueness	Overall assessment	Comment
Key Biodiversity Area (KBA) Criteria A–D	—	✓	—	✓	✓	The data required to conduct comprehensive application of the site-based threshold criteria across all species exists only in part and would likely require significant investment in expert elicitation or site assessments to conduct at the national scale. The criteria are not as flexible as Criterion E in considering other aspects of site design and interfacing with broader national policy principles (e.g. comprehensive, adequate, representative [CAR] and climate refugia aspects).
KBA Criterion E (irreplaceability)	✓	✓	✓	✓	✓	Criterion E – irreplaceability – is calculated with available decision support tools (e.g. zonation, Marxan, CPlan; Carwardine et al. 2007) but targets must reflect guidance given in the KBA criterions to ensure that species features and thresholds are met (Smith et al. 2019). The type of data that can be used within this criterion include existing vegetation, habitat and threatened species (Species of National Environmental Significance) data. Criterion E is efficient, flexible and interfaces well with broader policy principles (e.g. CAR and climate-refugia considerations).
KBA overall	—	✓	—	✓	✓	The overall score assigned to the KBA method is aligned with Criterion A-D rankings which reflect that while the KBA method is useful for identifying areas with high conservation value, the data required for site-based analyses is limited.
Biodiversity hotspots	✓	—	✕	✓	—	Biodiversity hotspots are considered effective based on the fit-for-purpose criterion. However, the method is based on strict criteria and data requirements, reducing its flexibility. The approach considers certain inclusiveness elements, such as species richness and endemism. The approach indirectly accounts for genetic diversity, but it does not account for ecological processes. The approach does not consider persistence criteria.
Outstanding Universal Value (OUV)	—	✓	—	✓	✓	The OUV method ranks well for feasibility, suitability and compatibility with global frameworks. It is moderately efficient, flexible to different data types, and scalable but it lacks responsiveness due to the detailed nature of assessment processes. This method is not a dedicated tool for biodiversity assessment, but it can indirectly contribute to the identification of areas with outstanding samples of genetic, species and ecosystem diversity and benefits from a comparative assessment approach. The method would most likely need to be paired with another or used in conjunction with spatially explicit tools to comprehensively assess important areas for biodiversity. The OUV method performs strongly with criteria related to uniqueness and irreplaceability.
Ramsar	—	—	—	✓	—	The Ramsar method and criteria align well with the specified species and species diversity criteria within wetland ecosystems. However, its focus on wetland conservation limits its ability to comprehensively address broader aspects such as ecological integrity, species' persistence, threats and climate resilience.

3.2.1 Key Biodiversity Areas

Blue Mountains National Park, Australia. Image: Humpalumpa CC-BY-NC-SA 2.0.

3.2.1.1 Description

A KBA is designated when a site has identified biodiversity elements (e.g. species or ecosystem) that meet a KBA criterion or thresholds (KBA Standards and Appeals Committee 2019). Several international schemes are types of KBAs, including Important Bird Areas, Important Plant Areas (Anderson 2002), and the Alliance for Zero Extinction (AZE 2023).

The KBA criteria were designed by a global task force which convened in 2012 and brought together two different conservation communities (IUCN criteria-based conservation and SCP) to develop the new KBA methodology (IUCN 2016). In doing so, the KBA criteria brought together the traditional site-based species and ecosystem threshold criteria-based approach (e.g. as used in important bird areas) and Criterion E, which introduced the concept of irreplaceability as a stand-alone criteria and one based on SCP principles of complementarity and target-based approaches (Smith et al. 2019). The current KBA methodology uses criteria based on high-level categories: threatened biodiversity, geographically restricted biodiversity, ecological integrity, biological processes and irreplaceability. KBA criteria A–D strongly relate to other criteria-based approaches such as OUV and Ramsar, while Criterion E can be a product of SCP and explicitly addresses design principles, which the other criteria do not (WWF 2017). Studies have demonstrated that criteria A–D and Criterion E identify spatially congruent priorities and are therefore consistent and complementary; however, each requires different data and tools (di Marco et al. 2016; Smith et al. 2019). The key difference between criteria A–D and criterion E is thus that the data, analysis and thresholds are specific to features and sites and cannot accommodate broader biodiversity features or other values. Criterion E uses complementarity-based algorithms to identify sets of priorities at the landscape scale. As these five criteria span two different types of methods, we analyse them individually and as a single KBA method.

Criteria A–D threshold approach

Criteria A–D of the KBA approach are applied on a case-by-case basis, identifying sites that meet the KBA criteria at threshold levels for one or more biodiversity elements. These elements are threatened, rare or range-restricted species or ecosystems and, thus, the criteria are restricted to species on the IUCN Red List of Threatened Species rather than broader biodiversity features. Calculating the thresholds requires species-specific and site-specific data and, where available information does not exist, it is common to use expert elicitation at the site level or further site level studies.

Criterion E: irreplaceability

Criterion E within the KBA method is also a method commonly used in SCP, which takes a data-driven and transparent approach to identifying conservation priorities (Margules and Pressey 2000). Core steps of SCP include identifying conservation features and associated data, setting targets for each feature (often species and ecosystems but can also be features such as refugia and processes) that reflect adequacy or persistence of those features, and then using complementarity-based algorithms to determine sets of sites that meet these targets and, in doing so, calculate site irreplaceability scores (Ferrier et al. 2000). Irreplaceability is therefore not a binary but rather a continuum of relative importance of values for the areas in a region, from 100% to zero. An area that is totally (100%) irreplaceable must be included in an efficient? system of conservation areas if all set conservation targets are to be achieved. By the same token, the loss of an irreplaceable site (e.g. to clearing) will cause one or more conservation targets to become unachievable (Smith et al. 2019). Irreplaceability can be approximated with conservation decision-support tools such as Marxan (using selection frequency), Zonation and C-Plan (Carwardine et al. 2007). The outputs of each are highly correlated and consistent with the mathematical formulation of irreplaceability. Smith et al. 2019 emphasise how SCP can utilise KBA, how KBA uses SCP (via Criterion E), and the complementary information and outcomes that each provide.

Strengths and limitations

The KBA method is strongly aligned with global conservation targets such as the GBF, given it is a lead indicator for Goal A targets. This method is also particularly useful for targeted investment towards the most critical species, ecosystems and ecological processes, and is an effective way to conserve threatened species. However, the criteria only apply to species listed as Critically Endangered, Endangered, or Vulnerable on the IUCN Red List of Threatened Species, which may result in certain ecosystems or species of high ecological importance being overlooked or under-represented in the KBA network (IUCN 2016).

While existing datasets support the method (e.g. the National Threatened Species List and vegetation data), these do not cover all biodiversity features and may have gaps in terms of data-deficient species. Furthermore, monitoring at declared KBAs may only result in data updates, and thus KBA status updates, every 8–12 years (Knight et al. 2007; IUCN 2016). In addition, the availability of high-quality data and quantitative analysis differs significantly among taxonomic groups and ecosystems (KBA Standards and Appeals Committee 2019). KBA criteria A–D are not designed to consider landscape connectivity (Langhammer et al. 2007). However, KBA Criterion E is designed to address this, to ensure complementary sites

are identified and can be listed as KBA even where the thresholds for criteria A–D are not met or cannot be calculated with available site-specific or species-specific data.

3.2.1.2 Assessment

In summary, the KBA method is useful for targeted biodiversity conservation and efficiently identifying areas with high conservation value (Table 3-4, Table 3-5). While it has strengths in addressing multiple criteria, there is room for improvement in explicitly addressing genetic diversity and taxonomic biases. Integrating KBAs into broader conservation frameworks and addressing these limitations could enhance its effectiveness for identifying areas important for biodiversity. We note that in assessing the overall score we rated based on any noted limitations in either method (thus reflecting lowest ratings rather than highest as a conservative assessment).

Table 3-3. Assessment of the Key Biodiversity Area method.

✓	The approach performs this function well.
—	The approach somewhat does this.
✕	The approach does not do this.

Criteria	Criteria A–D	Criterion E	Overall	Comment
	✓			**Overall assessment for Key Biodiversity Areas**
				Fit for purpose
Efficiency	—	✓	—	Criteria A–D require species or ecosystem specific data as the criterion thresholds are based on the site containing a specified percentage of the global size or extent of the feature. Data can be acquired from existing datasets (e.g. for threatened species via the Species of National Environmental Significance database) but data for broader set of species is likely to be absent. Investment is only required where there are data deficiencies. Criterion E can be measured with existing national datasets (e.g. vegetation, habitat condition, species distributions and known species site utilisation). Overall, the method can be time-consuming due to data gap filling and often expert elicitation. Furthermore, every KBA has to go through a stakeholder consultation, review and endorsement process, which involves data validation and boundary delineation using a standard methodology that considers the local context (IUCN 2016).
Feasibility	✓	✓	✓	The method's requirements are well documented. For example, guidelines for national and regional application of Key Biodiversity Area (KBA) criteria and thresholds are being developed (KBA Standards and Appeals Committee 2019).
Suitability	—	✓	✓	The method can be conducted with existing data. However, for the approach to be effective, it requires up-to-date, high-quality data specific to species, ecosystems, and sites. However, the

Criteria	Criteria A–D	Criterion E	Overall	Comment
				quality of data and the frequency with which it is updated is variable. Therefore, using this approach on a large scale would be challenging.
Flexibility	✗	—	✗	While the approach can incorporate data from several pre-existing sources, such as IUCN listings, comprehensive data for application at national scale in Australia doesn't exist for site level assessments. While Criterion E for KBA purposes is also focused on these types of species and ecosystems, as a methodological approach it is flexible and can consider a range of additional conservation features.
Compatibility	✓	✓	✓	The KBA method is consistent with the GBF, with the 'status of Key Biodiversity Areas' listed as a complementary indicator and 'protected area coverage of key biodiversity areas' as a component indicator. The method is also compatible with the IUCN Red List, as the species status is recognised under the KBA method. Therefore, it is consistent with the Post-2020 GBF reporting requirements.
Scale	✓	✓	✓	The KBA method offers a flexible approach that can be adapted to various levels, from global to national and regional scales. It can serve as a foundational tool for conducting gap analyses at the national or regional level.
Responsiveness/ timeliness	✗	—	✗	The approach being used is not responsive enough as the information for KBA sites, and based upon monitoring, is updated only once every 8-12 years following site listing. Nonetheless, new information can be included, which may lead to adjustments in KBA boundaries.
Inclusiveness				
Species diversity	✓	✓	✓	The KBA method is effective in identifying areas with high species diversity. It considers the number of species present (species richness) and the presence of endangered and endemic species. As a result, KBAs highlight regions with significant species diversity. Nevertheless, it is worth noting that the KBA method overlooks data-deficient species when identifying KBAs, resulting in their poor representation in the KBA networks (Kullberg et al. 2019).
Genetic diversity	—	✓	—	Genetic diversity is not included in the KBA criteria A-D; however, Criterion E can readily accommodate this where data is available.
Ecosystem diversity	✓	✓	✓	The KBA method encompasses ecosystem diversity by considering a variety of habitats, communities, and ecological processes. KBAs often cover landscapes that support diverse ecosystems which, in turn, contribute to the preservation of ecological and evolutionary processes.
Persistence				

Criteria	Criteria A–D	Criterion E	Overall	Comment
Ecological integrity	✓	✓	✓	Criterion C identifies sites with ecological integrity.
Species' persistence	✓	✓	✓	Criterion A addresses threatened species and ecosystem persistence. Criterion D addresses functions that will increase the adaptive capacity of species.
Vulnerability/ threats	✗	—	✗	No – the approach does not account for vulnerability or threats. However, Criterion E is capable of considering and incorporating threats as a methodological approach.
Climate resilience	✓	✓	✓	KBA approach cannot predict climate resilience. However, sites are reviewed every 8–12 years, allowing for detection of climate change impacts. Additionally, Criterion D2 considers the importance of ecological refugia during periods of environmental stress. Therefore, the method can identify areas that improve species resilience to climate change.
Uniqueness				
Uniqueness and irreplaceability	✓	✓	✓	Yes – Criteria A–D focus on threatened and range restricted species with an effective 100% target for identifying all sites important to them thus implicitly considering uniqueness. Criterion E explicitly measures site irreplaceability; thus, the approach can determine the irreplaceability of the site through quantitative analysis and accounts for uniqueness by safeguarding areas that contain rare species or ecosystems.

Table 3-4. Strengths, weaknesses, opportunities and threats analysis of the Key Biodiversity Area (overall) method.

Strengths	Weaknesses	Opportunities	Threats
KBAs utilise data from other initiatives (e.g. IUCN Red List, Important Bird Areas, Important Plant Areas). Due to this, even if some data is not available, the KBA process can begin immediately and be updated iteratively (Langhammer et al. 2007). Including Indigenous and local knowledge helps ensure the best available information is used. The requirement for free, prior and informed consent of Indigenous peoples ensures that the approach is conducted in a respectful and culturally appropriate manner (KBA Standards and Appeals Committee 2019). KBAs are compatible with the GBF 30-by-30 target and, therefore, can support international conservation efforts. KBA site assessments are feasible with existing capacity and expertise in biodiversity assessment and planning but would require additional site level data if applying Criteria A-D. KBAs address the uniqueness and irreplaceability of sites by prioritising areas with distinct and rare biodiversity.	KBAs (based on Criteria A-D) do not account for complementarity. This could lead to a situation where most of the available resources are directed to areas having similar species composition, or species that might already be well covered elsewhere in the protected area network, while some other species might be completely missing (Smith et al. 2019). While it is recommended to use up-to-date data, KBA Standards and Appeals Committee (2019) states that data collected more than 8-12 years ago might also be acceptable in some circumstances, leading to judgments based on inaccurate data. Species range maps are prone to errors (false positive and false negatives) (KBA Standards and Appeals Committee 2019). The focus of KBAs (Criteria A-D) is on threatened and restricted-range species that are identified on the IUCN Red List. If a species is not on the list, it is out of scope for the KBA approach (KBA Standards and Appeals Committee 2019). Criterion E offers greater flexibility to consider other conservation features. There are potential biases in taxonomic focus: data-deficient species are not included in the identification of KBAs and are, therefore, poorly represented. Small-range amphibians are not represented well by KBAs. The current network is heavily influenced by Important Bird Areas, which could lead to a situation where the prioritisation based on KBAs might favour bird species (Kullberg et al. 2019).	KBA is a widely recognised approach that can foster collaboration with the international community. Such partnerships can enhance the collective efforts towards biodiversity conservation, enabling the sharing of resources, expertise and best practices. Criteria from the KBA method could be integrated with other conservation methods to develop a comprehensive approach.	The KBA method (in particular Criteria A-D) only accommodates data on IUCN-listed species and ecosystems (threatened, rare and range restricted) which focuses on identifying areas often already at risk and degraded (by nature of focusing on threatened species). It can also result in taxonomic biases based on listed species and species with sufficient data (e.g. current KBAs mapped are Important Bird Areas).

3.2.2 Biodiversity hotspots

Tasmanian Midlands Biodiversity Hotspot – grassy woodland exhibiting natural tree regeneration with active land management. Image: Peter W Allen, University of Tasmania.

3.2.2.1 Description

Biodiversity hotspots can broadly be defined as areas with high concentrations of endemic species and with high habitat loss (Reid 1998; Olson and Dinerstein 2009; Marchese 2015). Conservation International developed a 'hotspots' method based on strict criteria (Conservation International 2023). To qualify, a site must contain at least 1,500 species of vascular plants found nowhere else on earth and have lost 70% of its primary native vegetation.

Strengths and limitations

Biodiversity hotspots focus on endemic species, which are often vulnerable to extinction. Therefore, it is a practical approach for targeting investment in protecting unique and irreplaceable species. However, authors advocate for more comprehensive approaches, as regions critical to the generation and maintenance of biodiversity are also required, regardless of whether they are species rich. As climate change threatens species' distributions and their dependent habitats, today's hotspots will undergo significant changes and may not retain their status as hotspots in the future. Species need to be conserved across diverse habitats to ensure adaptive variation is possible under climate change (Smith et al. 2001). Critics of the hotspot approach have also emphasised the importance of biodiversity 'cold spots'. Kareiva and Marvier (2003) argue that investing solely in hotspots and ignoring cold spots may lead to the loss of ecologically important areas (Marchese 2015).

3.2.2.2 Assessment

Biodiversity hotspots are considered effective based on the fit-for-purpose criteria (Table 3-6, Table 3-7). However, it is regarded as an inflexible method based on strict criteria and data requirements. The approach considers certain inclusiveness elements, such as species richness and endemism. The approach indirectly accounts for genetic diversity, but it does not account for the ecological processes needed for ecosystem diversity. The approach does not consider any element of the persistence criteria but considers both uniqueness and irreplaceability.

Table 3-5. Assessment of the biodiversity hotspot method.

✓	The approach performs this function well.
—	The approach somewhat does this.
✗	The approach does not do this.

Criteria	Mark	Comment
—		**Overall assessment for Biodiversity hotspots**
		Fit for purpose
Efficiency	✓	It is regarded as a cost-effective strategy for setting conservation priorities on terrestrial land (Marchese 2015). Biodiversity hotspots contain high levels of unique species – investing in hotspots can protect substantial biodiversity in a small area (does not consider the need for genetic diversity or connectivity benefits). It is straightforward to apply, as only 2 criteria must be met.
Feasibility	✓	Given the strict criteria, the approach is reasonably straightforward to apply. There is also extensive literature available on how the approach can be used to identify areas important for biodiversity, which could support staff in applying the method.
Suitability	✓	Extensive research and data about species richness and endemism are available. Species richness has been the main focus of conservation studies and is still widely used, mainly because it is easy to quantify and interpret data. In particular, conservation planning has traditionally used richness information combined with different irreplaceability measures (e.g. endemism or rarity) to prioritise some regions over others (e.g. biodiversity hotspots) (Marchese 2015).
Flexibility	—	The criteria for the approach are strict. However, data on species richness and endemism is common and can be sourced from many platforms – government, non-government organisations, etc.
Compatibility	✓	It has the potential to be compatible with wilderness approaches. Wilderness focuses on maintaining significant, undisturbed habitats. There may be conflict regarding size, as hotspots aim to be cost-effective by safeguarding biodiversity in the smallest and most efficient patches. However, areas of high species richness and endemism are also likely to occur in undisturbed areas. The hotspot approach does not consider quality aspects, such as connectivity, which are central to achieving the 30-by-30 target.

Criteria	Mark	Comment
Scale	✓	The method can be applied to any geographical scale.
Responsiveness/ timeliness	—	The method can be responsive in identifying and prioritising areas based on existing knowledge of species richness. However, it may require periodic updates as new information becomes available.
Inclusiveness		
Species diversity	✓	The biodiversity hotspot method addresses species diversity by focusing on areas with high species richness. It indirectly considers endangered and endemic species, as areas with high species richness often support these categories.
Genetic diversity	—	Genetic diversity is not explicitly mentioned in the identification of biodiversity hotspots. However, by protecting areas with high species richness and endemism, it may directly result in the protection of genetic diversity within those species. For example, high species richness often indicates a greater likelihood of wider genetic variation. However, if the aim is to conserve species within the smallest area possible for cost-saving purposes, this could undermine the potential for the approach to protect genetic diversity.
Ecosystem diversity	✗	No – the process does not account for ecological processes (Myers et al. 2000).
Persistence		
Ecological integrity	✗	The method primarily focuses on identifying areas with high species richness and may not explicitly assess the ecological integrity of ecosystems. It may indirectly capture aspects of ecological integrity by targeting regions with diverse habitats.
Species' persistence	✗	No – the method focuses on areas of greatest biodiversity (e.g. measured with species richness). It does not explicitly consider factors such as population dynamics, dispersal, contraction/expansion of species' ranges and the connectedness of habitats.
Vulnerability/ threats	✗	Common threats to biodiversity hotspots include climate change, land-use change and invasive species (Bellard et al. 2014; Kong et al. 2021). The method effectively identifies areas vulnerable to threats, especially those related to habitat loss and degradation. However, it may not provide detailed insights into specific threats like invasive species or climate change impacts.
Climate resilience	✗	The method does not consider climate or species resilience when identifying hotspots. Studies have shown that existing hotspots are likely to be lost due to climate change (up to 31% of existing sites) (Bellard et al. 2014).
Uniqueness		
Uniqueness and irreplaceability	✓	The method aligns with the criteria of uniqueness and irreplaceability, especially concerning the irreplaceability of endemic plant species.

Table 3-6. Strength, weaknesses, opportunities and threats analysis for the biodiversity hotspots method.

Strengths	Weaknesses	Opportunities	Threats
Biodiversity hotspots focus on endemic species, which are often vulnerable to extinction. Therefore, it is a practical approach for targeted investment in protecting unique and irreplaceable species. It is an internationally recognised approach which can facilitate funding, collaboration, and coordinated conservation action at a global scale. Biodiversity hotspots allow for focused conservation efforts, concentrating resources on areas that harbour a significant portion of the world's biodiversity and species at risk. There is high data availability given method relies primarily on species range maps to calculate richness. Biodiversity hotspots are recognised as a cost-effective method.	The method does not account for ecological processes, focuses solely on species, and omits invertebrates due to data gaps (Myers et al. 2000). The approach does not account for supposed 'cold spots' for biodiversity that still possess large, natural and ecologically important areas that contribute to ecosystem services (Kareiva and Marvier 2003). The approach ignores regions of ecological transition. Smith et al. 2001 advocate for a more comprehensive approach that includes regions critical to generating and maintaining biodiversity – regardless of whether they are species-rich. Due to data limitations, the current applications of the method have not considered invertebrates, such as herbivorous insects, fungi, and nematodes, in the decision-making process regarding global biodiversity hotspots. Since data on species distributions are usually scarce, the conservation of an entire global hotspot may be difficult and unsustainable. Because diversity, or evolutionary history, is distributed unequally between taxa as well as between areas, considering only traditional species diversity may not be sufficient to fully capture differences among species. Although species richness has been a useful criterion for identifying hotspots, it may not accurately reflect spatial diversity patterns for biogeography and conservation. A better approach might be to use biodiversity metrics that consider evolutionary history and functional diversity planning.	Biodiversity hotspots provide a clear framework for prioritising conservation planning and action, facilitating targeted efforts to protect and restore key habitats and species. The biodiversity hotspot approach can be expanded or adapted to incorporate additional criteria or factors, such as genetic diversity or ecosystem services, to enhance its effectiveness and inclusiveness.	Due to the 70% loss criteria, hotspots are inherently located in regions experiencing high rates of habitat loss and fragmentation and fails to capture areas of importance for biodiversity not under imminent threat of loss.

3.2.3 Outstanding universal values

Blue Mountains National Park. The Greater Blue Mountains Area was inscribed on the World Heritage List in 2000 under Outstanding Universal Value criteria (ix) and (x). Photo: Humpalumpa CC BY-NC-SA 2.0.

3.2.3.1 Description

OUV is a well-recognised criteria-based method for identifying exceptional natural sites that are important for present and future generations. Natural sites of significance qualify under 4 criteria: (i) to contain superlative natural beauty and aesthetic importance, (ii) to represent major stages of earth's history and geological processes, (iii) to represent significant ongoing ecological and biological processes in various ecosystems and (iv) to preserve crucial habitats for conserving biodiversity, particularly for species with OUVs in science and conservation (UNESCO 2021).

3.2.3.2 Assessment

The OUV method ranks well for feasibility, suitability and compatibility with global frameworks (Table 3-8, Table 3-9). It is moderately efficient, flexible to different data types, and scalable across various levels, but it may lag in responsiveness due to the meticulous nature of data acquisition and assessment. While this method is not a dedicated tool for biodiversity assessment, it can indirectly contribute to the identification of areas with representative samples of genetic, species and ecosystem diversity, particularly when these elements are intrinsic to the OUV of the site. The method would most likely need to be paired with another or used in conjunction with specific tools to comprehensively assess biodiversity. The purpose of the OUV criteria is related to recognising and preserving areas of human and natural heritage. While it indirectly touches on ecological integrity and species adaptability, more specific criteria or tools are required to provide systematic information. On the other hand, the OUV method performs strongly with criteria related to uniqueness and irreplaceability, because the purpose of the method is to identify sites that hold exceptional value, emphasising their distinctiveness and the need for their conservation to achieve specified targets.

Table 3-7. Assessment of the Outstanding Universal Value method.

✓	The approach performs this function well.
—	The approach somewhat does this.
✕	The approach does not do this.

Criteria	Mark	Comment
✓	**Overall assessment for Outstanding Universal Value (OUV)**	
	Fit for purpose	
Efficiency	✕	The OUV method may require comprehensive data gathering, processing and mapping to identify and assess the outstanding universal value of a site. This could involve historical, cultural and environmental data. The efficiency of the OUV method may be moderate, as it demands thorough research and analysis.
Feasibility	—	The feasibility of the OUV method depends on the availability of expertise in the relevant fields, such as history and environmental science. The technology required for data collection and analysis is generally available, but the feasibility might vary depending on the complexity and uniqueness of the site.
Suitability	—	The OUV method relies on the availability of a variety of data types to fulfill the criteria. If this is lacking or incomplete, the suitability of the OUV method may be compromised.
Flexibility	—	The OUV method is adaptable to different types of data, but its flexibility is limited to the specific criteria and guidelines outlined by UNESCO.

Criteria	Mark	Comment
Compatibility	✓	OUV methods can coexist with others, such as KBAs. For example, a site might be critical for the persistence of an endangered species, making it a KBA, while simultaneously possessing natural features that qualify it for OUV status. The number of hectares of UNESCO designated sites is also a complementary indicator on the Global Biodiversity Framework's (GBF's) monitoring framework. Therefore, it is consistent with the GBF.
Scale	✓	The OUV method is designed to be applicable at all scales – local to global. It can be employed to assess and recognise OUV irrespective of geographical boundaries.
Responsiveness/ timeliness	✗	The comprehensiveness of the assessment required for OUV may make it a time-consuming approach.
Inclusiveness		
Species diversity	✓	The OUV method may recognise and highlight the presence of unique and endemic species within a designated area, especially if these species contribute to the overall OUV of the site.
Genetic diversity	—	The OUV criteria do not assess the genetic diversity within species. However, genetically unique species may be identified indirectly if they contribute to the natural heritage values of a property.
Ecosystem diversity	✓	The OUV method considers the variety of habitats, communities, and ecological and evolutionary processes present, especially if these elements contribute significantly to the site's OUV.
Persistence		
Ecological integrity	✓	The OUV method does consider ecological and natural features as part of the outstanding universal value. While it may not comprehensively assess all aspects of ecological integrity, the recognition of exceptional habitats, ecosystems, and their response to change is inherent in the evaluation process.
Species' persistence	—	The OUV method can indirectly identify features necessary for species survival and adaptability. If a site is designated for its exceptional cultural or natural value, it might encompass elements such as essential habitats, ecological processes, and the adaptability of species to environmental changes.
Vulnerability/ threats	—	While OUV primarily focuses on the positive values of a site, it may provide insights into potential threats if they are considered in the evaluation process. However, the OUV method may not offer a detailed analysis of vulnerability and specific threats.
Climate resilience	—	During routine assessments of OUV sites, potential threats such as climate change may be identified, and measures can be suggested to enhance the property's resilience to preserve its OUV.
Uniqueness		
Uniqueness and irreplaceability	✓	The OUV method implicitly addresses the concept of irreplaceability. The designation of a site as having OUV suggests that the conservation of that specific site is crucial and that losing it would result in the loss of irreplaceable cultural or natural features. The OUV method, by design, recognises and emphasises the distinctiveness or rarity of sites. If a site is deemed to have OUV, it implies a level of uniqueness in terms of cultural, natural, or mixed heritage. This could include unique ecosystems, rare species, or exceptional cultural features.

Table 3-8. Strengths, weaknesses, opportunities and threats analysis of the Outstanding Universal Value method.

Strengths	Weaknesses	Opportunities	Threats
The OUV method benefits from the availability of established capacities, technologies and expertise, given its integration into the UNESCO World Heritage process. The OUV method aligns with global frameworks, such as the Post-2020 GBF, demonstrating compatibility with broader conservation initiatives. The sheer size of natural World Heritage sites in providing large and intact ecosystems could help preserve biodiversity and help some species respond to climate change.	The efficiency and responsiveness of the method weaken its standing. It is time-consuming due to the required data acquisition, assessment and the World Heritage designation process. While the method can contribute to biodiversity assessments, the OUV method is not a specialised method for comprehensive analysis of genetic, species and ecosystem diversity. This could limit its effectiveness in addressing specific conservation needs.	The OUV criteria could be used in conjunction with other compatible methods, such as KBAs, to form a comprehensive method. With ongoing advancements in technology and methodologies, there is potential for capacity building to enhance the efficiency and responsiveness of the OUV method. The regular OUV outlook assessments are valuable tools for monitoring the condition of the environment. The assessments trigger management actions that will support the persistence of biodiversity.	The OUV method's suitability is contingent on data availability, and limitations of inaccessible data can pose threats to its effective application in certain areas. The method's limited focus on specific biodiversity criteria may threaten achieving comprehensive conservation goals, mainly when detailed biodiversity assessments are crucial.

3.2.4 Ramsar sites

Looking out over the Nardab floodplain that are listed as Ramsar wetlands in Kakadu National Park. Photo: NESP Northern Hub.

3.2.4.1 Description

Ramsar sites are another criteria-based method for identifying exceptional values in the wetlands of international significance (Australian Government 2010). Group A of the criteria is relevant for sites containing representative, rare or unique wetland types, while criteria in Group B relate to sites important for biodiversity. There are also specific criteria for waterbirds and fish.

3.2.4.2 Assessment

The Ramsar method and criteria align well with the specified species and species diversity criteria within wetland ecosystems (Table 3-10, Table 3-11). Ramsar sites showcase representative diversity in these aspects. However, their focus on wetland conservation limit their ability to comprehensively address broader aspects such as ecological integrity, species' persistence, threats and climate resilience.

Additional criteria and methods may be necessary for a more comprehensive assessment beyond wetlands, especially when considering terrestrial ecosystems and their associated genetic and species diversity. Integrating other conservation approaches or frameworks and, therefore, encompassing a broader range of ecosystems could enhance the effectiveness of the Ramsar method in addressing these aspects.

Table 3-9. Assessment of the Ramsar method.

✓	The approach performs this function well.
—	The approach somewhat does this.
✕	The approach does not do this.

Criteria	Mark	Comment
—		**Overall assessment for the Ramsar method**
		Fit for purpose
Efficiency	—	The Ramsar method focuses on the conservation and sustainable use of wetlands and is relatively efficient, especially in areas where wetlands play a crucial role in biodiversity conservation. However, the efficiency may vary depending on the scale and complexity of the wetland ecosystem.
Feasibility	—	The feasibility of the Ramsar method depends on the capacity, technology and expertise available for wetland conservation. In areas where there is a commitment to wetland conservation and sufficient resources, the Ramsar approach is feasible.
Suitability	—	The Ramsar method is suitable for areas with available data on wetland ecosystems. The approach is specifically designed for wetland conservation, and its suitability is contingent on the presence of wetland ecosystems.
Flexibility	—	The Ramsar method is adaptable to different types of data. However, its flexibility is limited to the specific criteria and guidelines outlined by UNESCO.
Compatibility	✓	The Ramsar method aligns with other conservation initiatives and can be compatible with various data sources. The Ramsar Management Effectiveness Tracking Tool is also a complementary indicator for the 30-by-30 target.
Scale	✓	The Ramsar method is scalable and can be applied at different levels, including global, national, and regional scales.

Criteria	Mark	Comment
Responsiveness/ timeliness	—	The timeliness of the Ramsar method depends on the speed at which information on wetlands can be acquired, processed and visualised. The effectiveness may vary based on the availability of updated data and the responsiveness of monitoring systems.
Inclusiveness		
Species diversity	✓	The Ramsar Convention emphasises the conservation of biodiversity in wetlands. Wetlands are often rich in plant and animal species, including many that are unique and endemic to these ecosystems. Ramsar sites are expected to support a variety of species, including those that may be endangered or vulnerable. Therefore, the method can help identify areas with high species diversity. The presence of endangered and endemic species is considered in the designation of Ramsar sites, which aligns with the criteria for species diversity.
Genetic diversity	✗	The Ramsar Convention does not focus on genetic diversity within species.
Ecosystem diversity	✓	The Ramsar criteria recognise different wetland systems, such as swamps and marshes. As a result, the Convention emphasises the protection of a variety of habitats, ecological processes and the overall diversity of the wetland ecosystems.
Persistence		
Ecological integrity	—	As key ecosystems, wetlands, contribute to the overall ecological integrity of the landscape. However, the Convention does not explicitly address ecological integrity in terms of connectivity and adaption to changes. Additional criteria and considerations beyond wetlands would need to be considered.
Species' persistence	—	The Ramsar criteria does not consider the migration paths of fish stocks, nor whether the wetland is used as a refuge during adverse conditions.
Vulnerability/ threats	—	The assessment of a wetland considers the threats to the ecological character of a site. However, the method does not capture which wetlands are more vulnerable than others. It is conducted on a site-by-site basis.
Climate resilience	✓	The criteria of the Ramsar method identifies wetlands that serve as a refuge for species during adverse conditions, which could occur under climate change. The criteria also consider wetlands that support threatened species of fish and bird species. Wetlands are critical habitat for these species and would therefore increase their future survival.
Uniqueness		
Uniqueness and irreplaceability	✓	The Ramsar Convention acknowledges the importance of protecting unique and valuable wetland ecosystems. Wetlands often host distinctive flora and fauna, and Ramsar sites may include areas with vulnerable or unique species. The Ramsar Convention encourages the designation of sites containing representative, rare or unique wetlands, or wetlands that are important for conserving biological diversity. Therefore, it aligns with irreplaceability criteria within the scope of wetland environments.

Table 3-10. Strengths, weaknesses, opportunities and threats analysis of the Ramsar method.

Strengths	Weaknesses	Opportunities	Threats
This method provides a structured approach for identifying important wetlands. The approach is internationally recognised and consistent with the Global Biodiversity Framework indicators for the 30-by-30 target.	There is no scope to apply this method beyond wetlands. The Ramsar method does not capture all aspects important for biodiversity (e.g. genetic diversity).	The Ramsar method would need to be integrated with other more comprehensive methods, or criteria.	This method has limited effectiveness in addressing non-wetland biodiversity threats.

3.3 Jurisdictional methods and workshop findings

Figure 3-3 shows the areas identified as important at the jurisdictional level using methods used by Western Australia (WA), the Northern Territory (NT), New South Wales (NSW) and Victoria. While Queensland and the Australian Capital Territory (ACT) have well-developed methods for identifying areas, the mapped areas important for biodiversity are not public and thus are omitted from Figure 3-3. Tasmania and South Australia (SA) have documented methods for mapping areas important for biodiversity but have not yet implemented these to create mapped outputs. Figure 3-3 reflects this, with the absence of mapped areas within these jurisdictions. Section 3.3 contains more detailed state and territory maps.

Interviews with state and territory representatives revealed that numerous well-developed methods and applications are in place to identify areas important for biodiversity across Australia. We discuss in Appendix 3 how each method performed against the criteria developed for this project (Appendix 1).

Figure 3-4, Figure 3-5, Figure 3-6 and Figure 3-7 show the areas identified by Western Australia, the Northern Territory, New South Wales and Victoria, respectively, as important for biodiversity.

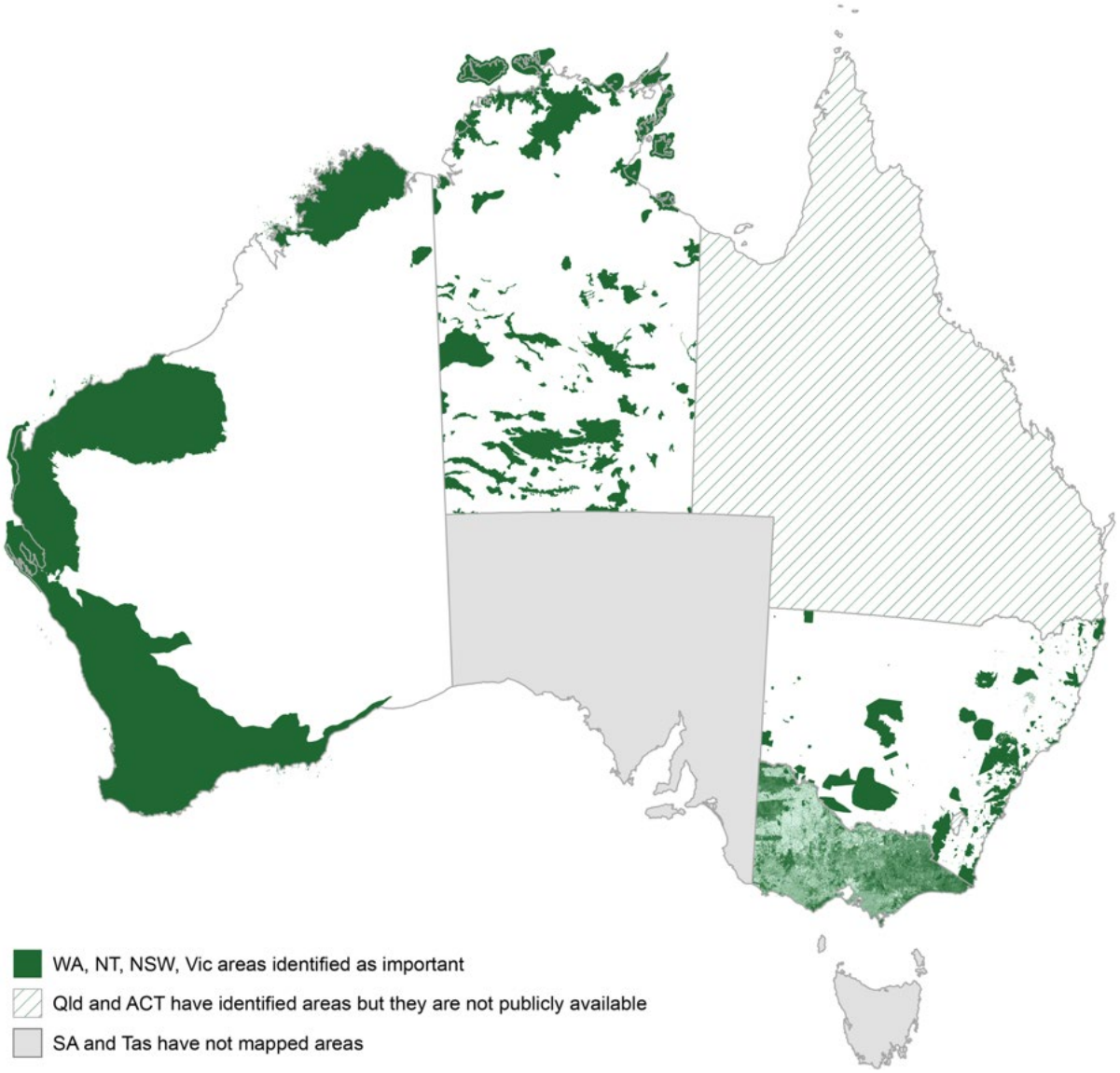

Figure 3-3. Areas identified by Western Australia, the Northern Territory, New South Wales and Victoria as important for biodiversity.

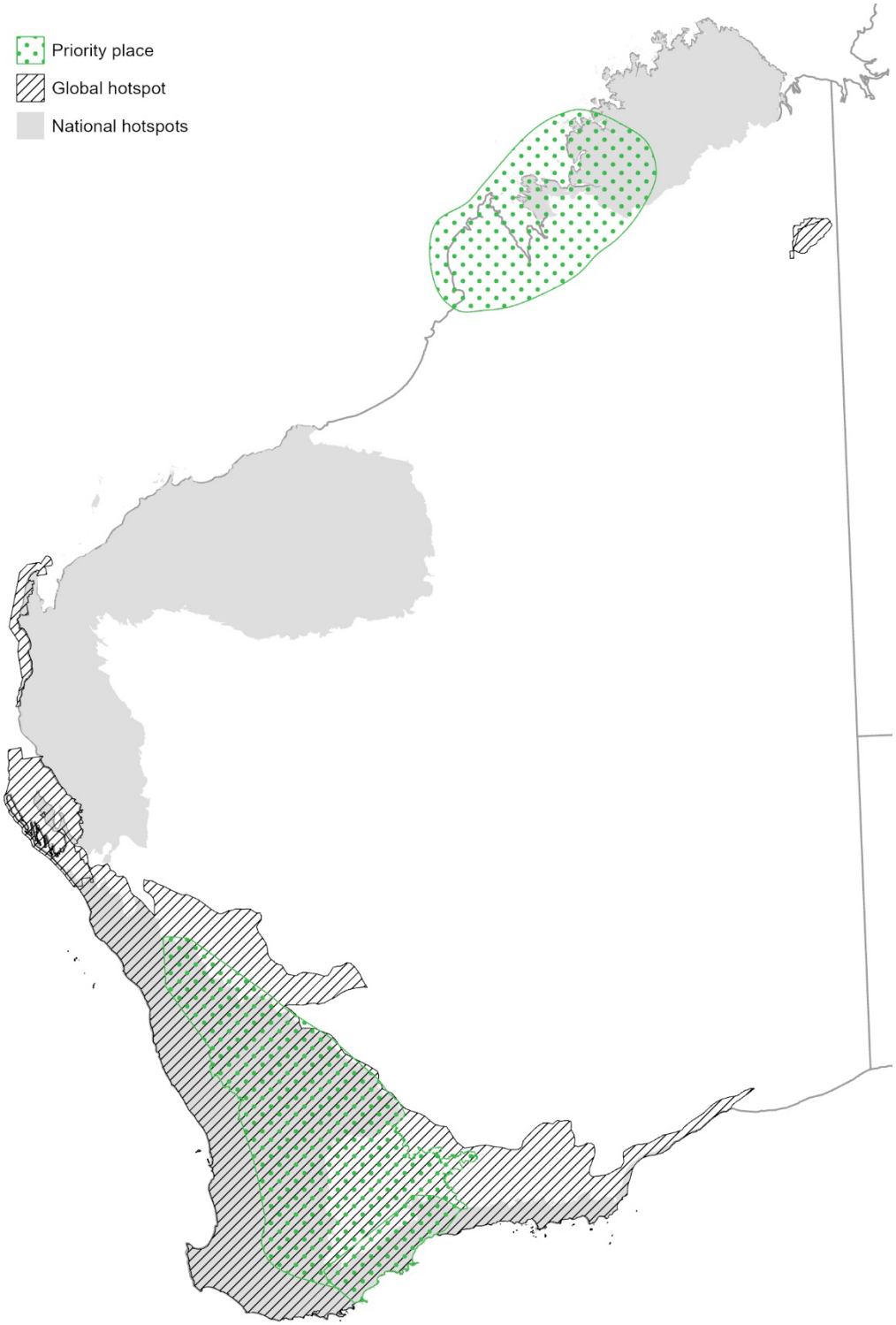

Figure 3-4. Map showing areas identified by Western Australia as important for biodiversity. Priority place: as identified in the Australian Government's *Threatened species action plan 2022–2032*.

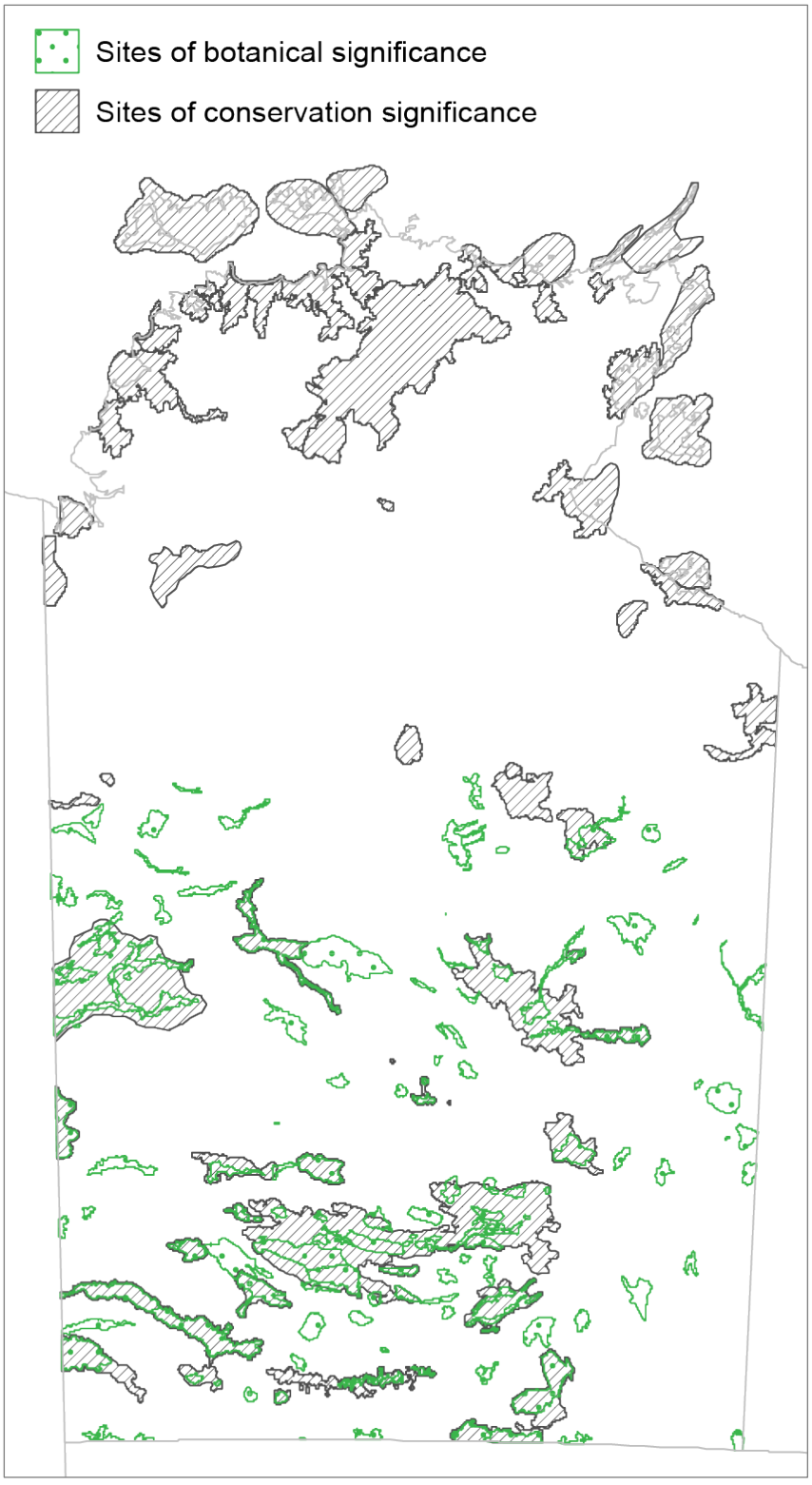

Figure 3-5. Map showing areas identified by the Northern Territory as important for biodiversity.

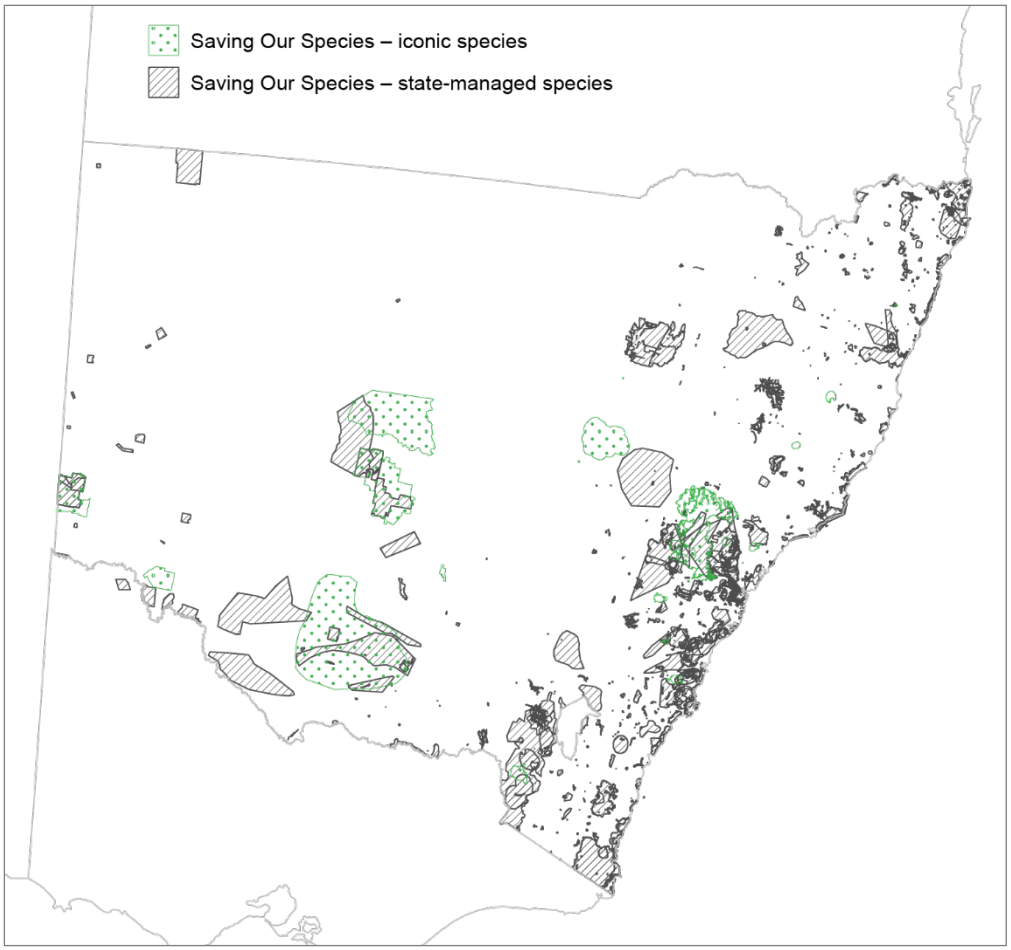

Figure 3-6. Map showing areas identified by New South Wales as important for biodiversity.

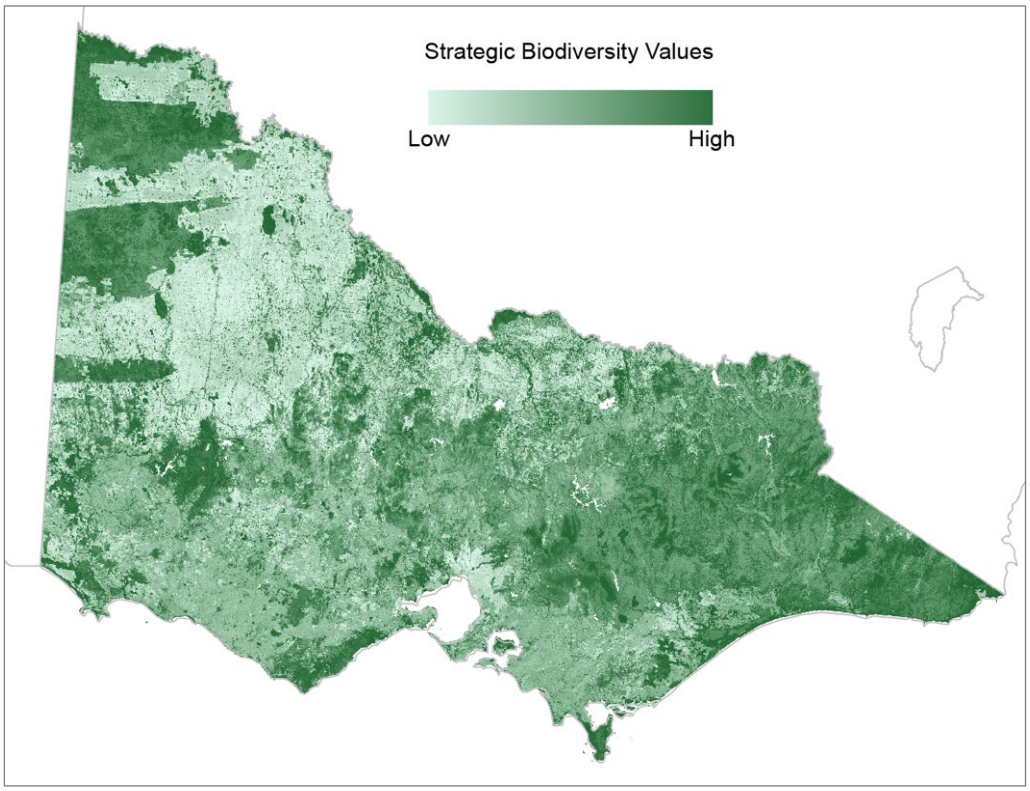

Figure 3-7. Map showing areas identified by Victoria as important for biodiversity.

3.3.1 Desktop results

Based on desktop review and interviews, the research team characterised the methods used by each state and territory into categories based on the internationally recognised methods – KBA criteria A–D, KBA Criterion E (irreplaceability), biodiversity hotspots, OUV and Ramsar and biodiversity hotspots. Another category that emerged through this process has been referred to as 'Priority Threat-Management Sites'. Several states, especially Victoria, have developed tools that prioritise locations based on threat management (as shown in Table 3-3).

The method most commonly used by Australian jurisdictions and NGOs is irreplaceability mapping through existing tools or in-house decision-support tools based on the mathematical formulations and principles of irreplaceability. Irreplaceability mapping corresponds to Criterion E used to define KBAs and refers to the unique and distinct species or ecosystems present within an area that cannot be found anywhere else in the world (Smith et al. 2019).These are complemented by NGOs working in these jurisdictions and using similar methods (5 of 6 employ irreplaceability mapping, 3 of 6 use hotspots).

A summary of the methods used by jurisdictions is shown in Table 3-3 and full summaries by jurisdiction are available in Appendix 3.

Table 3-11. Summary of methods currently employed by Australian jurisdictions and non-government organisations. An 'x' indicates that they align with that international method. We have bolded entries for Irreplaceability (Key Biodiversity Area Criterion E) to visually emphasise that most jurisdictions and non-government organisations use this method.

	Method name	Key Biodiversity Area (KBA) Criteria A–D	Irreplaceability (KBA Criterion E)	Priority threat management sites	Outstanding Universal Value/ Ramsar	Biodiversity Hotspots	Others (specific to non-government organisations)
Jurisdictions							
Queensland	Regional ecosystem and priority species mapping		**X**			X	
Australian Capital Territory	High priority zones				X	X	
Victoria	Strategic Management Prospects	X	**X**	X		X	
New South Wales	National Parks approach		**X**	X	X		
	Saving Our Species		**X**	X			
	Areas of Outstanding Biodiversity Value	X	**X**				
Tasmania	Conservation Information System	X	**X**			X	
South Australia	Landscape Assessment Framework (LAF) and Conservation Action Planning (CAP), New conservation planning and priority setting method	X	**X**	X	X	X	
Northern Territory	Sites of Conservation Significance	X	**X**		X	X	
Western Australia	Identifying new areas for the reserve network	X			X	X	
Non-government organisations							
In aggregate (n=6)	Methods used include: • the Interim Biogeographic Regionalisation for Australia framework for prioritising under-represented bioregions • irreplaceability mapping using software such as Zonation and Marxan • criteria-based mapping methods such as Key Biodiversity Area • species hotspot approaches.	3 of 6	**5 of 6**	1 of 6	3 of 6	2 of 6	IUCN Red List Species and Ecosystems; principles based on CAR (comprehensive, adequate and representative)

3.3.2 Workshop findings

To verify and further explore the desktop results, representatives from every state and territory were invited to participate in a 4-part workshop to discuss opportunities and barriers to identifying a nationally consistent approach to mapping areas important for biodiversity.

The analysis from the workshop showed that:

- Significant effort is already invested in identifying areas important for biodiversity.
- Many well-developed methods are already used to identify important areas for biodiversity.
- Methods currently employed (and areas identified using them) are comparable, given they share a methodological basis (in particular, employing the principle of irreplaceability) and, typically, similar underlying data.
- While the methods, and often underlying data, are well aligned, there remain some differences in application that result in anomalies in mapped areas, particularly at jurisdictional boundaries. A data harmonisation approach was discussed in the workshop to smooth these anomalies.

During the workshop, opinions were divided regarding the usefulness of a national approach, and there were discussions about its potential components. Supporters of a national approach argued that it could provide a unified framework and datasets that could be utilised for both national and international reporting. It could also provide a foundation for setting priorities that ensure that financial resources are directed at critical conservation areas deemed under common conservation priorities, such as the quality components of the 30-by-30 target – ecologically representative and connected.

Those favouring a national approach outlined the administrative burden that could result from a harmonised pathway (a blend of existing methods), especially for reporting purposes. If a nationally consistent approach was established, workshop participants proposed that it could be used to support other nature-positive projects as well as the 30-by-30 effort. However, participants expressed concerns about this option, including that irreplaceability calculations require fine-scale and uniform data, which is not currently available in all jurisdictions.

Despite this, participants agreed that an irreplaceability analysis could be valuable as a baseline for collaboration across jurisdictions, particularly those that share borders. Maps shown in the workshop depicted conservation priorities and how they differ across state and territory borders, reflecting differing methods and legislative requirements. However, these areas share species and ecosystems, so aligning conservation priorities along borders could yield significant benefits for biodiversity.

Some workshop participants strongly advocated for a ‘harmonised’ method to address national and global biodiversity targets. In practice, this would ‘stitch together’ all the methods and applications operating in each state and territory, rather than establishing a new, national method.

This was seen as a practical option, as different jurisdictions have varying levels of data availability and legislative requirements, making it difficult to create a one-size-fits-all method. Proponents highlighted that funding discrepancies across states may necessitate this option.

While a harmonised approach allows for customisation to specific state-based needs, it can lead to inconsistencies and challenges when trying to coordinate efforts in a nationally consistent way.

In conclusion, the results of the workshop highlight the need for a more harmonised and coordinated effort across jurisdictions. Achieving this necessitates efforts to address the challenges posed by varying data availability, financial resources, and jurisdictional priorities.

3.4 Findings from the questionnaire of non-government organisations

A quantitative survey (similar to the jurisdiction interview protocol) was sent to all NGOs in Australia that own private protected areas or have well-developed and implemented methods for identifying areas important for biodiversity at the national scale.

Just as a large number of methods were identified by governments, we found that NGOs were developing and applying many methods. The questionnaire results demonstrate strong parallels to the government results, with many NGOs using decision-support tools such as Marxan and Zonation to map irreplaceability (5 out of 6 organisations) (Table 3-12).

Table 3-12. Summary of methods used by non-government organisations.

Organisation	Key Biodiversity Area (KBA) criteria (A–D)	Irreplaceability (KBA Criterion E)	Priority threat management sites	Outstanding Universal Value/ Ramsar	Biodiversity hotspots	Others
Organisation 1		✓		✓		
Organisation 2	✓			✓	✓	IUCN Red List Species and Ecosystems
Organisation 3		✓				Comprehensive, adequate and representative (CAR) state level products used to collaboratively identify priorities
Organisation 4	✓	✓	✓	✓	✓	
Organisation 5		✓				
Organisation 6		✓			✓	CAR/priority landscapes

4. Recommendations and future research

4.1 Recommendations

We recommend irreplaceability (both as a stand-alone method commonly used by governments and conservation NGOs, and as Criterion E of the Key Biodiversity Area [KBA] method) as an appropriate nationally consistent approach for Australia to support in mapping areas important for biodiversity.

We note that the 30-by-30 target seeks that at least 30% of land and sea, 'especially areas of particular importance for biodiversity and ecosystem functions and services, are effectively conserved and managed through ecologically representative, well-connected and equitably governed systems of protected areas and other effective area-based conservation measures …'. This target emphasises ecological representativeness and connectivity alongside areas important for biodiversity. While the focus of this report is on methods appropriate for identifying areas important for biodiversity, we also captured the extent to which those methods might encompass or be complementary to considerations of representativeness and connectivity, in particular with our criteria of inclusiveness and persistence. Our recommended approach of KBA Criterion E (irreplaceability mapping) was judged to perform well across all of our evaluation criteria and could be applied to consider relevant design principles such as ecological representativeness and connectivity.

Applying our recommendation could include applying irreplaceability mapping at national scale. There are several decision-support tools available to aid this process. One approach is to adapt methods for calculating irreplaceability, as outlined by Ferrier et al. 2000. Alternatively, commonly used tools such as Zonation or Marxan provide approximations of irreplaceability (Carwardine et al. 2007; Ball et al. 2009; Wilson et al. 2009). Alternatively, such a map can be used embedded within a broader approach to recognizing areas already mapped by jurisdictions, in doing so also leveraging the often-finer scale and more complete data available within jurisdictions. This approach would capitalise on the widespread use of irreplaceability and using it as a starting principle for identifying important areas for biodiversity. However, harmonisation of approaches and underlying data will also be required across jurisdictions, particularly to account for discrepancies at state borders and different resolutions of jurisdiction level data sets.

To achieve harmonisation, attention should be given to ensuring that any nationally applied method and subsequent map of areas important for biodiversity is used in a consistent way across all jurisdictions. The methods used by jurisdictions are based on contemporary science, collaboration and jurisdictional priorities, and they use the best available data for that state or territory. Jurisdictional maps made from these methods are a valuable resource that should inform any national method. However, given jurisdictions use data of differing resolution or format, this necessitates the integration and smoothing (or 'harmonisation') of areas identified

as important for biodiversity across jurisdictional boundaries to rectify any artificial hard edges and fill gaps (e.g. the border between Victoria and New South Wales shows where choices of data, targets and representation of areas guided by irreplaceability mapping have resulted in continuity issues at the border [see Figure 3]).

In practice, harmonisation would first involve bringing together all jurisdiction-level irreplaceability products and rescaling them into a single scale or set of definitions (e.g. as a continuous measure of irreplaceability). Workshops with State and Territory experts would then guide the next steps of gap filling and harmonising. Second, gaps would be filled using an agreed-upon method – we recommend national scale irreplaceability mapping, given it is consistent with the methods already used by states and territories. Lastly, boundary issues – where areas mapped as important have anomalies due to jurisdictional boundaries – would be smoothed. For this smoothing step, methods could integrate information on underlying landforms and vegetation, which often drive species assemblages. This approach to harmonisation is shown in Figure 4-1 and further discussed in section 4.2. A national map produced using national datasets would be the starting point to identify areas of high irreplaceability.

We emphasize that data harmonisation of areas already identified as important for biodiversity, using irreplaceability to guide the process, could then enable the creation of a national map of areas important for biodiversity that matches and respects those currently delineated by each state and territory (Appendix 2). This would require collaborative agreement, by jurisdictions, of any national product against existing areas already mapped by jurisdictions. For example, this could involve comparing any national map of areas of high irreplaceability to those mapped by jurisdictions to confirm whether the areas correlate with each other. Any differences may need further investigation and, where necessary, adjustment to achieve harmonisation in a national approach.

This approach could then be workshopped to correct any border discrepancies and to help jurisdictions consider any gaps in their current maps. Our workshop participants agreed that states and territories with shared borders could work collaboratively on a shared set of priorities to overcome inconsistencies in the national map with centralised support – for example, access to appropriate national datasets (e.g. Appendix 4).

During our workshop with state and territory representatives for this project, participants advocated for a harmonised method that could potentially address national and global biodiversity targets. Participants saw this as a practical option, because each jurisdiction needs to meet their own state policy and legislative requirements. Employing a harmonised method at a national scale after correcting jurisdictional border discrepancies would ensure that areas reflect underlying biodiversity, rather than human-created jurisdictions.

This will help ensure the applicability of any national method, allow jurisdictions to keep meeting their state policy and legislative requirements, and prevent unnecessary duplication of effort (or ‘reinvention of the wheel’).

We note that new data regularly becomes available (e.g. threatened species location and range data). Therefore, a necessary aspect of implementing a nationally consistent method will be regular and iterative updates to mapped areas.

Sunrise at Misty Mountains, Point Lookout, Queensland. Photo: Eduardo il Magnifico CC-BY-NC-SA 2.0.

4.2 Potential future research

We propose these future research steps to provide the required technical and scientific basis for a nationally consistent method for mapping areas important for biodiversity (Figure 4-1).

1. **Map irreplaceability in a nationally consistent way to harmonise across jurisdictions.** There are several decision-support tools available to aid this process. One approach is to adapt methods for calculating irreplaceability, as outlined by Ferrier et al. 2000. Alternatively, commonly used tools such as Zonation or Marxan provide approximations of irreplaceability (Carwardine et al. 2007; Ball et al. 2009; Wilson et al. 2009).
2. **Cross-check the national irreplaceability map with areas already mapped by jurisdictions.** The methods developed by states and territories are well considered, based on contemporary scientific knowledge, and tailored to suit landscapes that are jurisdictionally unique. National and international methods also identify many of the sites identified by states and thus are robust to data and method. For example, the MacDonnell Ranges is a priority under the Australian *Threatened species action plan 2022–2032* and is also a

mapped NT site of conservation significance. The Save Our Species sites managed in NSW overlap with global biodiversity hotspots (the forests of East Australia) and priority places under the Australian *Threatened species action plan 2022–2032* (such as the Greater Blue Mountains).

3. **Host collaborative workshops to overcome boundary inconsistencies**. Collaborative workshops with neighbouring states and territories should be conducted using irreplaceability analysis as a foundation. The workshops would centre on identifying shared conservation priorities, resolving data gaps and border-related issues, and collectively evaluating gaps in biodiversity conservation.
4. **Develop a formal harmonised framework that is cross-checked with state and territory methods.** After the workshops, a formal and harmonised framework should be developed that recognises the diversity in data availability, legislative requirements and financial resources of the jurisdictions. The framework should be cross-checked with state and territory methods and emphasise irreplaceability as the agreed method for harmonising across jurisdictional borders. It should also align with the GBF's targets and reporting requirements, focusing on quality elements such as connectivity and ecological representation.
5. **Update iteratively.** It would be useful if the continuous improvement of implementation of state and territory methods could be facilitated federally by emphasising the need for regular updates to core datasets and access to these across jurisdictions. This will enable the prompt acquisition, processing and visualisation of new information that is crucial for the preservation of biodiversity.

These recommended next research steps collectively aim to establish the needed knowledge base for a cohesive and harmonised method for identifying important areas for biodiversity in a nationally consistent way by leveraging the knowledge and bespoke methods developed by states and territories that suit their unique landscapes.

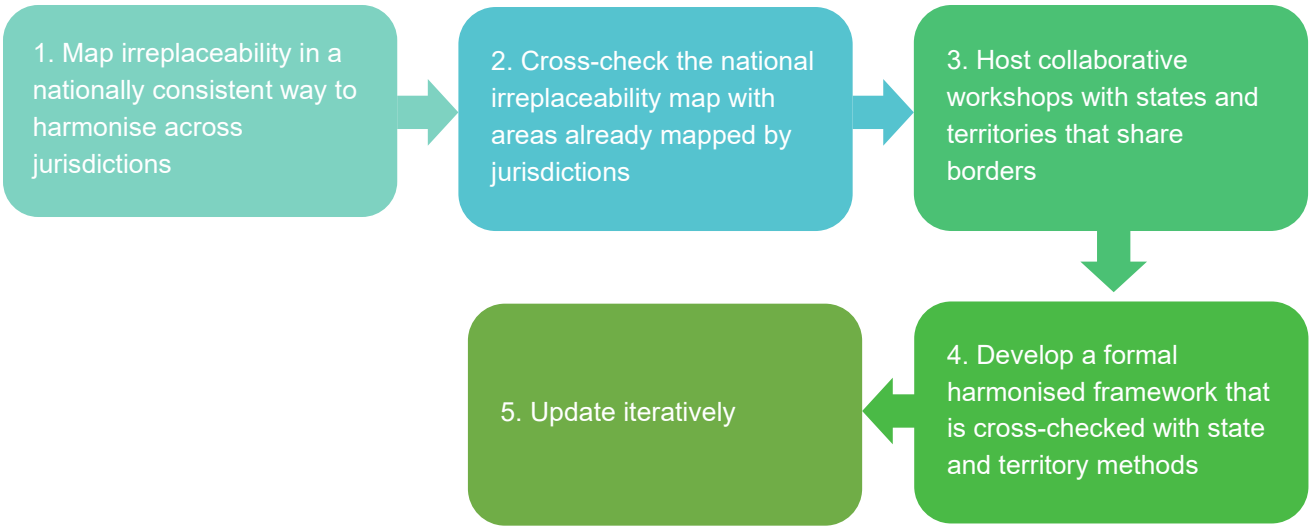

Figure 4-1. A flow chart of the potential future steps, some of which are beyond the life of this project.

Glossary and acronyms

30-by-30	Target 3 of the Kunming-Montreal Global Biodiversity Framework
ACT	Australian Capital Territory
AIS	Assets of Intergenerational Significance (NSW)
ALA	Atlas of Living Australia
AOBV	Area of Outstanding Biodiversity Value (NSW)
BAMM	Biodiversity Assessment and Mapping Methodology (Qld)
BPA	Biodiversity Planning Assessment (Qld)
CAR	comprehensive, adequate and representative
CBD	Convention on Biological Diversity
CIS	Conservation Information System (Tas)
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DEW	Department for Environment and Water (SA)
DIWA	Directory of International Wetlands in Australia
EPBC Act	Australian *Environment Protection and Biodiversity Conservation Act 1999*
EVC	Ecological Vegetation Class
GBF	Global Biodiversity Framework
GBIF	Global Biodiversity Information Facility
HCAS	Habitat Condition Assessment System (Commonwealth)
HDM	Habitat Distribution Model
IBRA	Interim Biogeographic Regionalisation for Australia
IUCN	International Union for Conservation of Nature
JANIS	Joint ANZECC/MCFFA NFPS Implementation Sub-Committee
KBA	Key Biodiversity Area
MNES	Matters of National Environmental Significance
NGO	non-government organisation
NSW NPWS	NSW National Parks and Wildlife Service
NRS	National Reserve System
NSW	New South Wales
NT	Northern Territory
OECM	other effective area-based conservation measure
OUV	Outstanding Universal Value

SA.....South Australia

SCP .....systematic conservation planning

SMP.....Strategic Management Prospects (Vic)

SoS.....Saving Our Species (NSW)

UNESCO .....United Nations Educational, Scientific and Cultural Organisation

WA.....Western Australia

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Appendix 1. Assessment criteria

What is biodiversity?

Biodiversity, or 'biological diversity', refers to the variability across living organisms (from genetics to species to ecosystems). This includes diversity within species, between species and of ecosystems (CBD 2023). The term encompasses the full spectrum of living organisms and their interactions with each other and their physical environment. There are 3 distinguishing elements – genetic (genetic coding and variation in genetic make-up), species (differences within and between populations of species) and ecosystem diversity (different habitats, biological communities and ecological processes) (Gaston and Spicer 2013).

When identifying areas that are important for biodiversity, it is important to consider elements such as species richness, endemic species, threatened or endangered species present, ecological or biogeographical uniqueness (areas with features that are important for conservation, e.g. unique geological formations or topography that may have unique flora and fauna that are not found elsewhere) and ecological function (areas that perform essential functions, e.g. habitat for migratory species).

Fit for purpose

Fit for purpose is the extent to which an approach is appropriate (scale based on efficiency, feasibility, responsiveness, and timeliness).

Efficiency: The relative cost of the approach compared to others (considering data acquisition, processing and mapping). What is the degree of efficiency of this approach compared to the others?

Feasibility: Is the capacity, technology or expertise available to use this approach, or can it be reasonably developed through training?

Suitability: Can this approach be undertaken with the data available?

Flexibility: Is the approach able to accommodate different data types?

Compatibility: Is the approach compatible with other data sources, mapping approaches and/or reporting requirements (e.g. the Kunming-Montreal GBF)?

Scale: Can the scale of the approach be applied at different levels (e.g. globally, nationally and regionally)?

Responsiveness/timeliness: Timeliness relates to the speed in which information can be acquired, processed and visualised. It also reflects the timeliness of data acquisition and updating systems. Can this approach capture and visualise data promptly as new information becomes available?

Inclusiveness

Inclusiveness refers to the presence of the species, ecosystems or ecological processes that is representative of biodiversity in Australia. To what extent does the approach detect this?

Species diversity: species richness, endangered and endemic species present.

Genetic diversity: range of traits within a species within the area, adaptive capacity of the species.

Ecosystem diversity: The variety of habitats, communities, ecological and evolutionary processes present.

To what extent can the approach identify an area with representative samples of genetic, species and ecosystem diversity?

Persistence

Persistence refers to the likelihood of long-term survival of species and other elements of biodiversity. This can be estimated based on the integrity of species and ecosystems, their adaptive capacity, and vulnerability to threats present in the area. To what extent can the approach account for these aspects to estimate the likelihood of survival?

Ecological integrity assesses ecosystems' quality and capacity to adapt to change. It covers habitats' extent, condition and connectivity, and how well ecosystems respond to change, including climate change and other pressures.

Species persistence depends on population dynamics, dispersal, immigration, and contraction/expansion of species' geographic ranges. Factors such as the degree of protection of essential habitat, the size, shape and connectedness of habitat, and the extent to which species/ecosystems will be able to adjust their ranges in response to climate change or adapt to climate change should be considered. For example, connectivity and minimum size are essential, as habitat layout can facilitate the transfer of ecological processes and genetic material and support migratory species and adaptability by allowing species to move in response to change. Does the approach identify features that are necessary for species survival and adaptability?

Vulnerability/threats: Some species and ecosystems are more vulnerable to threatening processes, such as climate change and invasive species. Does the approach provide insights into which species or ecosystems are most vulnerable and what threats are present in a specific area?

Climate resilience: Climate change is the most significant threat to species' survival and ecosystem integrity worldwide. With finite resources, it is vital that when areas that safeguard biodiversity are identified, they should have a high chance of survival under climate change. Does this approach capture the resilience of species and ecosystems?

Uniqueness

The uniqueness and irreplaceability of a site is the degree to which spatial options for conservation are lost if a site and its biodiversity are lost. Uniqueness refers to the distinctiveness or rarity of species or ecosystems, such as if an area contains vulnerable plants or animals or unique geological or hydrological species. Irreplaceability is the likelihood that a given site will need to be protected to achieve a specified set of targets or, conversely, the extent to which options for achieving these targets are reduced if the site is not protected (Margules and Pressey 2000). Does the approach capture the uniqueness and irreplaceability of a site?

Appendix 2. Methods of Australian states and territories

Australian Capital Territory

Governance

Relevant department: Environment, Planning and Sustainable Development Directorate.

Policy landscape

ACT nature conservation strategy (2013–23): This strategy (ESDD 2013) is underpinned by the NRS and has been largely successful – with 68% of reserve types protected in 2023. In 2012, when the plan was developed, all ACT ecosystems and habitats of all threatened species were represented in the reserve network. The current representativeness of the reserve still needs to be assessed. However, the large reserve estate would have inherent connectivity. The ACT is working on mapping connectivity and developing an index. There is data available that would enable the identification of connectivity (e.g. Local Links).

The strategy ends this year. A new iteration is under development that will consider condition and extent. However, these qualitative elements are yet to be defined.

Caring for Dhawura Ngunnawal: a natural resource plan for the ACT (2022–2042): This plan (EPSDD 2022) provides a road map of the key actions identified by extensive consultation with the primary stakeholders in natural resource management in the ACT and region. It integrates outcomes and experience from existing plans, including the *ACT climate change strategy 2019–25* (EPSDD 2019) and the *Environment, Planning and Sustainable Development Directorate's science plan 2020–2025*.

The plan's key focus is to conserve, protect and restore the natural environment, with a focus on threatened ecosystems and species. It focusses on specific natural landscapes: waterways, forest and woodlands, grasslands and bogs and fens. Each of these is profiled, detailing their pressures and current condition (e.g. water quality, riparian vegetation, native species, invasive species, sedimentation, erosion).

The strategy considers the risk of climate change to the viability of ecosystems and endemic species (particularly in sensitive areas such as alpine and sub-alpine areas) and includes an aim to facilitate the redistribution of species as changes to habitat occur. Connectivity is central to this; the plan utilises the *IUCN's guidelines for conserving connectivity through ecological networks and corridors*.

Blue-green network: This initiative sits under the ACT nature conservation strategy and aims to identify and protect key areas of the natural environment that conserve biodiversity, provide ecosystem services, and support cultural heritage and liveability, as well as support the connection of people with nature where this is compatible with biodiversity and conservation values.

Biodiversity investment plan: The investment plan has 3 main investment themes – Biodiversity, Sustainable Agriculture and Aboriginal Natural Resource Management. There are 3 biodiversity goals underpinning the approach: (1) resilient woodlands, grasslands and alpine bogs, (2) threatened species recovery and (3) climate change.

ACT native woodland conservation strategy and action plans: This strategy (ESDD 2019) is underpinned by the goal of protecting threatened species and communities, and other fauna and flora within and outside the reserve and improving ecosystem function through improved condition and connectivity.

ACT native grassland conservation strategy and action plans: Conservation sites of significance under this strategy (ESDD 2017) have high ecological condition (floristic score > 20) or represent key species habitat (category 1). There are 3 categories overall.

ACT aquatic and riparian conservation strategy and action plans: This strategy (EPSDD 2018) aims to protect aquatic and riparian ecosystems because they are important for plant and animal species (e.g. Macquarie perch and Murray crayfish).

Strategic bushfire management plan: This strategy targets biodiversity by maintaining unburnt buffers along riparian zones. This is echoed in the Regional fire management plan. Climate refugia will be for different vegetation types and will be linked with prioritising fire management for different Tolerable Fire Intervals. Natural Temperate Grassland and Box Gum Woodland (where they occur) are important conservation values in fire management planning.

Methods

The ACT focuses on threatened ecosystems, with an emphasis on conserving them. For example, woodlands were identified as high-priority areas based on Bird Restoration Hotspots. Connectivity is also a key consideration of key strategies, including the *ACT native woodland conservation strategy and action plans* and the *Caring for Dhawura Ngunnawal Plan*.

The ACT has identified high-priority zones based on conservation values – these include woodlands, grasslands, alpine bogs and riparian corridors (EPSDD n.d.) as part of its Biodiversity investment plan and *Caring for Dhawura Ngunnawal plan*. Bogs, fens, woodlands and grasslands correspond with threatened ecological communities defined under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) and are host to many of ACT's threatened species.

Our interview with ACT representatives suggested that these 4 ecosystems were selected based on the presence of threatened species, using threatened and declining criteria likely inspired by the EPBC Act definitions and the IUCN Red Lists of Ecosystems and Species. The *ACT native woodland conservation strategy and action plans* captures other areas essential to biodiversity, such as alpine and sub-alpine woodlands.

Grasslands and woodlands were identified as priorities under the ACT Biodiversity Adaption Pathways Project in 2016 (as well as in the associated *ACT native woodland conservation strategy and actions plans* and the *ACT native grassland conservation strategy and action*

plans). River corridors and wetlands were also identified. The project's objective is to enhance the adaptive potential of ecosystems and safeguard climate refugia.

Maps and data

- ACTmapi and ACT Government Geospatial Data Catalogue
    - vegetation mapped – can show percentage of exotic vs. native species. These were done in 2018. Likely to be re-run every 10 years
    - potential threatened woodland layer
    - threatened species habitat layer (going to be updated with Commonwealth definitions)
    - data included Functional Canopy Connection, General Habitat, Habitat Patches, Future Conservation Areas
    - there is a climate refugia map; however, it does not map climate resilience long term
- *Canberra nature map reserve management plan 2021* (EPSDD 2021)
    - contains survey information on plants and animals
- There are distribution maps and finer-scale vegetation mapping available internally.
- The *Science plan 2020–25* highlights the data needs and gaps with respect to climate change, ecosystem process, species and community ecology and threats.

Relationships with other states and territories

- The Australian Alps Liaison Committee is a long-standing collaboration between ACT, NSW and Victoria.
- Due to common threatened species along the border, there is a precedent of sharing data with NSW. There is a memorandum of understanding for invasive plants. However, everything else appears to be on a case-by-case basis. For example, ACT ran a grassland dragon model for both ACT and NSW, so there are established data-sharing exercises taking place.

There are shared National Wildlife Corridors between NSW and ACT, e.g. Southern Tablelands and Great Eastern Ranges. The *ACT nature conservation strategy (2013–2023)* was consistent with the *NSW biodiversity conservation investment strategy* objectives of connectivity and bioregional planning.

Assessment table: High-priority zones and conservation strategy priorities.

Criteria	Comment
Fit for purpose	
Efficiency	Identifying 'high priority areas', such as wetlands, can be done at a low cost. Additionally, it can be an efficient process when done on a national scale.
Feasibility	Can be done in-house.
Suitability	Yes – there is sufficient species data to support the method.
Flexibility	The data supporting the high-priority ecosystem approach can be quite flexible, since they do not rely on specific criteria or thresholds.
Compatibility	The focus on important ecosystems is consistent with the Australian *Environment Protection and Biodiversity Conservation Act 1999*, and the *ACT nature conservation strategy (2013–2023)* is consistent with the NRS. ACT also utilises the IUCN's guidelines on connectivity under the *Caring for Dhawura Ngunnawal plan*.
Scale	The current scale is statewide. However, vegetation mapping within the reserve can be mapped at a finer scale. Identifying high-priority areas at a national scale would be possible with existing knowledge.
Responsiveness/ timeliness	Vegetation mapping is updated every 10 years. Condition is tracked consistently in some areas, but not across the board.
Inclusiveness	
Species diversity	As shown by the focus on high priority zones, there is an inherent focus on protecting threatened species. By 2012, all threatened species had been captured in ACT's reserve network.
Genetic diversity	Knowledge exists for some species on a project-by-project basis.
Ecosystem diversity	All ACT ecosystems on a bioregional scale were represented in the 2012 iteration of the reserve network. This has only increased since then. Vegetation maps, habitats and climate refuges have been captured also. However, their condition is unknown.
Persistence	
Ecological integrity	Condition is tracked in some areas, although this is not done comprehensively or systematically. The next ACT nature conservation strategy will likely deal with this. Within the reserve network, there is more detailed information about the vegetation (e.g. exotic species present).

Criteria	Comment
Species' persistence	Climate refuges and habitat are mapped, and the areas of importance, such as bogs, fens and wetlands, are all significant to the persistence of some species. Connectivity is also a key feature of the new *Caring for Dhawura Ngunnawal plan*, which is targeting actions to facilitate change in habitat preferences under climate change.
Vulnerability/ threats	Wetland vulnerability to climate change has been mapped on ACTmapi, with consideration of landscape and soil capability, salinity hazard, erosion hazards, etc. Broad-scale threats to each target landscape under the *Caring for Dhawura Ngunnawal plan* are also discussed.
Climate resilience	Climate refuges have been captured; however, the specific resilience to ecosystems of species under climate change has not been done. However, this is a priority under *Caring for Dhawura Ngunnawal plan*.
Uniqueness	
Uniqueness and irreplaceability	The ACT does not utilise uniqueness or irreplaceability metrics when identifying areas important for biodiversity.

Table: strengths, weaknesses, opportunities and threats.

Strengths	Weaknesses	Opportunities	Threats
It is consistent with the IBRA, therefore could be achieved on a national scale. The focus on threatened ecosystems and the associated threatened species that reside there would be consistent with IUCN Red List of Ecosystems (a supported indicator of Target 3). Representativeness on a bioregional scale was 100% in 2012, although would need further investigation to determine current levels. There is strong alignment to the Commonwealth definitions. Strong history of collaboration between NSW and ACT.	Does not consider irreplaceability or uniqueness. While broadscale analysis has been done on the threats to ecosystem types, this information is not mapped.	An established relationship with NSW on data sharing. The size of the reserve estate means that the ACT is well positioned to meet connectivity objectives. Connectivity mapping is available to support the development of an index. The end of the *ACT nature conservation plan (2013–2023)* means there is capacity to update the current focal landscape methods with specific criteria or thresholds.	While climate refugia has been mapped and some scenario planning occurred under the ACT Biodiversity Adaption Pathway project, modelling has not been done to examine persistence.

Northern Territory

Governance

Relevant department: Lands, Planning and Environment NT.

Policy landscape

NT Parks Masterplan 2023–53

Under the *NT Parks Masterplan 2023–53* (DEPWS 2023), the Northern Territory (NT) has committed to growing the reserve estate, building on a CAR-based system supporting biodiversity conservation. It highlights that many terrestrial, coastal and marine biogeographic regions are underrepresented. There are also tourism and cultural heritage considerations.

The current park estate and its representativeness need to be assessed as part of the plan. Previously, the estate's biodiversity values were appraised and evaluated using the CAR system, which is discussed in Section 2.

The masterplan also has a goal around the conservation of 'natural biodiversity values'. This includes targets for zero extinctions by 2050 and a Climate Change Strategy developed by 2025.

The NT developed a method for identifying areas important for biodiversity values, which is discussed below. There are 5 relevant criteria: (1) concentrations of threatened species, (2) concentrations of endemic species, (3) wildlife aggregations, (4) wetlands and (5) botanic importance. These helped inform the mapped important biodiversity conservation sites (NTG n.d.), including pre-existing world and national heritage sites.

Methods

Method 1: Sites of Conservation Significance for Biodiversity Values (aimed at identifying new sites)

This method was developed to identify new areas at a territory scale (it was tenure blind). A site is recognised for having high conservation significance if it has wetland values, large aggregations of wildlife, concentrations of threatened or endemic species or botanical hotspots. International and Matters of National Environmental Significance (MNES) criteria and expert knowledge informed the design of the criteria.

The 5 criteria for assessing Conservation Significance for Biodiversity Values are:

1. Concentrations of threatened species – sites were considered of regional significance for threatened species if they contained the only records of a threatened species in the NT or significant numbers of records of a highly threatened species. If more than 10% of all recent records of a species in the NT came from within a site, that species contributed 1.0 to the threatened species 'score', but if less than 10% of recent records of a species came from a site, the contribution of that species to the score was reduced (if less than 1%, the contribution of that species was 0.2; 1–2%,

0.4; 2–5%, 0.6; 5–10%, 0.8). This was adapted from the IUCN criteria.

2. Concentrations of endemic species – sites with one or more species known only from the site or 10 or more species endemic to the bioregion were classified as of regional significance for endemic species. Results were based on vertebrates and plant species. There were not adequate data for invertebrates.

3. Wildlife aggregations – criteria for wildlife aggregations often require that a site 'supports' or 'regularly supports' more than a threshold number of individuals or proportion of a population. Expert opinion was used to identify sites of regional significance for wildlife aggregations if there were records of large numbers of animals at sites. This applied for marine turtles, seabirds, shorebirds – if a site was home to greater than 1% of the population, then it was considered of national and, in some cases, international significance.

Wetlands – inspired by Ramsar. Sites are classified as being of international or national significance for wetland values if they encompass existing Ramsar and Directory of International Wetlands in Australia (DIWA) sites or were identified in the Parks and Wildlife Masterplan (DNRETA 2005) for wetland values, or have been assessed as meeting multiple Ramsar or DIWA criteria. Expert opinion was generally used to identify sites of regional significance for wetlands, based on available data or personal knowledge – sites would need to meet DIWA criteria. **Rivers were also a consideration – however, at the time there was no definitive criteria for assessing them.**

4. Botanic importance:
    a. Rainforests were identified as internationally significant at greater than 20,000 ha, nationally between 500–5,000 ha, and regionally at greater than 100 ha.
    b. Numbers of restricted range and relictual species recorded in sites was also used to assess botanical significance, particularly in sites in the arid centre or savanna regions. Sites with more than 100 restricted range species or 30 relictual species were considered of international significance; nationally significant sites had 40–99 restricted range or 15–29 relictual species; and regionally significant sites had 10–39 restricted range or 5–14 relictual species.

Sites of conservation significance are rated based on their overall significance. If a site meets the criteria for international significance in at least one of the 5 categories listed above, it is given an overall rating of 'International significance'. If a site does not meet the criteria for international significance but meets the criteria for national significance in at least one of the categories, it is given an overall rating of 'National significance'.

Method 2: using the CAR system to value and evaluate the parks estate according to their biodiversity values based on the existing system

Each of the 3 conservation attributes identified in this method – intrinsic biodiversity value, contribution to CAR and resilience – were calculated by summing a series of sub-components which are outlined below.

Criteria	Scoring system
CAR sub-components	
Representation of bioregions (comprehensiveness) A measure of a reserve's contribution to a comprehensive reserve system by the proportion of bioregions they contain. Some reserves span more than one bioregion. In this case the higher % extent is used.	0 points :: < 1% of bioregion area. 1 point :: 1–5% of bioregion area. 2 points :: 5–10% of bioregion area 3 points :: > 10% of bioregion area
Sole representation of bioregion This criterion scores reserves that are the only sample of any bioregion. (Only 2 protected areas score in this respect; one is less than 1% of its bioregion and the other is an Indigenous Protected Area.)	0 points :: no bioregions reserved only in this reserve 1 point :: 1 bioregion reserved only in this reserve. 2 points :: 2+ bioregions reserved only in this reserve
Adequacy of reservation of NT vegetation types A key principle of sustainable conservation relates to the questions of what proportion of any given environment represents a threshold above which there is reasonable assurance that the present biota will be maintained. Assessment comprises 2 components – the extent to which the park contributes to overall adequacy of conservation of NT vegetation types and extent to which the park contributes to adequacy of protection for regional vertebrate fauna.	A 5-point scale against adequacy indices developed for both contribution to vegetation type conservation and vertebrate fauna. Scores are added making for a maximum possible score of 10.
Number of vegetation types included This criterion is based on the simple premise that a reserve with greater diversity of habitats or vegetation types makes a higher potential contribution to conservation than less diverse reserves. Vegetation types are the 112 NT vegetation types mapped at 1:1,000,000.	0 points :: representative sample of 1 or 2 vegetation types 1 point :: representative sample of 3-5 vegetation types 2 points :: representative sample of 6-9 vegetation types 3 points :: representative sample of 10+ vegetation types

Sole representation of vegetation types This criterion follows the premise that higher value is afforded reserves that contain the only representative sample of described vegetation types. Vegetation types are the 112 NT Vegetation types mapped at 1:1,000,000.	0 points :: no vegetation types reserved only in this reserve 1 point :: 1 vegetation types reserved only in this reserve 2 points :: 2 vegetation types reserved only in this reserve 3 points :: 3 vegetation types reserved only in this reserve 4 points :: 4+ vegetation types reserved only in this reserve
Intrinsic biodiversity value sub-components	
Wetlands In general, wetlands have special value for ecosystem function and biodiversity conservation. Assessment for this criteria is based on Northern Territory wetland sites listed as being of national significance through the Directory of Important Wetlands of Australia in addition to an assessment of arid and semi-arid wetlands taken to be of equivalent status here. Reserves are scored on the basis of the areal proportion of any listed wetland occurring within them.	0 points :: < 10% of listed wetland occurs in reserve 1 points :: 11-–50% of listed wetland occurs in reserve 2 points :: > 50% of listed wetland occurs in reserve. For each listed wetland occurring on the reserve.
Wildlife aggregations Some reserves have higher value for the exceptional significance for a plant or animal species or group of species because they support (at some time of the year or some years) an especially high proportion of the population or a substantial aggregation. This criteria takes stock of all sites recognised as being of regional, national or international significance for marine turtle breeding, seabird breeding and shorebirds (excluding wetlands counted in other criteria). Data is anecdotal rather than systematic assessment. 27 reserves are listed as having at least one significant aggregation.	0 points : no significant aggregations 1 point : for each aggregation of regional significance 2 points :: for each aggregation of national significance 3 points :: for each aggregation of international significance Plus an additional 1 point for any other known wildlife aggregations on the park, making for a maximum possible score of 10.
Reserve endemicity Based on the premise that reserves that are the only protected areas in which species are represented gives those reserves higher value. The number of plant and vertebrate species known to be represented in the park network by only one park together with an importance value calculated from an averaged proportional value of representation across all species in a park.	Singleton species scores scaled 0–5, Proportional representation index scaled 0–5, adding up to a potential score of 10.
Species richness Species richness is a basic attribute of biodiversity. This measure make a comparison across parks in	Scoring system from 0 (least value) to 5 (highest value) for both plants and vertebrates added

the known number of plant and vertebrate species recorded and the expected number recorded based on modelling based on sampling effort, park size and park position on rainfall gradient.	together for a maximum possible score of 10.
Threatened species Conservation of threatened species is a fundamental rationale and responsibility of reserves and should be a major driver of reserve management. Scores are given based on both a simple tally of threatened species for each park and a weighted tally – the number of parks per threatened species. The latter factors in the principle that more management attention should be given to a reserve that is the only case of reservation of a species than if a species is recorded on many reserves.	Maximum possible score of 10, based on scoring comprising 0–5 for no. of threatened species [0 = 0; 1 = 1; 2 = 2–5; 3 = 6–10; 4 = 11–20; 5 = > 20), plus 0–5 for weighted index (based on reciprocal of number of parks from which the threatened species has been recorded (0 = 0; 1 = 0.01–1; 2 = 1.01–5; 3 = 5.01–10; 4 = 10.01–20; 5 = > 20.
Resilience sub-components	
Area/shape index This measure accounts for the principle that reserves are more resilient to disturbance the higher their area to boundary ratio, because the outer margin of a reserve is prone to 'edge impacts' from unreserved adjoining land, and the margin of impact is an increasing proportion of the reserve area as the reserve decreases in area, is narrow or contains excisions. Shape index uses formula: (4 × Pi × area)/perimeter^2, with units in km and km^2 and a maximum potential value of 1 (for a circle).	Index score < 0.2 = 0 points Index score 0.2–0.4 = 1 point Index score 0.4–0.6 = 2 points Index score > 0.6 = 3 points
Resilience to climate change: ruggedness and rainfall variation All things being equal, a species is more likely to persist in a reserve if that reserve offers a larger range of climatic conditions and refugia. Scores are based on an index developed for rainfall variance across the area of each reserve together with an index derived from measures of reserve elevational range and ruggedness. Both measures have a 6-point scale giving a maximum possible score of 12.	Maximum possible score of 12, derived from scores of 0–3 for each of rainfall actual range, rainfall % range, altitudinal range and topographic roughness (standard deviation).
Neighbouring land use A value is given for every protected area for land use modification within 1 km of its boundary and within 10 km of its boundary. The mean of these values is taken as the index for the criterion. Low values apply for reserves surrounded by highly modified lands, higher values for reserves surrounded by lands least modified.	Index score < 1 = 0 points Index score 1–1.99 = 1 point Index score 2–2.99 = 2 points Index score 3–3.99 = 3 points Index score 4–4.99 = 4 points Index score > 4.99 = 5 points
Threats	
Threats to biodiversity values	0 points :: no or very little impact

Conservation values assessment has been based largely on hard data. Similar data for threats to biodiversity, however, is not available. Scores for threats come from park managers with scores based on their knowledge of the conservation values of this park, the threat level presented by fire, feral animals, weeds, and other (if any) threats, on a 3-point scale. The perception of threat level was therefore combined with perception of conservation value, with threat levels for parks perceived as having lower conservation value invariably scoring lower on threats. Scores are added, making for a maximum possible score of 12.	1 point :: moderate impact, low-key management necessary 2 points :: high impact, significant management input necessary 3 points :: very high impact, very significant management input necessary

Maps and data

- The methods utilise data from the Atlas of Living Australia (ALA), as well as local data.
- Shorebird aggregations are the most up to date.
- Tree clearing is tracked but vegetation condition is not.
- Threat mapping of feral animals (e.g. buffalo densities) and weeds is also available.
- Natural Resource Maps is a mapping tool that filters data about soil, water and vegetation resource surveys, weeds, bores, flora and fauna and water management areas. The Significant Conservation Sites also have their own overlay.
- NT Atlas and Spatial Data Directory is a catalogue of spatial datasets available from the various government departments of the NT. It contains information on land use, natural resources (rivers and national parks) and topography.
- Land, soil and vegetation information
    - information includes:
        - spatial data and derived map products in a range of formats, including GIS data and PDF
        - map unit descriptions of landform, soil and vegetation
        - landscape, vegetation and soil profile description
        - technical reports
        - general land suitability
        - land, soil and vegetation technical information
        - technical information on land soil and vegetation are available in following factsheets:

            i. Soils of the NT (PDF 248.7 KB)
            ii. Native vegetation types in the NT (PDF 3.3MB)
            iii. NT guidelines and field methodology for vegetation surveys.

Information and maps about the distribution of plants found in the NT are available on the FloraNT website.

Assessment table: Method 1 and Method 2.

Criteria	Comment
Fit for purpose	
Efficiency	The methods have not been rolled out due to constrained resources in the past. Could be expensive.
Feasibility	Yes – there is sufficient internal knowledge and resources that could support the roll out of the method.
Suitability	Despite data gaps, the method was still undertaken to identify sites of significant biodiversity values. However, the current available data may skew results in favour of certain species (e.g. to favour locations for shorebirds, which are the most up-to-date datasets).
Flexibility	The method can accommodate different data types, both state-owned and Atlas of Living Australia datasets.
Compatibility	Compatible with IUCN criteria, RAMSAR criteria and Directory of International Wetlands in Australia criteria. The CAR principles utilised in the second method would be compatible with national approaches and likely other states.
Scale	The Conservation Sites of Significance was conducted at a jurisdictional scale. However, the criteria and methods could likely be adapted and applied nationally.
Responsiveness/ timeliness	Given the large number of the criteria, the assessment is likely to be time consuming. This method is well-suited for initially scoping areas that are important for biodiversity.
Inclusiveness	
Species diversity	Yes – this approach considers species richness, endemism and threatened species present in Method 2. Method 1 considers concentrations of threatened species, endemic species and wildlife aggregations.
Genetic diversity	No – genetic diversity is not one of the resilience criteria. Resilience to climate change is more focussed on refugia.
Ecosystem diversity	Method 2 in particular considers comprehensiveness in terms of the reserve network. There are also criteria that consider the types of vegetation represented as well as sole vegetation types included, which infers a greater diversity of habitats.

Persistence	
Ecological integrity	The vegetation criteria implies a consideration of habitat. Extent is also monitored in NT; however, condition is not tracked. Connectivity is not considered an important principle in the NT given the landscape types.
Species' persistence	The criteria for Method 2 considers the size, topography and layout of the reserve design, which is vital for the persistence of species. Connectedness is less of a consideration – park sizes are large. The approach, however, does not consider how the landscape will respond to climate change under different scenarios.
Vulnerability/ threats	Yes – there are criteria for threats in Method 2 that considers feral animals, weeds and fire.
Climate resilience	There are resilience criteria in Method 2, which is to do with the shape and topography of the landscape. Does not consider the adaptive capacity of species.
Uniqueness	
Uniqueness and irreplaceability	Some criteria in Method 1 and Method 2 that consider uniqueness: • Method 1: considers of wetlands, concentrations of threatened species, endemism and botanic importance. • Method 2: endemism and sole vegetation types.

Table: strengths, weaknesses, opportunities and threats

Strengths	Weaknesses	Opportunities	Threats
Method 2 is well aligned with the NRS and CAR while also capturing other more specific biodiversity requirements. CAR principles in Method 2 mean alignment with other states. Incorporation of international criteria (e.g. Ramsar) would mean it would align with GBF indicators. Considers the design of reserves which is important for climate resilience. Has developed a grading system that could be rolled out on a national scale.	Sites are heavily skewed towards shorebirds, waterbirds and sea birds, as that is the best data available. The criteria ranks international and national sites as more important, which misses sites of regional importance (e.g. smaller wetlands). Does not consider condition. Resource intensive to complete all of the criteria. Does not assess resilience of species against climate scenarios.	Opportunity to build on CAR principles as the NT has done, and utilise more specific criteria to capture biodiversity values. Could be adapted for a national scale approach.	Connectivity is less relevant for the NT; however, criteria may need to be adapted to incorporate this into the method in order to meet the quality components of Target 3.

New South Wales

Governance

Relevant departments: Office of Environment and Heritage, NSW National Parks and Wildlife Service and Biodiversity Conservation Trust.

Boards: NSW has recently appointed a Nature Positive Advisory Panel to deliver on the new national and global targets for Australia to protect 30% of Australia's land by 2030.

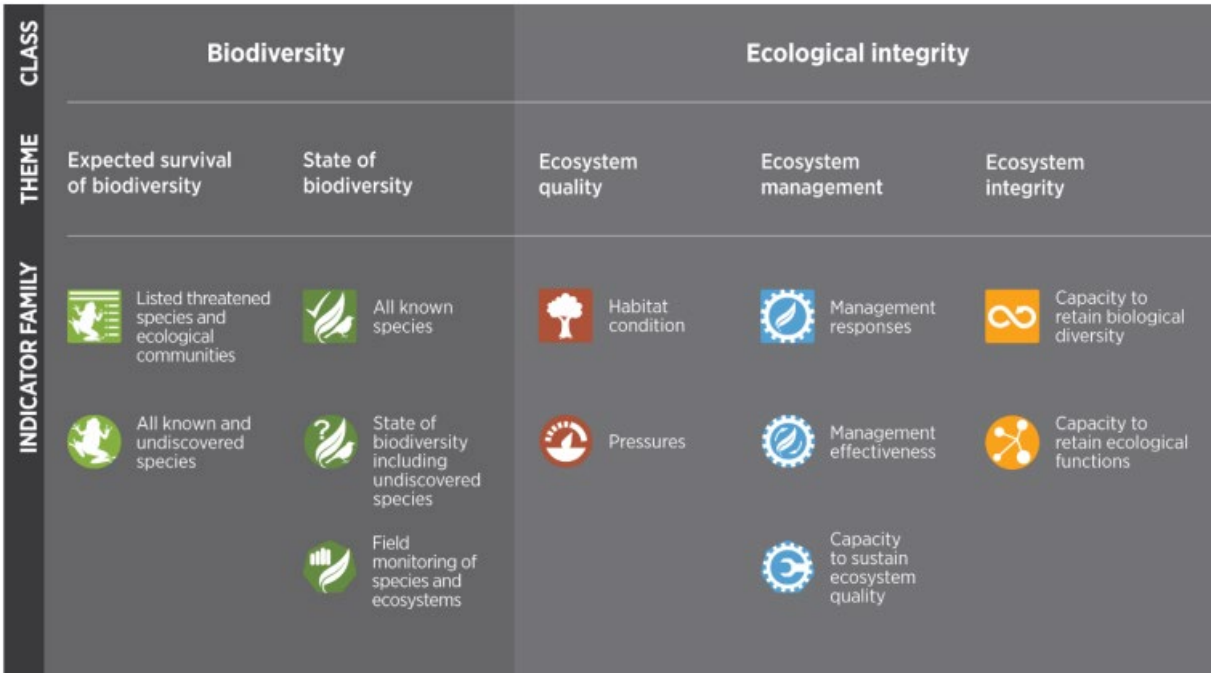
Policy landscape

Biodiversity Indicator Program

The Biodiversity Baseline Assessment is a mechanism for assessing and reporting on the status and trends in biodiversity and ecological integrity in NSW, as required by the *Biodiversity Conservation Act 2016*.

A series of indicators have been developed by the Office of Environment and Heritage and the Commonwealth Scientific and Industrial Research Organisation (CSIRO). The indicators are divided up into 5 main themes:

The **expected survival of biodiversity** indicators assesses threatened species and ecosystems in NSW (including those that are likely to be threatened but have not been formally assessed and listed by the Scientific Committee).
The **state of biodiversity** indicators takes a much broader view of biodiversity. It includes using models to measure the status of biodiversity as a whole, including species that are yet to be described.
The **ecosystem quality** indicators assess the condition of ecosystems, the habitats that plants and animals depend on, and the pressures that threaten biodiversity.
The **ecosystem management** indicators assess our management responses and their effectiveness in conserving biodiversity.
The final indicator theme, **ecosystem integrity** (OEH 2019), integrates the other indicators to measure ecosystems' ability to adapt to change (including climate change) and retain their biological diversity and functions into the future.



NSW indicator framework.

Method for identifying new reserve areas

New South Wales National Parks establishment plan 2008

This NSW National Park Establishment Plan (DECC 2008) utilises CAR principles to identify areas for protection on public land. It recognises the need to protect poorly reserved ecosystems, threatened species and habitats and to connect these areas to allow for the movement and dispersal of animals and plants. Other priorities include the allocation of land that improves reserve design (e.g. land that minimises harm to a park like a buffer) or essential water catchments and places containing geodiversity (caves, canyons or unique landforms). The plan also encourages the protection of culturally significant landscapes and places based on their heritage, aesthetic, scientific or social value.

Draft NSW National Parks System directions statement 2017

This statement (OEH 2017) offers updates on the *NSW National Parks establishment plan* (DECC 2008) and provides strategic guidance on land acquisition, community consultation and reporting. It discusses the importance of private land acquisition and landholder relations to maintain biodiversity. It is underpinned by the IBRA framework and was developed to meet national and international commitments of the day (e.g. the Aichi Targets).

The conservation priorities identified in the statement are:

- regional ecosystems that are poorly represented in the national parks system, to support and complement landscape conservation efforts and mechanisms such as the priority investment areas identified in the *Biodiversity conservation investment strategy* (DEH 2018)
- landscapes and places of special significance to Aboriginal people
- improve external boundary configurations or acquire inholdings of an existing park

- buffer parks from adjoining land uses that may be threatening park viability
- secure public access to existing parks
- support and complement the Saving our Species (SoS) program

A rewrite is currently underway. This is an election commitment of the current government. The revised plan will address contemporary challenges and opportunities, including:

- supporting the Australian Government's commitment to international targets under the GBF
- ensuring adequate sampling of all landscapes at the sub-regional level
- the NPWS zero-extinction target
- climate change resilience and adaptation.

Threatened species framework for zero extinctions

Managed by NSW National Parks and Wildlife Service (NPWS), the framework (NSW NPWS n.d.a) aims to improve or stabilise the on-park trajectory of all threatened species.

Measures being implemented to protect threatened species on national parks include:

- declaration of important threatened species habitat as Assets of Intergenerational Significance (AISs) (NSW NPWS n.d.b)
- acquisition of key threatened species habitat for addition to the national park estate
- establishment of a network of feral predator-free areas to support the return of more than 25 locally extinct species
- delivery of the largest feral animal control program in national park history
- establishment of a dedicated ecological risk unit to ensure threatened species are considered in new fire plans
- rolling out a world-class ecological health framework across national parks.

Private land

Biodiversity conservation investment strategy 2018

This strategy guides investment in private land conservation and was designed to complement the National Parks system. The 2022 target of the strategy aimed to have 30 NSW landscapes (based off IBRA subregions) in the protected area system. It is administered by the Biodiversity Conservation Trust.

Priority areas are identified on 4 criteria:

1. High environmental value – consists of areas that have threatened ecological communities, over-cleared vegetation types, threatened species habitats, wetlands, littoral rainforests or core koala habitat.
2. Connectivity and resilience to climate change – data such as extent of native vegetation with priority given to NSW landscapes that have been cleared by 70–90%.
3. Areas that contribute to CAR – dataset: 'Proportion of NSW Landscapes permanently protected in the protected area system', with the highest priority given to NSW

Landscapes that furthest from achieving 17% protection (in line with Aichi target 11) with this data set used as a surrogate for 'adequacy'.

4. Areas of Outstanding Biodiversity Value (AOBVs) – areas containing irreplaceable biodiversity values in NSW, Australia or globally. Criteria is based on the *Biodiversity Conservation Regulation 2017.*

Saving our Species 2016–21: more plants and animals to be saved from extinction

While out of date, this strategy (OEH 2016) represents the NSW's approach to reducing biodiversity decline. Its purpose is to do the minimum number of actions at a minimum number of sites to secure species or ecological communities for 100 years into the future. It is delivered under the *Biodiversity Conservation Act 2016* through the Biodiversity Conservation Program.

The program involves promoting private landholder agreements in areas that are priority sites for threatened species under the SoS program. The program also looked at ways to improve outcomes, such as monitoring, helping species adapt to climate change, and better managing threats.

It is common under the program to collaborate with other states on 'partnership species', which by definition means that less than 10% of the species occurs in NSW.

Methods

Identifying areas for acquisition within the national park estate under the *Directions statement*

1. CAR principles are applied across various scales – bioregions, sub-regions, landscapes and sub-landscapes to determine the most under-represented areas across the state.
2. Thematic conservation priorities are also considered;
    a. Threatened species are a key consideration, therefore, there is a focus on identifying endangered ecological communities that represent threatened species habitat.
    b. Cultural heritage is also a driver.
    c. There is also a focus on acquiring koala habitat due to the NSW Koala Strategy.
    d. Wetlands.
    e. Climate refugia.
3. Interviews also flagged that wildlife movement and the creation of relevant corridors will be a key consideration moving forward.

Conservation: Assets of Intergenerational Significance (within national parks only)

AISs were created after AOBVs (see next section) and represent any area of exceptional value – natural or cultural – that warrants special protection including dedicated management measures within the park's estate. This is managed under the *National Parks and Wildlife Act* 1974. The first tranche of AIS is intended to protect the most important habitat for threatened species.

Potential declarations of environmental AIS will be informed by a range of considerations including:

- sites for critically endangered, endangered or vulnerable species
- important areas for breeding, feeding or shelter
- locations where locally extinct mammal species are being reintroduced
- where the national park otherwise provides important habitat.

AISs are declared to bolster protections for an area with exceptional environmental or cultural values, like important habitat for the iconic Wollemi pine, koala and the greater bilby. For each threatened species AIS, NSW NPWS has a statutory obligation to prepare and implement a concise conservation action plan. Adopted conservation action plans are available here.

The AIS Interactive Map is available here.

Areas of Outstanding Biodiversity Value

AOBVs are special areas with irreplaceable biodiversity values that are important to the whole of NSW, Australia or globally. An area proposed as an AOBV must meet one or more of the criteria set out in the *Biodiversity Conservation Act 2016*, which is currently under review, and the *Biodiversity Conservation Regulation 2017*.

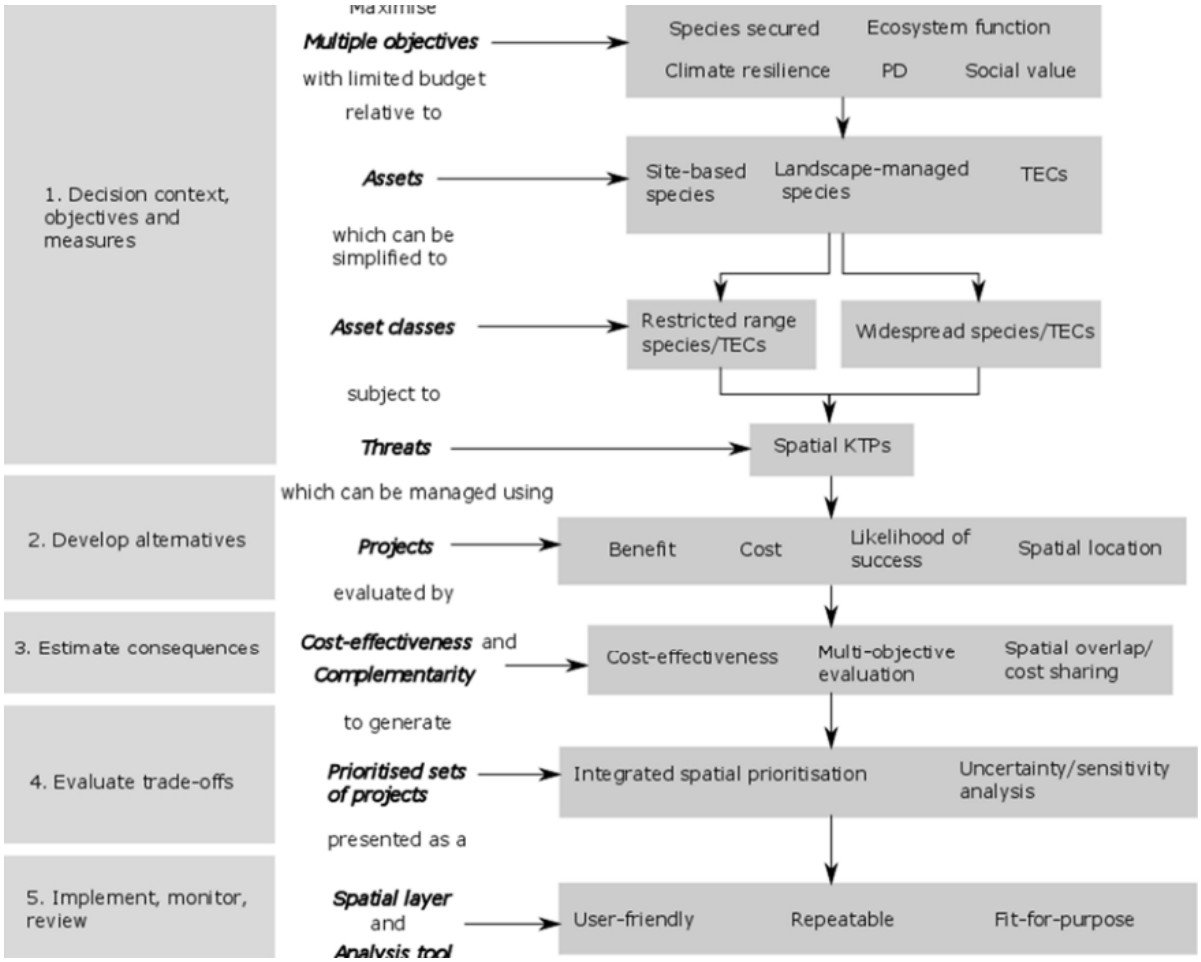
The criteria (DPIE 2021) were designed to identify the most valuable sites for biodiversity conservation in NSW, focusing on sites with highly distinctive biodiversity or features critical to the future survival of biodiversity in NSW. They include unique components of genetic diversity that enable species to adapt to changing environments, habitat critical for the survival of threatened species, or features that support species migration and dispersal.

Once an area has been declared, it will be shown on the Biodiversity Values Map. This map identifies land with high biodiversity value that is particularly sensitive to development and clearing impacts. Any development proposal located in an AOBV will trigger the Biodiversity Offsets Scheme. The proposal's impacts must then be assessed using the Biodiversity Assessment Method. If the impacts on the AOBV cannot be avoided, offsets and/or other mitigation measures may be required for the proposal to proceed.

The *Independent review of the Biodiversity Conservation Act 2016* revealed that the AOBV criteria will now be incorporated into a spatial tool that will be used to identify 'no-go' areas. However, it appears that the scheme will not be proceeding in its present form.

SoS prioritisation framework

Developed based on Hugh Possingham's work in New Zealand – the Optimal Allocation of Resources among Threatened Species work – the framework is an expert elicitation program that occurs species by species. Through that process, critical sites are identified (e.g. based on threats). This has been conducted for over 400 site-managed species in NSW. It is difficult to apply for threatened ecological communities that are widespread, and for mobile, dispersed species. A similar approach has been further applied for the landscape-managed species and compiled and integrated into a spatial prioritisation developed by the CSIRO (Chadès et al. 2019), which looks for complementarities in the landscape.



Summary of the optimisation tool developed by Chadès et al. (2019).

The optimisation tool can integrate the prioritisation of management actions for restricted range and widespread biodiversity assets, such as species or ecological communities. For any budget, the tool identifies which complete sets of management actions are the most efficient for maximising the number of species persisting. The tool does not enable species to be partially managed as this would risk a lack of security for the species. Hence if the asset has a restricted range, a set of pre-defined sites will be selected with location-specific, or 'site-based', actions. If the asset has a wide range, broad scale 'landscape' management actions are selected over an area of 2,700 km^2, as this area was found to approximate a persistence probability of 95%.

The method, however, does not have habitat requirements function; therefore, it is difficult to determine how much is needed for each species. For example, identifying the minimum amount of habitat a squirrel glider need in terms of thousands of hectares is a really difficult question. Rapid estimation and metapopulation persistence modelling is being developed to determine habitat suitability. The rapid estimation modelling also has a climate lens on it based on 2070 projections sourced from AdaptNSW.

Maps and data

- For the application of CAR, the department maintains their own reservation statistics at a sub-landscape level on an ongoing basis.

- Threatened species data is sourced from BioNet.
- Individual field assessments are conducted for land acquisition.
- There is also an ecological health program being established to track condition and threats for particular assets. Performance score cards will be developed for ecological health.
- Data for SoS is acquired mostly through expert elicitation.
- NSW has satellite imagery that has been used to develop various mapping products including;
    - Vegetation map of the entire state at regional scale – this replaced the regional approach. It includes 70,000 field records using cladistic methods. It includes pre-clearing extent (1750) and current extent.
    - Land clearing is also tracked through the Biodiversity Indicator Program. This demonstrates that the bioregions that have had the most clearing are also the most at risk of ecosystem collapse of looking at the threatened species retention curve.

Assessment table: method for identifying new reserve areas.

Criteria	Comment
Fit for purpose	
Efficiency	The efficiency of the method is dependent on the availability of high-quality data. If field surveys are required to fill gaps, it would affect the efficiency of the method.
Feasibility	There is a significant amount of knowledge and technology available to support the approach, with much of it focused on protecting threatened species.
Suitability	In some cases, for land acquisition, more data is gathered through field surveys.
Flexibility	Yes – there are a wide range of considerations, including climate refugia and cultural heritage, as well as information on Matters of National Environmental Significance, such as wetlands.
Compatibility	The *NSW National Parks establishment plan 2008* has evolved over the years to align with national and global biodiversity targets. It is being re-written and will likely align with the new targets. CAR principles are also utilised to scope under-represented landscapes. This aligns with other state and territory methods.
Scale	It is conducted at various scales – sub-regions, landscapes and sub-landscapes – to determine representativeness.
Responsiveness/ timeliness	Vegetation data is regularly updated and can be visualised in a timely manner. It is likely that BioNet information can also be updated and visualised as more information becomes available.
Inclusiveness	
Species diversity	Yes – given the approach is underpinned by CAR, species richness would be a consideration. Threatened species are also a thematic conservation priority.
Genetic diversity	Genetic information is available for some species, however, is not a key consideration under the *NSW National Parks establishment plan 2008*.
Ecosystem diversity	Yes – the *NSW National Parks establishment plan 2008* identifies the need to protect poorly reserved ecosystems. Other priorities include climate refugia and other buffer zones (e.g. caves, canyons, unique landforms).

Persistence	
Ecological integrity	Vegetation extent and condition are tracked within the reserve, while the Biodiversity Indicator Program does provide insight into how certain ecosystems will respond under climate change. Climate refugia for species is also a thematic conservation priority.
Species' persistence	The interviews indicate that wildlife movements and the creation of relevant corridors will be a consideration moving forward. Climate refugia is also a key consideration; however, this is likely not species specific, and is more general (e.g. caves).
Vulnerability/ threat	Species threats are tracked through the SoS Program, which is supported by the allocation of new land to the reserve network. There is also a commitment to improve the design of the reserve under the *Directions statement* to include buffer zones to minimise land use threats.
Climate resilience	Sites for vulnerable species and climate refugia are considerations within the *NSW National Parks establishment plan 2008*.
Uniqueness	
Uniqueness and irreplaceability	A site may be identified as unique with respect to endangered species, while another may be irreplaceable if it is the last of its kind, and not represented in the reserve network.

Assessment table: SoS Program.

Criteria	Comment
Fit for purpose	
Efficiency	Given the amount of expert elicitation required on a species-by-species basis, it is unlikely that this would be an effective tool. However, the prioritisation tool could be utilised to find complementarities along borders.
Feasibility	The CSIRO tool could likely be adapted.
Suitability	So far there is only information for 400 species.
Flexibility	The method only accommodates data from the SoS database.
Compatibility	The approach could be used to identify important sites for threatened species exclusively – including their relevant threats (e.g. climate). Does not consider other factors relevant for biodiversity. Compatible with IUCN criteria.
Scale	The method is done on a species-by-species basis.
Responsiveness/ timeliness	Resource intensive and time are concerns of this approach given the need for expert elicitation.
Inclusiveness	
Species diversity	The method considers richness of vulnerable species, as it is seeking the most cost-effective action.
Genetic diversity	Retaining genetic diversity is not yet accommodated due to data deficiencies. However, the method does identify whether a species is wide range or restricted range which could have an impact on genetic diversity.
Ecosystem diversity	The approach is unable to identify habitat requirements. Does not identify evolutionary processes or ecological communities present.
Persistence	
Ecological integrity	The approach does consider the climate resilience of species, but not on an ecosystem scale.

Species' persistence	The approach cannot determine habitat requirements, but it does consider climate resilience of species.
Vulnerability/ threats	Yes, the approach does consider the relevant threats for each species.
Climate resilience	Climate resilience of each species is considered using scenarios from AdaptNSW.
Uniqueness	
Uniqueness and irreplaceability	Not applicable.

Assessment table: Areas of Outstanding Biodiversity Value.

Criteria	Comment
Fit for Purpose	
Efficiency	Data can be acquired from existing, publicly available data sets (e.g. BioNet). However, the nomination process is time consuming. However, the new spatial tool will likely be very efficient.
Feasibility	Similar to KBAs, the process is designed to be objective, repeatable and transparent. There are also guidelines on how to apply the criteria, therefore it should be possible to upskill existing staff on the process.
Suitability	No sites have been declared AOBVs since the mechanism's inception.
Flexibility	Yes – due to the extensive criteria list, there are various data types that can be utilised.
Compatibility	Many of the criteria are based on the KBA approach, which is inbuilt within the CBD. It is also compatible with IUCN species data.
Scale	Yes – the approach considers data that is important for local, national or global importance.
Responsiveness/ timeliness	No – this approach, like KBAs, are based on a lengthy nomination process, and are not identified through the acquisition of new data.

Inclusiveness	
Species diversity	The method considers endemic and endangered species under criteria 3.1(3).
Genetic diversity	The method deals with genetic diversity from an adaptive approach. Areas will be safeguarded if they have unique components of genetic or phenotypic diversity that will enable species to adapt to changing environments (Criterion 3.1(2)). The approach also accounts for functional diversity, which includes the representation of functional traits (Criterion 3.1(3)).
Ecosystem diversity	Ecosystem diversity is protected under Criterion 3.1(4) – persistence of ecological processes, or ecological integrity and 3.1(3) persistence of biological distinctiveness.
Persistence	
Ecological integrity	Criterion 3.1(4) discusses the quality aspects of ecological integrity; areas that are identified as having intact ecological communities (or the best remaining examples) in which large-scale ecological processes continue to function are considered as AOBVs (3.1(4).
Species' persistence	The method has specific criteria for identifying areas critical to species persistence, including connectivity, which allows species to migrate in response to a changing environment (Criterion 3.1(2)). The method also highlights genetic diversity, which is essential for species persistence (Criterion 3.1(2)). The approach is flexible in terms of minimum size/configuration. Like KBAs, there is no minimum or maximum size. The configuration of an AOBV will be based on the ecological components that triggered the listing, and it will usually include a buffer zone to minimise impacts from surrounding areas.
Vulnerability/ threats	While there is discussion about including elements increase the likelihood of species persistence in response to climate change, the method itself does not identify threats.
Climate resilience	This approach does not capture the specific resilience of species; however, it does identify aspects that would increase their adaptive capacity, e.g. genetic diversity. Additionally, the method also aims to identify areas that offer refuge during climate events (Criterion 3.1(2)).
Uniqueness	
Uniqueness and irreplaceability	Irreplaceable biological distinctiveness is also considered under clause 3.1(3).

	Uniqueness is considered in relation to genetic or phenotypic diversity (clause 3.1(2)). Areas eligible for listing under clause 3.1(4)(a)(ii) represent the most intact remaining site of a species' occurrence that provides habitat features vital to the conservation of that species. Such areas have very high irreplaceability for NSW, national or global persistence of biodiversity.

Table: strengths, weaknesses, opportunities and threats.

Strengths	Weaknesses	Opportunities	Threats
National Parks and Assets of Intergenerational Significance			
Underpinned by CAR principles and is therefore aligned with other states, territories and the Commonwealth. Can be done on various scales. There is sufficient data available to not require additional field surveys for the purposes of this project. Strong consideration of climate adaptation of species and ecosystems. Includes reserve design principles which are important for persistence.	Connectivity not yet a priority. Largely focused on threatened species. Only applies for public land. Does not explicitly identify threats. Has different criteria from other NSW approaches, such as AOBVs. Inconsistent species data.	The current plan is being updated; therefore, it is likely that the new plan will align with the GBF. Opportunity to build alignment with the *Biodiversity conservation investment Strategy.*	
Saving our Species			
Complementary principles could be a valuable tool to identify sites. Strong consideration of species persistence under climate change.	Not fit for purpose, as it is focused on a species scale. Data deficiencies mean that genetic diversity of species is not captured. Does not identify habitat requirements for each species. More relevant for Target 4 of GBF.	Complementary principles could be a valuable tool to identify sites along borders.	

Areas of Outstanding Biodiversity Value			
Data is available from existing data sets. Repeatable and transparent approach. Compatible with the KBAs and IUCN criteria. Compatible with the indicators of the GBF. Addresses irreplaceability.	Time-consuming nomination process. Does not consider vulnerability and threats or specifically climate resilience. No sites have been identified in 7 years.	Could be a viable option to achieve Target 3, as it is compatible with indicators from the CBD. New spatial tool will streamline the process, improving efficiency.	The time required to develop the spatial tool may rule out this method due to the 2030 deadline.

Queensland

Governance

Relevant department: Department of Environment, Science and Innovation (DESI).

Policy landscape

Conserving nature – a biodiversity conservation strategy for Queensland

The overall vision for Queensland's parent biodiversity strategy is that 'nature is actively supported to thrive in Queensland' (State of Queensland 2022). Key initiatives for implementing the strategy are the Threatened Species Program to coordinate conservation efforts. Other strategies include *Queensland's protected area strategy 2020–2030* (see below) and the *South East Queensland koala conservation strategy 2020–2025*. The approach encourages a state-wide focus on adequate representation, connectivity, condition and extent across the landscape, and tenures will support protection and restoration at state, regional and local scales. It also lists habitat fragmentation as a key threat to biodiversity, encouraging the creation of corridors to support a functioning and resilient natural system. It also highlights the link between connectivity and climate change. Initiatives such as the Great Eastern Ranges Initiative focus on reconnecting critical parts of the landscape to improve their health and resilience. The Queensland Government supports private land managers to buffer and connect public protected areas through related programs, such as the Private Protected Area Program (State of Queensland 2024).

Queensland's protected area strategy 2020–2030

Queensland's protected area strategy 2020–2030 (DES 2020), guided by Traditional Owners, aims to enhance and maintain Queensland's protected areas. It complements other Queensland Government strategies and programs, including the *Conserving nature – a biodiversity conservation framework for Queensland*, the Threatened Species Program, *South East Queensland koala conservation strategy and Queensland's environmental offsets framework* to address this by supporting the protection and conservation of biodiversity in protected areas, and providing and managing significant habitat for threatened species. The relevant strategic objective for this project is 'Grow', which aims to expand Queensland's protected area system that safeguards biodiversity and cultural values, and protects threatened species. CAR principles underpin the strategy – it seeks to create a protected area system that protects samples of the biodiversity of all biogeographical regions of the state.

Methods

Method 1: Strategic Conservation Analysis (Regional Ecosystem and Priority Species Mapping)

The method compares land parcels by the proportion of each species or ecosystem threshold they contained and, hence, the potential value of a transaction (for targeting new protected areas) or the relative importance of the conservation portfolio (for existing protected areas).

- Regional Ecosystem Mapping – pre-clearing, and current extent (established in 2016)
- Priority Species Mapping (new) – 1,600 taxa are recorded – freshwater terrestrial, inland water and threatened species.
- MNES and other datasets.
- Cadastral and protected area datasets.

Species data:

- Three categories are used across the 3 data sets (Commonwealth's categories of confidence): known habitat, likely habitat and maybe habitat. Weighting is then applied to each of those: known = 1, likely = 0.5, maybe = 0.1.
- Each taxon (usually species but can be subspecies or population) is given a 'unit'. Of all the units, the map shows how a parcel of land on a plan contributes to any area of interest.
- This data is used by the private protected area and land acquisitions teams.
- Scale: regional ecosystems are smaller than ecoregions. It's based on vegetation and land class within a bioregion. It is used as a surrogate for comprehensiveness and adequacy.
- Limitation: priority areas likely to be different due to the revocation of data licence with the Commonwealth and sourcing of better species mapping and identification of conservation significant taxa over time.

Ecosystem data:

- Similar principles apply; however, better data exists than species. There is an adequacy threshold established in the *Vegetation Management Act 1999* (minimum of 30% per regional ecosystem). Once a threshold is set, then an ecosystem is the base unit in the same way a species is. All ecosystems are treated equally.
- A 'contribution metric' is applied to land parcels. So, if you contain an entire regional ecosystem in a parcel of land, you get 100% for the contribution metric (of the 30% threshold).
- There is also an 'irreplaceability metric', which is how much that contribution can come from that land parcel of land alone.
- There is also an 'urgency' metric applied, which looks at likelihood of land clearing (looks at the risk of land clearing, which is effectively how much what proportion has been cleared in the past combined with how under protected the regional ecosystem is – i.e. the proportion that's not protected). Does not consider climate.
- These factors give an indication of how important an acquisition or a new nature refuge might be.

Method 2: Biodiversity Assessment and Mapping Methodology

The Biodiversity Assessment and Mapping Methodology (BAMM) (DEHP 2014) is a scientific methodology utilised to evaluate biodiversity values at a landscape scale in Queensland. It offers a consistent approach to determine the conservation significance of terrestrial ecological values in a region, or bioregion, through a Biodiversity Planning Assessment (BPA). BPAs guide decision-making about appropriate land use for governments, members of the community, and landholders.

The BAMM consists of 2 stages. In the first stage, existing data is used to assess ecological concepts such as rarity, diversity, fragmentation, habitat condition, resilience, threats and

ecosystem processes in a uniform and reliable way across a bioregion. These criteria filter available data and provide an initial determination of significance generated through a geographic information system.

The second stage includes expert elicitation to identify features such as wildlife corridors and areas with special biodiversity value, such as centres of endemism or wildlife refugia. This stage also incorporates data that may not be uniformly available across the bioregion.

The overall biodiversity significance is a combination of the first and second stage values.

Maps and data

- Regional biodiversity network maps (DESI 2018) – the maps of regional biodiversity networks reveal regions that hold significant ecological value and should be protected from further habitat loss, fragmentation, and degradation. These maps serve as a valuable resource and have already been included in some regional land-use plans.
- WildNet (DESI 2024) supports Queensland's biodiversity and protected areas by providing important wildlife information that underpins conservation policies, programs and management responses. WildNet contains information on more than 21,000 species, including plants, fungi, mammals, birds, reptiles, amphibians, freshwater and cartilaginous fishes and select invertebrate groups, and includes:
    - wildlife information, including nomenclature, conservation statuses and notes about their distribution, habitat.
    - wildlife location records and associated ecological survey data
    - species lists for a range of Queensland area types, including reserves, local government areas and catchments
    - documents, images, maps, sounds, websites related to species and reserves
    - data source and project metadata.

Assessment table: Method 1 Strategic Conservation Analysis.

Criteria	Comment
Fit for purpose	
Efficiency	There are several data sources utilised, although only some of these are publicly available (e.g. Matters of National Environmental Significance data). Vegetation data is updated regularly as part of day-to-day operations, so there would not be additional cost. However, given the apparent data deficiencies for species (only 1,600 mapped), it could be costly to improve on this. Where there is strong efficiencies and equitability is across the weightings of both species and ecosystems = all are treated equally regardless of their status.
Feasibility	There is sufficient in-house knowledge to support this method.
Suitability	Somewhat. Species data deficiencies need to be overcome. Without it, all relevant information is lacking to appropriately identify important sites.
Flexibility	There are 2 methods under consideration – one for ecosystems and one for species (though Queensland uses the combined outcome of these methods). It accommodates both state-collected and Commonwealth data, and non-government organisation data (e.g. Atlas of Living Australia).
Compatibility	It is consistent with IBRA and CAR principles.
Scale	Regional ecosystems are vegetation communities in a bioregion that are consistently associated with a particular combination of geology, landform and soil (Sattler and Williams 1999, *Vegetation Management Act 1999*). It is IBRA based but is more refined.
Responsiveness/ timeliness	Yes. Datasets and maps can be generated on an as-needs basis for land acquisition, metrics are recalculated once or twice yearly, and new vegetation data is updated every 2 years and used for this purpose.
Inclusiveness	
Species diversity	Somewhat. Species data is still new. So far only 1,603 taxa records are utilised. It is likely that this will be expanded in the near future.
Genetic diversity	No – genetic diversity of populations is only indirectly incorporated where they have been identified and mapped separately because of their conservation significance (e.g. subspecies or disjunct populations).

Ecosystem diversity	The method has captured ecosystem diversity to a regional ecosystem scale and up to the identified threshold (minimum of 30% of pre-European extent).
Persistence	
Ecological integrity	Does not measure condition, only extent (satellite data).
Species' persistence	The method does not capture the adaptive capacity of species. Prior methods did, however, but were replaced in favour of a more CAR-focused approach (see 'Climate resilience' for further information). In addition, connectedness is considered but is not a primary focus for Queensland. In the interview, it was acknowledged that Queensland has some highly fragmented landscapes, and the reality is that you could only protect small parcels if you were to try to connect them. Restoration is a significant component of protecting these landscapes.
Vulnerability/ threats	In the future, Queensland is looking to consider sensitivity and exposure to threats (including climate). However, this is not yet available.
Climate resilience	NA. Queensland did operationalise a method between 2012 and 2016 that considered the adaptive capacity of 1,300 vertebrates. It was called the Landscape Resilience Program. It looked at scenarios between 2008 and 2080. The big issues uncovered by the approach was that you ended up with the same places that were already protected areas, e.g. the areas of high topographic relief close to the coast, e.g. Great Dividing Range, which is not where our biggest conservation issues are and, similarly, that approach is actually not helping those species most at risk from climate change.
Uniqueness	
Uniqueness and irreplaceability	Yes – irreplaceability of ecosystems is a key criterion of the Regional Ecosystems method.

Table: Strengths, weaknesses, opportunities, threats.

Strengths	Weaknesses	Opportunities	Threats
Equal weightings make the approach very efficient. Consistent with IBRA. Irreplaceability metric may mean it is consistent with KBAs.	Does not yet consider threats or climate resilience of species or ecosystems, impacting the persistence criteria. Only covers 1,600 taxa. Does not consider ecosystem condition. Does not consider genetic diversity. Connectedness is not a focus for Queensland.	To expand the species data to improve the outputs of the method, as well as potential threats to each (e.g. climate).	Very limited human resources, no succession plan.

Assessment table: Method 2 – Biodiversity Assessment and Mapping Methodology

Criteria	Comment
	Fit for purpose
Efficiency	This 2-step approach is likely time-consuming due to the requirement for an expert panel and collating the additional information they require to improve the accuracy of the 'first cut' map. The expert panel requires additional information to address their criteria; for example, for Criteria K, threatening processes, additional information on pests, weeds, soil erosion, salinity, etc, must be compiled to assist the experts in getting a rounded picture of vegetation condition.
Feasibility	There is capacity and technology in-house to deliver this method. However, data inconsistencies across each bioregion could impact the overall feasibility of the approach. For example, some of the bioregion data has not been updated since 2007 (e.g. Central Qld Coast and New England Tableland).
Suitability	Inconsistencies for data across each bioregion could impact the overall suitability of the approach. However, there are baseline data available to deliver the approach.

Flexibility	The approach considers a wide range of data types across each of the criteria: • Criteria A and H: records based upon georeferencing precision of ≤ 2,000 m and which are collected ≥ 1950 (flora) or 1975 (fauna) • Criterion B: regional and local assessments of significant ecological communities, such as wetlands, are used in assessment criteria for determining ecosystem value. • Criteria D and G: Cartography • Criterion E: Vegetation mapping by the Queensland Herbarium. • Criterion I: Considers data from Herbrecs, Corveg, WildNet, and Queensland Museum records. Expert panels can be provided with GIS-derived data sets for individual values such as endemic taxa, disjunct taxa and species richness, as well as the location of data gaps. • Criterion K: The condition of remnant vegetation is affected by threatening processes such as weeds, ferals, grazing and burning regime, selective timber harvesting/removal, salinity, soil erosion and climate change. Available data sets and information about these and related processes should be compiled to assist experts in evaluating vegetation condition.
Compatibility	The method is consistent with IBRA and IUCN Red List criteria.
Scale	Criteria has been developed so that the approach can be conducted at state, regional and local scales.
Responsiveness/ timeliness	Given the age of some datasets, and how intensive the expert consultation phase is, this does not seem like a timely or responsive process.
Inclusiveness	
Species diversity	Criteria A and H consider critical habitats for threatened species. Criterion F uses Simpson's Diversity Index (0–1) to highlight areas of high densities of regional ecosystems and ecotones. The expert panel also considers individual values, such as endemic taxa and species richness, under Criterion I (special biodiversity values).
Genetic diversity	Criterion H considers critical habitats for taxa beyond endangered species. This includes essential taxa for maintaining genetic diversity (such as complex spatial patterns of genetic variation, geographic range limits, and highly disjunct populations). Sub-criterion I(f) identifies species with lineages in Earth's evolutionary history, which could help preserve some evolutionary processes. However, this seems more species-focused.
Ecosystem diversity	

Persistence	
Ecological integrity	This approach considers extent (Criterion C), condition (Criterion E) and connection (Criteria G and J). In particular, the expert consultation involved with connectivity bolsters the approach.
Species' persistence	This approach considers extent (Criterion C), condition (Criterion E) and connection (Criteria G and J). There are established thresholds for tract sizes, ensuring sufficient habitat areas are established. Special biodiversity values under criteria I(b) consider wildlife refugia essential for adaptability. They also allow taxa to survive during extreme events such as drought, fire and, in the longer term, climate change. Criteria H and I(d) also consider fauna migratory ranges under key habitats.
Vulnerability/ threats	The approach under Criteria E (condition) and K (threatening processes) considers each bioregion's vulnerability and direct threats. These include weeds, feral animals, grazing and burning regimes, selective timber harvesting/removal, salinity, soil erosion and climate change.
Climate resilience	Criteria I(b) (wildlife refugia) and K (threatening processes) do consider areas that safeguard biodiversity and increase survival under climate change.
Uniqueness	
Uniqueness and irreplaceability	Criteria I – under special biodiversity values, the approach does consider wildlife refugia that are uncommon or do not occur elsewhere.

Table: Strengths, weaknesses, opportunities, threats

Strengths	Weaknesses	Opportunities	Threats
Can accommodate a wide range of data inputs and scales. Considers species diversity and species beyond threatened species.	The 2-step approach is time-consuming and is not responsive or timely. Mainly concerned about threatened species. Does not consider genetic diversity directly.		Data inconsistencies across bioregions, as well as poor maintenance (some have not been updated since 2007).

South Australia

Governance

Relevant department: Department for Environment and Water.

The Department for Environment and Water (DEW) is the primary state agency responsible for biodiversity in SA, encompassing policy and regulation, strategic planning and prioritisation, and delivery. DEW is directly responsible for the management of the state's protected area network.

The work of DEW is complemented by 9 regional landscape boards that have been established under the *Landscape South Australia Act 2019* to support sustainable natural resource management across entire landscapes. The *State landscape strategy* (Landscape South Australia 2020) outlines the priorities that are shared by each of the landscape boards. One key focus area is nature conservation and biodiversity, with the objective that 'biodiverse landscapes are protected, restored, enhanced and climate resilient'. The boards each have their own plans and priorities, and have been the primary delivery mechanism in SA for Australian Government investment under the National Landcare Program.

Policy landscape

The biodiversity policy landscape in SA is going through a period of major renewal, with several strategies and policies concluding and in the process of being replaced. New biodiversity legislation is also currently being developed (the SA *Biodiversity Act*). As such, the information captured below is more reflective of the historic policy landscape rather than the new directions.

Conserving nature: a strategy for establishing a system of protected areas in South Australia (2012–2020)

This is SA's formal protected area strategy (DENR 2012) – it is underpinned by CAR and a desire to create a resilient protected area system to cope with the changing climate. At the time, it also represented the state's commitment to the Aichi targets.

The vision of the strategy is to establish a comprehensive, adequate, representative and resilient protected area system on public, private and Aboriginal land that secures long-term conservation for the full range of SA's ecosystems, and protects places and sites of special value to people. To achieve its vision, the strategy sets 3 major objectives. These are to: (1) conserve the full range of ecosystems, (2) build the capacity of natural systems to adapt to climate change and other stressors, and (3) protect places of special meaning for people.

A replacement strategy is currently being drafted.

No species loss – a nature conservation strategy for South Australia (2007–2017)

This strategy (DEH 2007) represented the most formal approach to biodiversity conservation at a state-wide level and was delivered across government. It was a goal-based approach that considered landscape, ecosystem and species level of biological organisation, and was underpinned by an implementation plan and associated performance-based reporting.

NatureLinks (2003–13)

NatureLinks was an attempt to implement the Wilderness Society's 'WildCountry' philosophy and sought to foster government agencies, conservation organisations, landholders and local communities to work together to restore, connect, and sustainably manage natural systems and processes at landscape scales, using protected areas as the foundation stones.

Methods

CAR methods

The use of CAR principles and spatial metrics have been used for decades in SA as a basis for the selection of areas of conservation significance to legally protect (on both public and private land). These methods continue to be used and are reported as part of the state's environmental trend and condition report card processes. Along with clearance controls (the *Native Vegetation Act 1991*), this forms the 'coarse-filter' approach to conservation in SA.

Human industrial footprint and 'intactness' (wilderness) assessment

Another 'coarse-filter' approach that has been recently undertaken for SA is a wilderness assessment, combining a spatial representation of human industrial footprint along with a geographic approach to assessing intactness. The resulting work is to complement the CAR approach to reserve selection, with an emphasis on wilderness areas (Watson et al., 2023).

Threatened species and ecological community recovery

Threatened species and ecological community recovery programs and associated planning have also been operating in SA for decades. Although focussed on the conservation of specific species or ecological communities, these programs and their planning have often formed the basis for the identification of important areas for conservation and the impetus for formal protection (both on public and private land). This represents a 'fine-filter' approach to conservation in SA.

Landscape Assessment Framework (LAF) and Conservation Action Planning (CAP)

Complementing the CAR and threatened species/community approaches were regional approaches, such as the LAF and CAP. Although not consistently and comprehensively applied, they were implemented across much of the state. This was often undertaken in combination, where the LAF provided important analytical insights on conservation values and systemic conservation issues (focussing on systemic needs, rather than the more idiosyncratic requirements threatened species and communities) and the nature and location of required interventions, which were then integrated with other conservation issues through the CAP process. The LAF represents a 'meso-filter' approach to conservation, complementing the coarse-filter and fine-filter approaches.

New conservation planning and priority-setting approach

To provide a more consistent and comprehensive basis for conservation planning and prioritisation, recent analytical work has been completed across the SA agricultural zone. This work has been undertaken as a pilot, with the intent to roll out this process across the

entire state. This approach is seeking to bring together new analyses and trait-based information to set coarse-filter and meso-filter based conservation priorities, associated spatial planning information, and operationally relevant conservation and restoration insights.

This work undertakes new analyses and provides insights on:

- species:
    - abundance assessment
    - trend assessment
    - sensitivity assessment (to future change, including climate scenarios)
    - an overall assessment of conservation need
    - an assessment of habitat use and area requirements
    - collation of trait data on each species (e.g. diet and foraging requirements, life history parameters) to help inform management
- ecosystems:
    - definition of the different ecosystems of the state (including their biological composition and environmental drivers) and their spatial delineation (both extant occurrence and historic occurrence)
    - linkage between the Ecosystems of SA and the Global Ecosystem Typology, and the capture of relevant ecosystem dynamics from the Typology
- habitat patch and landscape assessments:
    - the importance of each habitat patch, potential restoration patch and landscape unit has then been calculated using a variety of 'irreplaceability' metrics. The multiple metrics provide insights for different taxonomic groups, different timeframes (where all biological records are used or just recent records), and whether any weighting is applied (such as how urgent the conservation needs of the species are)
    - additionally, at the landscape scale, an assessment is provided for which species have sufficient/insufficient amount of habitat within each landscape, as well as how much additional habitat would be require to maintain viable populations.

This combination of outputs is being used to inform:

- strategic planning and priority setting
- opportunistic planning and priority setting
- operations (such as landscape, ecosystem and species priorities, as well as patch-level assessments based on the needs of specific conservation values, to inform management and monitoring).

The bundle of methods being applied utilise a vast array of biological data (such as data from the Global Biodiversity Information Facility (GBIF), the SA Biological Survey Program, ALA, NGOs, research institutions and volunteers), physical environmental data, remote-sensing data, as well as future climate projections (including NARCliM 1.5).

Maps and data

- For the toolkit, threatened species assessment info has not been included. Instead, they are broad species categories – e.g. likely to be threatened, immediate concern,

things that we are likely to lose if we don't act (termed 'potential conservation concerns'.

SA Biological Survey Program includes data on vegetation and fauna condition, floristic vegetation maps, habitat and species distributions. Since then, research has been ad hoc.

- Wilderness data: following the March 2022 election, there was an election commitment to conduct a wilderness assessment to determine the extent of remaining large intact ecosystems and a climate refugia assessment to inform the extension of the protected area estate and create wildlife corridors that allow species to move and adapt to climate change. This was recently completed by The University of Queensland.
- Vascular Plant Biodiversity Hotspot Mapping 2016 SA (Guerin et al. 2016)

Table 2. Identified centres of plant biodiversity in South Australia.

Region	Biodiversity assets	Associated conservation issues
1.Western Kangaroo Island	1. Higher than expected GWE and GPE; 2. Concentrations of conservation-dependent species and categorical endemics; 3. High *species richness*	1. High fire frequency
2. Southern Mount Lofty Ranges	1. Higher than expected GWE and GPE; 2. Concentrations of conservation-dependent species; 3. High *species richness*	1. High levels of habitat fragmentation; 2. Many introduced species
3. APY lands (NW South Australia)	1. Higher than expected GWE and GPE	1. High fire frequency; altered fire regimes; 2. Management of Buffel Grass invasion
4. Southern Flinders Ranges	1. Concentrations of conservation-dependent species; 2. High *species richness*	1. High grazing disturbance levels; 2. High climate sensitivity
5. Southern Eyre Peninsula	1. Concentrations of conservation-dependent species and categorical endemics; 2. High *species richness*	1. High levels of habitat fragmentation; 2. Many introduced species
6. Lower South East	1. Higher than expected GWE and GPE; 2. Concentrations of conservation-dependent species (herbarium data)	1. High levels of habitat fragmentation

Identified centres of plant biodiversity in South Australia, from Guerin et al. (2016).

- NatureMaps provides a common access point to maps and geographic information about SA's natural resources in an interactive online mapping format. It includes datasets on:
    - flora and fauna
    - landscapes
    - soils
    - protected areas
    - wetlands
    - vegetation mapping
- SA Climate Ready is the most comprehensive set of downscaled climate projections data available in SA. Data is available for 6 climate variables (rainfall, temperature maximum, temperature minimum, areal potential evapotranspiration, solar radiation and vapour pressure deficit) using 2 emission scenarios (intermediate and high 'representative concentration pathways') through to 2100.
- AgInsight South Australia – an interactive website that offers a comprehensive range of agricultural mapping and economic data.

Relationships with other states

There is established data sharing with the eastern states due to the Murray–Darling Basin.

Assessment table

Criteria	Comment
Fit for purpose	
Efficiency	The toolkit is still being piloted, and there will likely be a cost to make it fit for purpose for Target 3. However, there is expertise in house to refine for the purposes of this project given how flexible it is.
Feasibility	Yes – SA is currently doing training internally within government to test the new conservation planning method.
Suitability	The methods require supplementary information from the Global Biodiversity Information Facility and the Atlas of Living Australia.
Flexibility	Yes – the data comes from multiple sources; however, it is an arduous process to clean the data (removing errors, biases and duplicates).
Compatibility	Species assessments undertaken are compatible with the IUCN, however it is not SA's intent to meet all the Red List criteria. Landscape assessments are done on an IBRA sub-region scale which would be compatible with other states and commonwealth.
Scale	State-wide
Responsiveness/ timeliness	The intention of the new approach being piloted is that it will serve as a planning tool. However, it is noted that patch-level assessments will be conducted on an as-needed basis to inform operations. That said, vegetation mapping has not been updated recently. Some of the data is still being sourced from the SA Biological Survey Program which ended in the early 2000s. Consistent and up-to-date data would be required to improve the timeliness of the response.
Inclusiveness	
Species diversity	The approach utilises occupancy models to identify spices richness and trends of vascular plants and vertebrates statewide. Trend assessments are also conducted which would detect both present and potential vulnerability of endangered species.
Genetic diversity	The new approach being piloted in SA does include the collation of trait data of each species (e.g. foraging requirements and life history) to inform management. Sensitivity and trend assessments are also conducted that would provide an indication of adaptive capacity.

Ecosystem diversity	Yes, the Ecosystems of SA has defined the different ecosystem types based on floristics, while the habitat patch and landscape assessments consider habitat requirements for each species to guide conservation planning.
Persistence	
Ecological integrity	Using the Rangeland Condition Assessment Tool, the new toolkit in SA will have an indication of land degradation overtime, giving an indication of vegetation cover and condition. Whilst not a leading consideration, the SA toolkit can identify connectivity when it is relevant.
Species' persistence	Yes, the approach considers this well. It examines the persistence of species under climate change to determine which species will be the most vulnerable, preferred habits and trade information.
Vulnerability/ threats	The method does display which species are vulnerable and where they occur. The Ecosystems of SA utilises predictive modelling to provide an understanding of environmental drivers that determine where ecosystems occur. The next step of the Ecosystems of SA project will involve forecasting based on water availability, landforms, soil condition and microclimate, as well as remote sensing information. This will likely provide insight into which ecosystems may be vulnerable, particularly to climate change.
Climate resilience	Sensitivity species assessments and the Ecosystems of SA project will provide insight into the climate resilience of each.
Uniqueness	
Uniqueness and irreplaceability	The approach utilises irreplaceability metrics for their habitat and landscape assessments. The multiple metrics provide insights for different taxonomic groups, different timeframes (where all biological records are used or just recent records), and whether any weighting is applied (such as how urgent the conservation needs of the species are).

Table: strengths, weaknesses, opportunities, threats

Strengths	Weaknesses	Opportunities	Threats
Flexible approach can be retrofitted for bespoke needs. Considers multiple data inputs, including global platforms. Very thorough analysis of species/species persistence. Training is ongoing; therefore, there would be materials that could be distributed.	The intensive process to clean and remove taxonomic ambiguity and duplicates. Connectivity is not a key consideration. Only considers vascular plants and vertebrates.	Given the intended flexibility of the approach it would be possible to utilise the tool to meet the objectives of Target 3.	SA no longer has a rolling program to collect biological data across the state. As such, new data is strongly driven by the focus of individual projects (which may be delivered through government, researchers, NGOs, industry or the community). As such, there may be issues with currency and coverage of data in some areas, undermining outputs veracity. The species analyses being undertaken are compatible with IUCN, but are not attempting to address all the Red List criteria as the focus is on holistic planning and prioritisation. The State has separate threatened species listing processes that follow the IUCN standards.

Tasmania

Governance

Relevant department: Department of Natural Resources and Environment Tasmania.

Policy landscape

Natural heritage strategy for Tasmania 2013–2030

The strategy (DPIPWE 2013) aims to improve conservation outcomes in Tasmania by implementing a landscape approach. A landscape approach is a systematic planning and management approach that integrates conservation management across land tenures and uses. This approach considers the environment and social, economic, and cultural factors.

Protected Areas on Private Land Program

The Protected Areas on Private Land Program (PAPL; DNRE n.d.) is linked to objective 2 of the *National Heritage Strategy for Tasmania*. PAPL was part of the National Reserve System Program, which recognised the important role private landowners play in efforts to conserve Tasmania's unique natural values. The aim of the PAPL program was to contribute to Tasmania and Australia's CAR reserve system by promoting and facilitating voluntary Conservation Covenants between the Tasmanian Government and landowners with important natural values on their properties. Natural values of interest included under-reserved vegetation communities, freshwater values, threatened species and geoconservation areas.

Formerly this project utilised the JANIS criteria. Now the program is used to look at specific conservation priorities (e.g. swift parrot habitat).

Method

Tasmania has developed a tool that identifies areas with biodiversity value.

Conservation Information System

While the Conservation Information System (CIS) has not yet been used to expand the reserve network, there are layers relevant to biodiversity. The CIS establishes a simple mechanism to organise, analyse, and provide access to spatial data layers, which are central to conservation planning.

There are vegetation layers, including unreserved communities in the Tasmanian Reserve system and ones that are a priority for reservation based on the JANIS criteria. Also included is the distinctiveness of areas for threatened and common plants; therefore, there's an irreplaceability component. There is also a layer for biogeographic distinctiveness and very tall forests not included in the World Heritage Area.

Further details of the CIS layers are outlined in the assessment table below.

Maps and data

- Tasmania does not have information on vegetation condition.
- TASVeg is updated when sufficient new data warrants it. The map depicts the extent of more than 150 vegetation communities, including coastal heathlands, eucalypt forest and alpine communities.
- Natural Values Atlas contains species point information on 20,000 species from Tasmania and Australia, showing their location and extent. Observations are done on an ad-hoc basis. The system is often used for environmental impact assessments.
- There is also information on significant geodiversity conservation sites that are listed in the Tasmanian Geoconservation Database.

Tasmanian Reserve Estate spatial layer provides the mapped extent of the reserve system in Tasmania. This reserve system extends over land, inland waters, estuaries and marine areas. The layer provides a spatial representation of Tasmania's Reserve Estate for use as the authoritative source of information on the extent, type and distribution of the CAR reserve system in Tasmania. The layer is generally created with an as-at date of the end of each financial year. It is available at the end of November following the as-at date. The 2023 report is available here. The Tasmanian Reserve Estate spatial layer as at 30 June 2022 indicates a total reserved area of 3,622,200 hectares, including formal and informal reserves on public land, private land, and in marine protected areas.

- ListMap – includes MNES information, reserve boundaries, topographic information, climate information and plant and animal distributions.

Assessment table – CIS tool

Criteria	Comment
Fit-for-Purpose	
Efficiency	Yes – this tool would be an efficient, cost-effective way to quickly provide an indication of important sites.
Feasibility	Yes – The tool itself is intuitive, and there is online information about weights, etc.
Suitability	May require more information, such as condition.
Flexibility	Likely that it could accommodate additional spatial layers.
Compatibility	Utilises the IUCN criteria for species and ecosystems, therefore would be compatible for global reporting methods.
Scale	Coarse scale compared to the Natural Values Atlas.
Responsiveness/ timeliness	Yes – new information can be updated and visualised in the system.
Inclusiveness	
Species diversity	The biogeographic distinctiveness layer considers endemic plants, and the conservation and reservation status of the community's layer considers threatened vegetation. Does not contain information on fauna or species richness.
Genetic diversity	Does not consider genetic diversity.
Ecosystem diversity	The approach does consider the representativeness of vegetation communities and identifies areas of biogeographic distinctiveness. Therefore, the tool may pick up on ecological and evolutionary processes indirectly.
Persistence	
Ecological integrity	The method does consider TasVeg information, which covers vegetation extent. Condition, however, is not tracked. There is climate modelling occurring on ListMap, but the function is not within CIS yet.
Species' persistence	The method contains information on fire and disease refugia, as well as important bird habitats, both of which are important for persistence. Climate change is not a direct consideration, and habitat is only limited to bird species.

Vulnerability/ threats	Fire and disease are 2 considerations. Weeds and other introduced species are tracked on the Natural Values Atlas.
Climate resilience	Not a direct consideration.
Uniqueness	
Uniqueness and irreplaceability	Sub-layers of CIS do include irreplaceability considerations. For example, the focus on distinctiveness does show a consideration of uniqueness and irreplaceability is shown in the Very Tall Forests in the World Heritage Area layer.

Table: strengths, weaknesses, opportunities, threats

Strengths	Weaknesses	Opportunities	Threats
They utilise the Common Assessment Method, so there is harmonisation in species listing with the Commonwealth. Utilises the IUCN Red List criteria. Therefore, it is consistent with IUCN and aligns with GBF indicators. The focus on distinctiveness does mean some degree of uniqueness and irreplaceability is considered.	Species information is only species point information and does not include distribution models or preferred habitat. More significant consideration of climate change is needed to improve persistence scoring. Only considers habitat for bird species. Does not track condition.	To build on the CIS tool to provide indicator sites for areas important for biodiversity.	The approach relies on biodiversity indicators and does not capture essential biodiversity considerations, such as species' genetic diversity

Victoria

Governance

Relevant department: Department of Energy, Environment and Climate Action.

Policy landscape

Protecting Victoria's environment – biodiversity 2037

Biodiversity 2037 (DELWP 2017) is Victoria's long-term strategy for biodiversity, with a vision that 'Victoria's biodiversity is healthy, valued and actively cared for'. The state's environmental agenda comprises of social awareness, environmental protection and improved management. The plan aims to create alignment across government, business, communities, Traditional Owners and private land managers to restore biodiversity. It was developed to address both national and international obligations, including the CBD and the national conservation strategy. It also complements the Sustainable Development Goals, which includes improving biodiversity conservation on land and in water environments.

Methods

Spatial products and methods that inform conservation planning in Victoria

Victoria has developed a suite of products that identify areas with biodiversity value.

Strategic Biodiversity Values

The Strategic Biodiversity Values (DELWP 2018a) map combines maps of habitat suitability for threatened flora and fauna with information on vegetation types and conditions to show the relative value of landscapes in Victoria. This can help identify priority areas for protection.

- inputs: Habitat Distribution Models (HDMs) (optionally Vegetation Type, Vegetation Condition, Recent Disturbance)
- method: Zonation Conservation Planning Tool (Core Area Zonation)
- interpretation: ranks areas by their relative contribution to the provision of habitat for all native species and all vegetation communities in Victoria
- uses: Biodiversity values assessments, impact assessments.

Status: last released in 2017 at 225-m resolution (only for threatened vertebrate, vascular flora and full range of native vegetation).

Protection Priority Rank

This is an extension of Strategic Biodiversity Values analysis that ranks areas based on the principle of complementarity. A high-ranking area would complement the existing conservation reserve based on CAR objectives. Pre-existing and unavailable sites are not included.

- inputs: HDMs, Land Tenure
- method: Zonation Conservation Planning tool, with protected areas masked in
- uses: planning – prioritising new areas for conservation protection.

Status: not yet released.

Strategic Management Prospects

Strategic Management Prospects (SMP) (DELWP 2018b) is a comprehensive tool for assessing the relative benefits and cost-effectiveness of landscape-scale conservation actions (priority threat management). It ranks location-specific actions based on their cost-effective contribution to state-wide conservation objectives.

SMP is a raster-based, landscape-scale, spatial conservation planning tool developed for Victoria, integrating heterogeneity of landscapes, species distributions, threats and management costs and benefits across the state. Empirical data was used to establish current and pre-European distributions for 4,400 native terrestrial species. There are also spatially detailed models for 19 threats to biodiversity. To determine the anticipated benefits to species and the associated implementation costs of 17 different management actions, both individually and in combination, Victoria employed structured expert-elicitation techniques and machine learning. These actions were then prioritised based on their cost-effective contribution towards minimising the risk of species loss over 50 years. This was achieved through a modified adaptation of the Zonation conservation planning framework (Thomson et al. 2020).

A more detailed summary of the method is available here (Thomson et al. 2020).

- inputs: HDMs, Threat Layers, expert-elicited threat impact, expert-elicited action benefits, action cost layers
- uses: planning and assessing biodiversity management programs, prioritising conservation actions.

Status: Version 4.0 released in 2023.

Native Vegetation Condition

This modelling represents the fine-scale condition of Victoria's terrestrial ecosystems based on field data and Habitat Hectares benchmarks.

Bioregional Conservation Status of Ecological Vegetation Class (EVC)

The combination of EVC and bioregion is used to determine the bioregional conservation status (BCS) of an EVC (DEECA n.d.). This is a measure of the current extent and quality for each EVC, when compared to its original (pre-1750) extent and condition. Mapped BioEVCs will have a BCS of endangered, vulnerable, depleted, least concern or rare.

Rarity-Weighted Richness (RWR)

Rarity-weighted richness is the sum of species-specific proportional habitat values within a pixel or planning unit (multiple pixels). Proportional habitat value is the proportion of the total (modelled) habitat area for a species that occurs within a given area. At a pixel scale, RWR is essentially a measure of weighted local richness, where greater weight is given to species with narrower distributions (areas with more endemic species will generally have higher RWR values). RWR values increase with area – a larger area will contain more species, and a greater proportion of each individual species total habitat, than a small area. RWR is

mathematically equivalent to the effective number of full habitat extents contained within an area.

- inputs: HDMs (optionally Vegetation Condition)
- method: aster calculation
- uses: biodiversity values assessments, impact assessments

Status: not yet released.

Rarity-Weighted Risk (RWRisk)

HDMs are modified by threat layers and expert-elicited species-specific vulnerabilities to those threats, producing modified HDMs that reflect the relative likelihood of species persistence (for 50 years) at a location assuming no threat management (DoNothing persistence). The difference between the current HDM and HDMDoNothing is a measure of the local habitat value at risk from known threats, which can be expressed as a proportion of the total current habitat at risk, or proportional risk, PropRisk = (HDM-HDMDoNothing-)/sumHDM. The sum of PropRisk values across all species is a measure of the relative biodiversity value at risk from all known threats at a location (or a projected loss of weighted, local species richness, where the weights are proportional to rarity).

- inputs: HDMs, threat layers, expert-elicited threat impacts
- method: raster calculation
- uses: provides an overview of where significant biodiversity values are most at risk from known threats (including climate change).

Status: not yet released.

Maps and data

SMP data is available publicly via NatureKit. It shows which actions in what locations will be the most cost effective and beneficial to most species. However, the models that inform the method have not been refreshed since 2014.

Information from the *Victorian biodiversity atlas* (DEECA 2024) informs HDMs that feed into SMP.

The *Biodiversity knowledge framework* is a mechanism for prioritising where there are gaps or uncertainties in knowledge and where investment is needed in research.

Relationships with other states

Data-sharing relationships exist with NSW and SA of quadrats to inform models about the full range of species. There is also sharing of data for feral species, such as pig control. The bushfires also represented the best example of established data sharing.

Assessment table: Victoria's spatial products and methods

Criteria	Comment
Fit-for-purpose	
Efficiency	Removing cost-effectiveness weighting may mean SMP can identify important areas for biodiversity.
Feasibility	There are sufficient online resources and existing knowledge to support the method and use of spatial products.
Suitability	There is sufficient data to support this approach,
Flexibility	There are specific input requirements, such as habitat distribution models, that are required for these tools to function.
Compatibility	This approach is unique to Victoria.
Scale	Bioregional EVCs are the standard unit for classifying vegetation types in Victoria. Strategic Biodiversity Values mapping was last done at 225-m resolution.
Responsiveness/ timeliness	The models work on a continuous improvement format and can be updated as information is added to NatureKit.
Inclusiveness	
Species diversity	Habitat distribution models used in Victoria cover endangered species present. Newer tools yet to be rolled out consider species richness and indirectly address areas with rare endemic species (RAR).
Genetic diversity	Genetic information is not considered across the spatial products and methods.
Ecosystem diversity	There is consideration of suitable habitat for threatened vertebrates, vascular flora and a full range of native vegetation, which would likely encompass a wide array of ecosystems and vegetation communities. Complementarity is also employed under PPR, which would capture unprotected ecosystem types.
Persistence	
Ecological integrity	Change in Suitable Habitat considers the type, extent, and configuration of a species' habitat. Vegetation condition and extent are considered within SMP. Landcover is also tracked on NatureKit. There is also modelling for natural vegetation conditions for Victoria's terrestrial ecosystems.

Species' persistence	Under RWRisk, HDMs are modified by threat layers and expert-elicited species-specific vulnerabilities to those threats, producing modified HDMs that reflect the relative likelihood of species persistence (for 50 years) at a location assuming no threat management (Do Nothing persistence). Change in suitable habitat is tracked in Victoria for priority species – important for long-term survival under climate change. Does not consider the genetics of key populations. The extent and condition of vegetation are, however, tracked.
Vulnerability/ threats	Threat and environmental models are used to track potential threats such as pest species and climate change.
Climate resilience	Change in Suitable Habitat is designed around the premise of selecting actions that will improve the resilience of species against climate change. The method does not focus on ecosystems, mostly on species survival.
Uniqueness	
Uniqueness and irreplaceability	The emerging RAR and RWRisk tools address rarity in relation to persistence and richness of species. Therefore, there is some consideration of irreplaceability (given risk of species loss).

Table: strengths, weaknesses, opportunities, threats

Strengths	Weaknesses	Opportunities	Threats
Can be easily updated and visualised. Strong focus on habitat and climate resilience which are both paramount for the persistence of threatened species.	There are data gaps across invertebrates and nonvascular plants.	There is an opportunity to incorporate joint distribution modelling within the method to cover ecosystem considerations.	Not dynamic enough – does not account for recently lost habitat.

Western Australia

Governance

Relevant department: Department of Biodiversity, Conservation and Attractions.

Policy landscape and methods

The following strategies underpin WA's method for identifying new areas for the reserve network:

WA has a *Forest management plan 2024-2033* **(**CPC 2023) for the conservation reserve system for forests that aims to protect the Southwest Forests – a dedicated biodiversity hotspot. CAR criteria and wilderness and old growth values underpin the strategy's method.

- *A 100-year biodiversity conservation strategy for Western Australia (2006)* draft (DEC 2006) advocates consolidating a terrestrial and marine conservation reserve system that meets the CAR criteria and contributes to ecosystem resilience and continental-scale connectivity.

Plan for our parks (DBCA 2023), which aims to increase the protected reserve system to 20% by 2024 and fill identified gaps in the bioregional network in WA. There were also overlays of the state of priority species and threatened species to select which locations.

Maps and data

- The Dandjoo biodiversity data repository is new. Only contains species related data mapped, not communities. More to be released soon.
- There are varying scales of wetland mapping across the state. It could be used as a tool for identifying important areas in WA.
- Data for information new reserve areas is derived from internal data, which includes Native Title data. This is mostly done on a bioregional scale to identify gaps.
- Data on vegetation communities and assemblages are mapped internally.
- Data around mining and other elements are also considered when designing the protected area network so that there is an understanding of where the challenges are in creating these areas.
- WA utilises the Common Assessment Method to align threatened species lists with the Commonwealth. However, ecological communities are not yet aligned with the Commonwealth.

Relationships with other states

- Utilises the Common Assessment Method – therefore is consistent with the IUCN Red List and Commonwealth data on a species front.
- There is collaborative planning for fire management across jurisdictions.

Assessment table

Criteria	Comment
Fit for purpose	
Efficiency	The method is underpinned by CAR principles which is aligned with both the Commonwealth and other states. Therefore, it is likely to be an efficient method. However, there are widespread data gaps across the state, and additional considerations, such as mining considerations, that may impact the methods efficiency.
Feasibility	There are the skills within WA and the Commonwealth to support this method.
Suitability	Yes. However, further research would be needed to overcome data gaps across the state.
Flexibility	Able to accommodate state and Commonwealth data.
Compatibility	It is compatible with the NRS.
Scale	Operating at a bioregional scale is easier at a national level. However, there are data deficient areas within the state. Studies of IBRA have shown that our understanding of biodiversity at a bioregional scale is patchy, even for well-studied taxa.
Responsiveness/ timeliness	Data is updated as it becomes available.
Inclusiveness	
Species diversity	The method does consider whether the species is represented within the reserve network.
Genetic diversity	Genetic data is a consideration where the data is available.
Ecosystem diversity	The method considers the representativeness of bioregions using CAR; therefore, ecosystem diversity is a consideration at a high scale.
Persistence	
Ecological integrity	Initial gap analysis does not consider ecological integrity; however, the secondary step of looking at vegetation communities and other assemblages would consider this. There are also habitat considerations. Connectivity does not seem to be at the forefront of the WA method; however, the team does acknowledge that connectivity is critical.

Species persistence	Yes. The secondary stage of the approach considers critical habitat, connectivity, threatened species represented in the reserve etc. This can inform land acquisition for the reserve.
Vulnerability/ threats	Not applicable.
Climate resilience	Not applicable.
Uniqueness	
Uniqueness and irreplaceability	The secondary step of the approach does consider uniqueness, by examining the rarity of species and whether the area contains vulnerable plants and animals.

Table: strengths, weaknesses, opportunities, threats

Strengths	Weaknesses	Opportunities	Threats
Consistent with Commonwealth approach (IBRA), and likely would align with other states.	Vegetation communities classed differently to Commonwealth. Currently the protected area system in WA is heavily fragmented. This demonstrates that connectivity is secondary to other conservation priorities. There are data deficiencies within certain parts of the state which inhibits the ability to accurately capture biodiversity complexity – especially at a bioregional scale. Does not consider irreplaceability.	Opportunity now to embed connectivity as a core principle in the NRS.	

Appendix 3. Detailed results of the methods used by jurisdictions

Criterion 1: fit for purpose

Efficiency

What is the relative cost of the approach compared to others (considering data acquisition, processing and mapping)? What is the degree of efficiency of this approach compared to the others?

Efficient methods are utilised in Tasmania, the ACT, Queensland and WA. Victoria's Strategic Management Prospects (SMP) method could be used to identify sites important for biodiversity by removing the cost-effectiveness weightings. New tools that will soon be released are expected to enhance further the ability to identify sites important for biodiversity in the state. NSW's method for identifying new areas for the protected estate is efficient if data is available. However, field surveys may be required in areas where data is lacking. In NSW, the nomination process for AOBVs and the expert elicitation requirements of the SoS Program limit the efficiency of those methods. Nevertheless, the yet-to-be-developed AOBV spatial tool could be valuable and improve that method's efficiency. Although the NT method is efficient, the interviews revealed that it had not been rolled out due to resource constraints, raising concerns about its cost effectiveness. SA program is adaptable and can be tailored to meet the requirements of various programs and projects. Once a project's requirements are defined, the available tools could be used to meet the requirements of Target 3.

Feasibility

Is the capacity, technology or expertise available to use this approach, or can it be reasonably developed through training?

Most methods can be run in-house, or there is an existing knowledge base to develop those skills. The AOBV is the only method yet to be conducted in-house; currently, it is a public nomination process. This will change in the future as the spatial tool is developed.

Suitability

Can this approach be undertaken with the data available?

The methods employed in Victoria and the ACT are well supported by available data. Tasmania's CIS tool may require more information, such as vegetation condition. Data gaps in the NT and Queensland could handicap the methods and skew the results in favour of specific locations, such as the habitat for shorebirds in the NT. Data availability varies across NSW, with significant gaps existing throughout the state. As such, the effectiveness of AOBVs and NSW NPWS' methods depends on the area. If applied statewide, the results may be skewed towards data-rich regions. On the other hand, the SoS Program has collected information for threatened species and identified sites for site managed species

and broader regions for other Management Stream,s thus matching management to species needs at a state-wide level. SA supplements their data gaps by using information from the GBIF and ALA. Further research is needed to address data gaps across WA.

Flexibility

Is the approach able to accommodate different data types?

The NT's method is adaptable and can incorporate data from various sources (e.g. internal and external ones such as the ALA). Similarly, Queensland is also flexible, using data from organisations such as ALA and the Australian Government, as well as state-based data. Tasmania's CIS tool can be customised to include additional spatial layers based on specific requirements. On the other hand, some states, like Victoria, have specific input requirements, such as HDMs, that must be included for their spatial tools to function. In contrast, NSW NPWS and AOBV methods are comparatively more flexible, with various criteria and priorities considered. However, NSW's SoS Program solely relies on data from the SoS database. SA's tools can accommodate data from multiple sources, including GBIF; however, an extensive process is required to eliminate errors, biases, and duplicates.

Compatibility

Is the approach compatible with other data sources, mapping approaches or reporting requirements (e.g. the Post-2020 GBF)?

States have aligned with various national and global priorities to different extents. Across multiple states, the CAR principles were a recurring theme, with the 'representative' aspect aligning well with some of the qualitative components of the GBF. Queensland and WA's methods are compatible with CAR principles and IBRA regions, while SA assesses landscapes on the scale of IBRA sub-regions. The NSW NPWS method scopes potential areas for national parks using CAR principles. A new strategy aligned with the new GBF targets is also in development. ACT's *Nature conservation strategy* and threatened ecosystem approach strongly align with the CAR principles and the EPBC Act.

Most states align with the IUCN's KBA criteria. NSW's AOBV method is a close adaptation of the IUCN criteria. The NT, Tasmania, Victoria and NSW SoS's programs also have information that could be utilised if a KBA method was employed nationally. Queensland does not have data that aligns with the first 4 KBA criteria; however, it does have information available to conduct an irreplaceability score across the state, consistent with KBA criterion 5. While ACT does not align with KBA scorings, they have used the IUCN's guidelines on connectivity when developing the *Caring for Dhawura Ngunnawal plan*, which delivers on the connectivity quality component of the GBF. Species assessments in SA are IUCN compliant; however, does not meet all of the Red List criteria.

ACT, NT and the NSW NPWS method also consider OUV areas and Ramsar wetlands. All states except NSW have the data to support the identification of biodiversity hotspots.

Scale

Can the approach be applied at different scales (e.g. globally, nationally and regionally)?

Most of the methods have the potential to be utilised nationwide. Victoria, Queensland and WA are aligned with the NRS and can be implemented at a bioregional scale. ACT, NSW NPWS and the NT's methods could be applied at the national and jurisdictional levels. AOBV's criteria allow for the incorporation of local, national and global data and, therefore, could be utilised in a nationally consistent way. Tasmania has access to coarse-scale mapping available through the CIS tool, which could be used for a state-wide perspective. SA's new method is being trialled regionally, but will be able to show a statewide perspective.

Timeliness

Timeliness relates to the speed in which information can be acquired, processed and visualised. It also reflects the timeliness of data acquisition and updating systems. Can this approach capture and visualise data in a timely manner as new information becomes available?

Victoria, Queensland, Tasmania and NSW NPWS regularly update the data used in their methods. Victoria has a continuous improvement process for their maps and updates them with new information. Tasmania updates its CIS when new data becomes available. Similarly, WA updates its maps when new data is acquired. In NSW, vegetation data is updated regularly and can be visualised promptly, while Queensland's data is updated every 2 years.

However, ACT's vegetation data is updated only once every 10 years. Updating the data for NSW's SoS method, SA and NT would require significant resources and time, as much of that information needs to be updated.

Criterion 2: inclusiveness

Species diversity

Includes species richness, endangered species present, endemic species present.

Conservation efforts across Australia are primarily focused on identifying and preserving areas where endangered and threatened species exist. This is a key conservation priority of Victoria, Queensland, NSW, ACT and NT. Victoria's HDMs consider the presence of threatened species. All NSW methods prioritise the preservation of threatened species, with supporting criteria around species richness of vulnerable species under AOBV and SoS. By 2012, the ACT had captured all the threatened species within its reserve network at the bioregional scale. WA, like the ACT, operates using CAR principles and works to ensure that all threatened species are represented in the reserve network.

The NT's methods consider all aspects of species diversity, including concentrations of threatened species, endemic species and wildlife aggregations. Tasmania's CIS tool does

not contain information about species richness. However, the biogeographic distinctiveness layer considers endemic plants.

Priority species mapping in Queensland is relatively new and considers only 1,600 taxa, including freshwater terrestrial and threatened species. It is expected that this list will be updated and expanded over time. SA's toolkit can identify areas of occupancy and, therefore, can identify species richness. The method also considers species' preferences for habitat and future habitats based on future projections. However, it is important to note that this method only considers vascular plants and vertebrates.

Finally, soon-to-be-released tools in Victoria will also take into account species richness and identify areas with rare endemic species.

Genetic diversity

The range of traits within a species within the area; adaptive capacity of the species.

SA, WA and NSW's AOBV method and SoS program are the only ones that take genetic diversity into account. The AOBV method has criteria that address genetic diversity specifically. On the other hand, the SoS method does not directly address it, but it does identify the species that are restricted to a specific range, which may affect genetic diversity. As for WA, they will consider genetic diversity if the necessary data is available. The new approach being piloted in SA does include the collation of trait data of each species (e.g. foraging requirements, life history) to inform management. Sensitivity and trend assessments are also conducted that would provide an indication of adaptive capacity.

Ecosystem diversity

The variety of habitats, communities, ecological and evolutionary processes present.

CAR principles underpin many of the state and territory methods when identifying areas that are important for biodiversity. Tasmania has focused on this with its CIS tool, which considers the representativeness of vegetation communities and identifies areas of biogeographic distinctiveness. Therefore, the tool may indirectly pick up on ecological and evolutionary processes. The ACT also considers the representativeness of ecosystems at a bioregional scale. NSW also considers under-represented ecosystems in their National Parks reserve.

The use of CAR principles and spatial metrics have been used for decades in SA as a basis for the selection of areas of conservation significance to legally protect (on both public and private land). SA has also undertaken an 'intactness' assessment to complement the CAR approach to reserve selection. This will inherently protect ecological and evolutionary processes present. SA has also defined ecosystem types based on floristics through the Ecosystems of South Australia project. The Landscape Assessment guides conservation planning by considering each species' habitat requirements.

The NT's new method focuses on the comprehensiveness of the reserve network. There are also criteria that consider the types of vegetation represented and sole vegetation types included, which infers a greater diversity of habitats. WA also uses CAR principles, focusing on the representativeness of bioregions in the state reserve.

Queensland also uses CAR principles, emphasising adequacy (a minimum of 30% of each regional ecosystem must be protected). For each land parcel, Queensland also uses an 'irreplaceability' metric and an 'urgency' metric, considering how under-protected each regional ecosystem is. This would safeguard a variety of habitats, communities and ecological processes.

Victoria's Protection Priority rank employs complementarity to capture unprotected ecosystem types. A high-ranking area would complement the existing conservation reserve based on the CAR objectives. Victoria also focuses on suitable habitats for threatened vertebrates, vascular flora and the full range of vegetation types. This encompasses a wide array of ecosystems and vegetation communities.

While the methods we examined strongly focus on preserving a variety of ecosystems and habitats, only the AOBV method specifically addresses the protection of ecological and evolutionary processes. This method has specific criteria that address those processes.

Criterion 3: persistence

Ecological integrity

This assesses the quality of ecosystems and their capacity to adapt to change. It covers the extent, condition and connectivity of habitats and how well ecosystems respond to change, including climate change and other pressures.

Tasmania, Victoria, Queensland, NSW and the NT track vegetation extent. Victoria also tracks changes in suitable habitat. This considers the type, extent and configuration of habitat for a species. Vegetation condition and condition extent are considered within SMP. Land cover is also tracked on NatureKit. SA has identified species' preferred habitats based on their diet preferences and climate modelling. Tasmania's TasVeg depicts the extent of more than 150 vegetation communities, including coastal heathlands, eucalypt forests and alpine communities. Queensland monitors the extent using satellite data. NSW has satellite imagery available that tracks extent, as well as modelling for pre-1760 extent. Land clearing is also tracked through the Biodiversity Indicator Program. The NT also tracks clearing and vegetation types.

The NT, SA, Tasmania, WA and Queensland, however, do not track condition. Tasmania has yet to gather data on vegetation condition, but various organisations have already collected it. Tasmania intends to digitise this data on the Natural Values Atlas. In Victoria, there is modelling for vegetation condition for Victoria's terrestrial ecosystems, while in NSW, vegetation condition within the reserve network is monitored. Although ACT monitors vegetation conditions, it is not comprehensive. However, more detailed information about vegetation, such as the presence of exotic species, can be found within the reserve network.

The ACT is currently developing a connectivity index to map connectivity. There are also data available, such as the Local Links project, that would support identifying connectivity. Connectivity is also a conservation priority in NSW under the *Biodiversity conservation investment strategy* and the AOBV criteria. However, the interviews revealed that connectivity was perceived as a secondary consideration or not applicable for the landscape

types, particularly in Queensland, SA, WA and the NT. The creation of large reserves seemed to be the preference for some states.

Species' persistence

Does the approach identify features that are necessary for species survival and adaptability?

All the methods consider features that increase the likelihood of species' persistence but do so in a diversity of ways. As discussed under ecological integrity, habitat connectivity is a conservation tool mainly applied in parts of NSW and the ACT. In the ACT, connectivity features in the new *Caring for Dhawura Ngunnawal plan*, which targets actions to facilitate change in habitat preferences under climate change. Climate refuges and habitats are also mapped. The areas of importance, such as bogs, fens and wetlands, are all protected with the aim of species persistence. NSW fosters connectivity by creating wildlife corridors for both habitat and climate refugia.

The AOBV method also focuses on the importance of connectivity. NSW also considers the configuration of protected sites. While no minimum size is specified, buffer zones are encouraged around the boundary to minimise impacts on species from surrounding areas. On the other hand, the NT considers the reserve design's size, topography and layout to ensure species' persistence.

WA's CAR-based method considers critical habitats, connectivity and threatened species within the reserve network, which can inform land acquisition.

Victoria focuses on threats to identify habitats and increase the persistence of species. HDMs are modified by threat layers, producing modified species distributions that reflect the relative likelihood of species persistence for 50 years at a location, assuming no threat management is undertaken.

SA similarly focuses on threats, specifically using climate scenarios to determine which species will be the most vulnerable based on their preferred habitats and traits. The method, however, does not identify any threats other than climate change.

Tasmania's CIS tool contains information on fire and disease refugia and important bird habitats – both are important for persistence. However, climate change is not a direct consideration, and habitat information is limited to bird species. Queensland's methods do not consider the adaptive capacity of species. Prior methods did; however, this was replaced in 2016 in favour of a more CAR-focused method.

Vulnerability/threats

Some species and ecosystems are more vulnerable to threatening processes such as climate change and invasive species. Does the approach provide insights into which species or ecosystems are most vulnerable and what threats are present in a specific area?

All states except Queensland consider the threats. Queensland intends to develop the capability to identify threat sensitivity or exposure; however, this information is not yet available.

Victoria uses threat models to track the impact of pest species and climate change. The ACT, on the other hand, focuses on priority ecosystem vulnerability. Wetland vulnerability to climate change has been mapped on ACTmapi, considering landscape and soil capability, salinity, erosion hazards, etc. Broad-scale threats to each target landscape under the *Caring for Dhawura Ngunnawal plan* are also discussed. SA focuses on the threat that climate change poses to species and ecosystems.

NSW tracks species threats through the SoS program, which is supported by the allocation of new land to the reserve network. The state has also committed to improving reserve design under the *Directions statement* by including buffer zones to minimise land use threats.

Tasmania and the NT have criteria and spatial tools considering pest species and fire risk. Tasmania identifies fire and disease refugia in the CIS tool and tracks weeds and introduced species on the Natural Values Atlas. The NT uses criteria that consider the impact of feral animals, weeds and fire.

Climate resilience

Does this approach capture the resilience of species and ecosystems?

Neither Tasmania nor Queensland focus on climate resilience. Queensland conducted programs in the past, such as the Landscape Resilience Program, that considered the adaptive capacity of 1,300 vertebrates. Areas identified within these programs were highly similar to areas already within the protected area system and thus were discontinued.

On the other hand, methods in NSW and SA do consider climate resilience. The NSW NPWS method prioritises sites that represent climate refugia for vulnerable species. The SoS program considers the climate resilience of each species under the scenarios from AdaptNSW. SA considers the vulnerability of species to climate change based on their preferred habitat.

Criteria in the NT also identify climate refugia; however, the territory does not consider the adaptive capacity of specific species. The ACT has also captured climate refuges. Victoria, on the other hand, focuses on species resilience over ecosystems. The Change in Suitable Habitat concept is designed around selecting actions that will improve the resilience of species against climate change.

Criterion 4: uniqueness and irreplaceability

All states except the ACT have information relating to irreplaceability or uniqueness. Irreplaceability refers to the unique and distinct species or ecosystems present within an area that cannot be found elsewhere (Smith et al. 2019).

Metrics such as rarity-weighted risk (RWRisk) in Victoria address the rarity of the persistence and richness of species. Therefore, consider irreplaceability (given the risk of species loss). WA considers the rarity of species and whether the reserve network contains vulnerable plants and animals. NSW's NPWS method also considers a site irreplaceable if it is the last of its kind and not represented in the reserve network.

SA and Queensland both inform their methods with metrics specific to irreplaceability. SA's new method utilises irreplaceability metrics for their Habitat and Landscape Assessments. SA identifies restoration areas by considering irreplaceability weighted by immediacy based on species of concern. Queensland focuses on the irreplaceability of ecosystems.

The NT and NSW's AOBV methods have specific irreplaceability criteria. Clauses 3.1(2) and 3.1(3) of the AOBV method address irreplaceable biological distinctiveness, while Clause 3.1(4) identifies sites vital for species conservation. Such areas are irreplaceable for the persistence of biodiversity in NSW, nationally and globally. Both methods developed in the NT also have irreplaceability and uniqueness criteria, including consideration of wetlands, concentrations of threatened species, endemism, sole vegetation types and botanic importance.

Appendix 4. Australian Government data and spatial tools

Department of Climate Change, Energy, the Environment and Water (DCCEEW)

Statistical modelling has been completed for threatened species listed under the EPBC Act using Marxan. An established spatial ecologist team sources raw species observation data to support the models. Data is acquired from ALA, states, territories and researchers. Using a probability-based model, data is then separated into 3 categories – known (based on validated points), likely (suitable habitat) and may (broad environmental envelope where species may occur). Experts are engaged in data interpretation, and then the models are developed in consultation with the Biodiversity Division.

The data for EPBC-listed species is available on the Species of National Environmental Significance.

EPBC-listed ecological communities are also captured. This data is developed differently from species data, focussing more on vegetation mapping units rather than distribution.

Currently, the Australian Government is exploring how to define critical habitat.

The Habitat Condition Assessment System

The Habitat Condition Assessment System (HCAS) is Australia's first nationally consistent and repeatable approach to the habitat condition assessment developed by DCCEEW and CSIRO (Williams et al. 2021). The KBA method was the inspiration for the project.

Under HCAS, 'habitat condition' at a location (or site or pixel) refers to the capacity of the habitat to support the wildlife expected there under natural conditions. HCAS assesses habitat conditions with reference to ecosystem dynamics across space and time and observable characteristics of ecosystem structure, function and composition. It is based on the premise that natural vegetation occurring at places with similar abiotic environmental conditions (e.g. similar soil, landform, water availability) should look similar when viewed from space using satellite remote sensing, averaged across seasons and years. Where 2 such places have markedly different remotely sensed spatial and temporal characteristics, this may indicate a difference in their condition for biodiversity. Dissimilarity analyses such as these are valuable tools for identifying unique areas and how depleted they are. The tool can also be used to project through time under climate change scenarios to indicate which areas are essential for the long-term persistence of biodiversity.

Inputs

1. remote sensing time series data (v2.1 uses MODIS at 250-m resolution; v 3.1 uses Landsat at 90m). Current version (v3.1) is 34-year time series from 1988–2024.
2. environmental layers (soil, landform and long-term climate)
3. location data for 'natural' reference areas (i.e. represent least modified example of their ecosystem type).

HCAS integrates these data sources to compare how a pixel appears (observed) with how it is predicted to appear if it were in ‘unmodified’ or reference condition.

HCAS uses data for a specified period of remote sensing (e.g. 2001–18 in HCAS v2.1). The long timeframe enables the HCAS algorithm to use information about trends and variability in the remote sensing signals in estimating habitat condition for a specific location. This helps address the limitations of approaches which use short-term remote sensing data, such as a single season or year. The longer timeframe, as used in the HCAS base model, allows us to separate the influence of weather and other seasonal changes (which should generally have minimal impact on condition) from the effects of management that directly impact the condition.

The HCAS has 4 stages:

1. reference vegetation modelling
2. vegetation benchmarking
3. calibration
4. evaluation and output.

The reference vegetation model is statistically trained to predict the MODIS remote sensing signal for the best possible habitat condition of a site with given environmental characteristics. The vegetation benchmarking stage uses the predicted and observed remote sensing signals to identify and apply reference sites most appropriate for comparison to each location. This results in an unscaled index. Then the index is calibrated to generate habitat condition scores, across Australia, that vary continuously between 0.0 (removed) to 1.0 (intact).

HCAS operates at a 250-m resolution, providing detailed insights into habitat conditions. The system offers a more nuanced presentation of condition, compared to the binary classifications offered by alternative systems. While systems like ENVIS might be able to display native vs. non-native, HCAS employs a gradient distinguishing various levels of habitat degradation. This fine-grained tool is valuable for pinpointing specific areas within larger regions that require attention, and could support programs such as the Nature Repair Market.

HCAS-based tools and applications

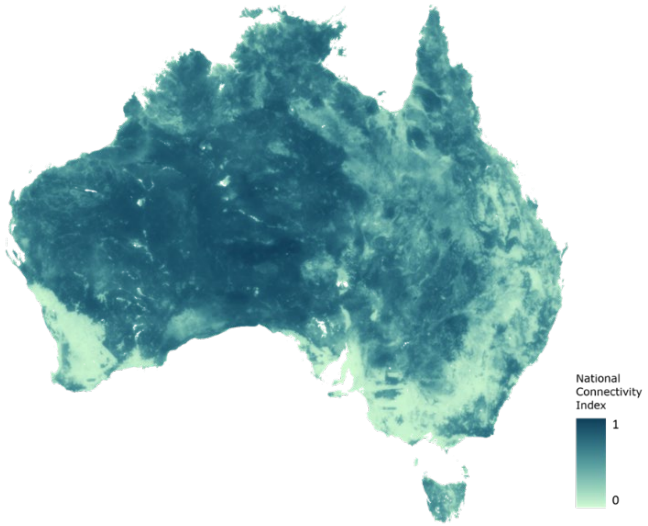
Habitat Condition Across Matters of National Environmental Significance

HCAS is compatible with species models. Integrating habitat condition data with the modelling can provide insights into potential areas for biodiversity conservation. The Habitat Condition Across MNES is a conservation prioritisation tool which integrates HCAS data with the spatial distributions of threatened species and ecosystems to help inform priorities for protection or restoration.

HCAS utility extends beyond potential habitat classification into connectivity analysis.

National Connectivity Index

Developed for DCCEEW collaboratively between CSIRO and NSW Government in 2022. The National Connectivity Index v2.0 score for any given location is a measure of the amount of connected habitat around that location. Scores are between 0 and 1.



National Connectivity Index.

Further information

- project website – https://research.csiro.au/biodiversity-knowledge/projects/hcas/
- HCAS v2.1 Technical Report – provides a technical explanation of the HCAS model, https://doi.org/10.25919/n3c6-7w60
- HCAS v2.1 data download – https://doi.org/10.25919/nkjf-f088
- Contact: DCCEEW – geospatial@dcceew.gov.au