NSW GOVERNMENT

DEPARTMENT OF PLANNING, INDUSTRY AND ENVIRONMENT

NSW Biodiversity Outlook Report

Results from the Biodiversity Indicator Program: First assessment

Foreword

Biodiversity — the variety of living organisms — is fundamental to a healthy and resilient natural environment.

In 2017, the NSW Government implemented new measures for biodiversity conservation and land management. These changes include the introduction of the Biodiversity Conservation Act 2016, which is designed to:

- conserve biodiversity across the state
- maintain genetic and species diversity and quality of ecosystems and enhance their capacity to adapt to change and provide for the needs of future generations
- slow the rate of biodiversity loss and conserve threatened species and ecological communities in nature.

The Biodiversity Conservation Act requires the establishment of programs for the collection, monitoring and assessment of information on biodiversity.

The Department of Planning, Industry and Environment (the Department) has established the Biodiversity Indicator Program and collaborated with CSIRO, the Australian Museum and Macquarie University to publish a peer reviewed method, *Measuring Biodiversity and Ecological Integrity in NSW: Method for the Biodiversity Indicator Program*. This method has been used to create a baseline for reporting on future trends for biodiversity in New South Wales. The baseline represents the status of biodiversity after European settlement and up to the commencement of the Act. The baseline will be used for assessing future changes in biodiversity. This is the first report of its kind and allows New South Wales to track the status and trends of biodiversity in New South Wales going forward.

New South Wales has experienced extensive bushfires throughout spring and summer 2019–20. The immediate effect of these recent fires on the habitat condition and state of biodiversity indicators has been analysed. This work is published in the NSW Fire and the Environment 2019–20 Summary as a companion document to the first Biodiversity Outlook Report.

The Biodiversity Outlook Report outlines the ongoing impacts of settlement and development, together with other threats, on biodiversity in New South Wales. The consequences for habitat effectiveness (i.e. the ability of our natural habitat to support biodiversity), threatened species and ecological communities will continue to be monitored and will inform conservation activities.

The Biodiversity Indicator Program focuses our work and underpins continuing efforts to protect and restore biodiversity in New South Wales, and to also guide recovery actions in response to the recent bushfires.

I thank the dedicated scientists whose rigorous work has produced these biodiversity indicators.

Dr Paul Grimes
Coordinator-General - Environment, Energy and Science

Contents

SNAPSHOT vii

INTRODUCTION 1

Assessing the status of biodiversity 2

Measuring biodiversity and ecological integrity 3

Reporting results 5

BIODIVERSITY: EXPECTED SURVIVAL OF BIODIVERSITY 8

Theme insights 9

Report card: Listed threatened species and ecological communities 10

Report card: All known and undiscovered species 16

BIODIVERSITY: STATE OF BIODIVERSITY 21

Theme insights 22

Report card: State of biodiversity including undiscovered species 24

Field monitoring of species and ecosystems 31

- Species trends 32
  - Case study: Mountain pygmy-possum 32
  - Case study: WildCount 2012 to 2016 33
  - Case study: Monitoring kangaroos 34
- Ecosystem trends 35
  - Case study: Spinifex–mallee ecosystem trends 35

ECOLOGICAL INTEGRITY: ECOSYSTEM QUALITY 36

Theme insights 37

Report card: Habitat condition 38

Pressures 44

- Land-use and management practices 45
  - Case study: Horticultural land-use mapping 45
- Inappropriate fire regimes 47
  - Case study: Fire thresholds 47
- Inappropriate hydrological regimes 48
  - Case study: Waterbirds and wetland health 48
- Invasive species 49
  - Case study: Controlling hawkweed 49

ECOLOGICAL INTEGRITY: ECOSYSTEM MANAGEMENT 50
Theme insights 51
Management responses 51
Areas managed for conservation in perpetuity 54
Case study: National parks and conservation areas 54
Areas managed for conservation under formal or informal agreements 56
Case study: Conservation on private land 56
Community appreciation of biodiversity 57
Case study: Who cares about the environment? survey 57
Management effectiveness 58
Effectiveness of on-ground biodiversity conservation programs 59
Case study: Gould's petrel 59
Community-based maintenance of biodiversity values 60
Case study: Citizen science programs for restoration 60
ECOLOGICAL INTEGRITY: ECOSYSTEM INTEGRITY 61
NEXT STEPS 63
Glossary 64
Acknowledgements 67

Key insight

In 2013, about one-third of NSW's original habitat effectiveness for supporting native species remained, and up to three-quarters of the original diversity of species and ecosystems in New South Wales were estimated to be persisting.

Snapshot

Expected survival of biodiversity

Without effective management,

50% of listed threatened species in NSW are likely to become extinct within 100 years

73% of all NSW native plant species are likely to survive in 100 years

59% of listed threatened ecological communities are expected to exist in 100 years

State of biodiversity

79–91% of original within-species plant genetic diversity remains

80–84% of original vascular plant ecosystem diversity is likely to persist

Field monitoring provides key data and insights on biodiversity conservation and management effectiveness

Snapshot

Key insight

With our collective actions, such as vegetation management, private land conservation and national parks, and community volunteers, we can maintain and enhance habitats for biodiversity and reduce the rate of loss of species, including threatened species.

Ecosystem quality

33%

of NSW's original habitat effectiveness for supporting native species remained in 2013

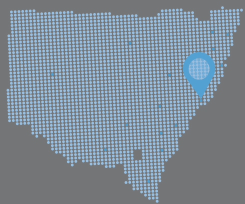
62% of the 7.1m hectares of national parks and **2%** of the 73.9m hectares of other tenures remain at least 60% effective in supporting their native plants and animals

Managing pressures

on biodiversity is key to maintaining or improving the status of species and ecosystems

Ecosystem management

9% of NSW is protected in reserves



More than 270,000 hectares of other NSW land tenure has some private land conservation

Monitoring effectiveness of

on-ground management

ensures conservation that's right for the site

The

Saving our Species

program aims to reverse the decline in priority listed threatened species

Community volunteers

are key to our conservation efforts – from data collection to on-ground management and decision-making

Undertaking research in the Nymagee area.
Photo: Peter Robey/DPIE

INTRODUCTION

Assessing the status of biodiversity

New South Wales is home to an amazing diversity of native species and ecosystems. Species and ecosystems vary across NSW's different landscapes and occur naturally in all places.

Changes to our landscapes create living environments for people and provide food and materials to sustain us. These changes also alter habitats and may make them less suitable for biodiversity. Now almost 1000 plants and animals are assessed to be at risk of extinction.

To address these risks, the Environment, Energy and Science Group (EES) of Department of Planning, Industry and Environment (the Department) has collaborated with leading biodiversity experts at CSIRO, Macquarie University and the Australian Museum to measure:

- **biodiversity:** the variety of living animal and plant life (including fungi, lichen and microorganisms), including diversity within and between species and diversity of ecosystems
- **ecological integrity:** the ability to maintain the diversity and quality of ecosystems and enhance their capacity to adapt to change and provide for the needs of future generations.

A range of indicators have been designed to track the status of both biodiversity and ecological integrity, and how we manage our landscapes and protect natural areas. These indicators will, over time, provide a record of the management actions we undertake, as well as the effectiveness of those actions at improving the habitats that support biodiversity.

It is important to accurately assess the status of biodiversity, now and into the future, so that we can understand how well our land management and conservation actions are working, and whether we need to make adjustments to accommodate the survival of more of our unique biodiversity.

Coffs Coast Regional Park ocean view.
Photo: Shane Ruming/DPIE

Measuring biodiversity and ecological integrity

Monitoring all the plants, animals, fungi and their habitats and ecosystems throughout an area as large and diverse as New South Wales is a large task.

To simplify the task, we have developed a suite of indicators to measure different aspects of biodiversity and ecological integrity at regional and statewide scales, and to track changes in biodiversity over time.

For this Outlook Report, we have assessed certain biological groups (e.g. vascular plants, birds) based on the ecological importance of the group and available data. For future outlook reports, other biological groups will be assessed.

The method is detailed in a technical report, *Measuring Biodiversity and Ecological Integrity in NSW: Method for the Biodiversity Indicator Program*. A Summary of the method is also available.

Implementation reports detail how indicators have been assessed. These reports will be published, and their data packages uploaded to the open-access NSW Government's Sharing and Enabling Environmental Data *SEED Portal* and *CSIRO Data Access Portal* (Figure 1).

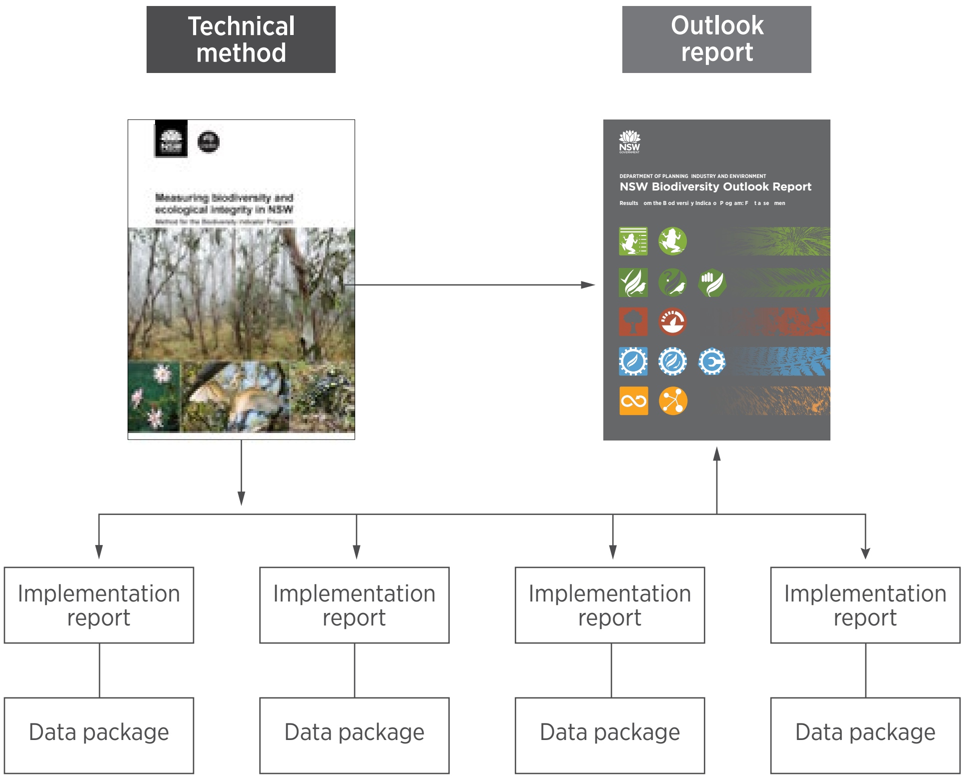


Figure 1 Products of the Biodiversity Indicator Program

We need to measure all the different parts of biodiversity (genes, species and ecosystems) across scales, as well as the ecological integrity of supporting habitats, to get a full picture. One way is by tracking changes in the status of species and ecosystems considered at risk of extinction, and the effectiveness of management actions to secure them in the wild.

We also need to track changes in other plants and animals, including those we are still learning about, as well as the condition of habitats, extent of threatening processes, and management actions undertaken to minimise impacts.

The technical method identifies five **themes** of indicators: two for biodiversity and three for ecological integrity (Figure 2). Within themes, indicators are grouped under **families**.

Measurement methods are changing rapidly and so the first-assessment indicators we present in this Outlook Report represent different ways to measure biodiversity and ecological integrity, allowing for updates as technologies advance. The indicators apply remote sensing and modelling and are complemented by direct measures of biodiversity from long-term monitoring programs.

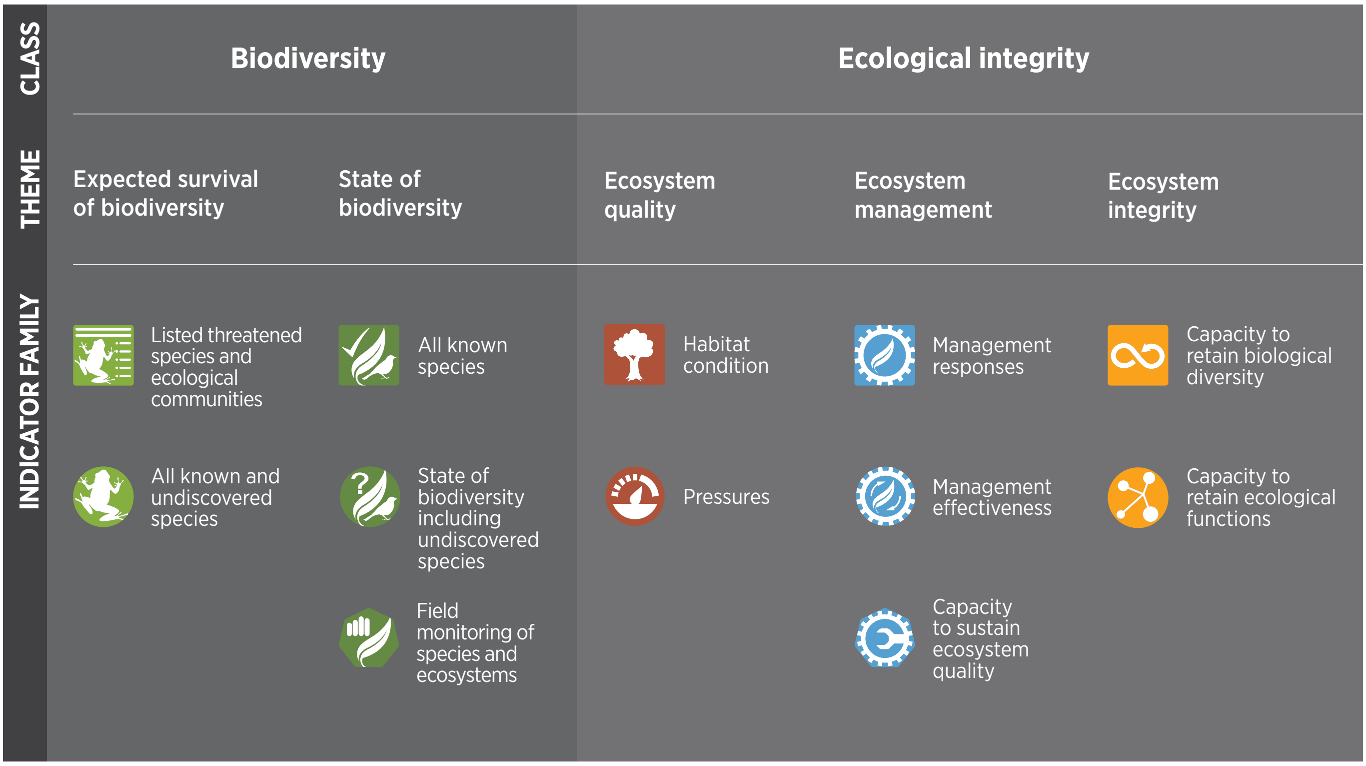


Figure 2 Indicator classes, themes and families

Reporting results

Report cards

This first *NSW Biodiversity Outlook Report* presents four 'first-assessment' indicators which have been implemented:

- Listed threatened species and ecological communities
- All known and undiscovered species
- State of biodiversity including undiscovered species
- Habitat condition.

Indicators with common methods or measurements are grouped together in **report cards**. These groupings are mainly at the family level as shown in Figure 2, unless otherwise described. Where an indicator has not yet been assessed, a description of the indicator family is provided.

Results for these first-assessment indicators are provided in report cards. Each report card links to technical implementation reports that provide detail about the data and methods used.

Each report card includes an infographic that summarises the indicator results (Figure 3). Results are reported in percentages, with an arrow showing the status of the indicator along a band. The level of confidence for each result is expressed by the parts of a circle.

In some cases the indicator is reported for multiple years, for example 2007, 2012 and 2017 as shown below. This allows trends over time to be assessed.

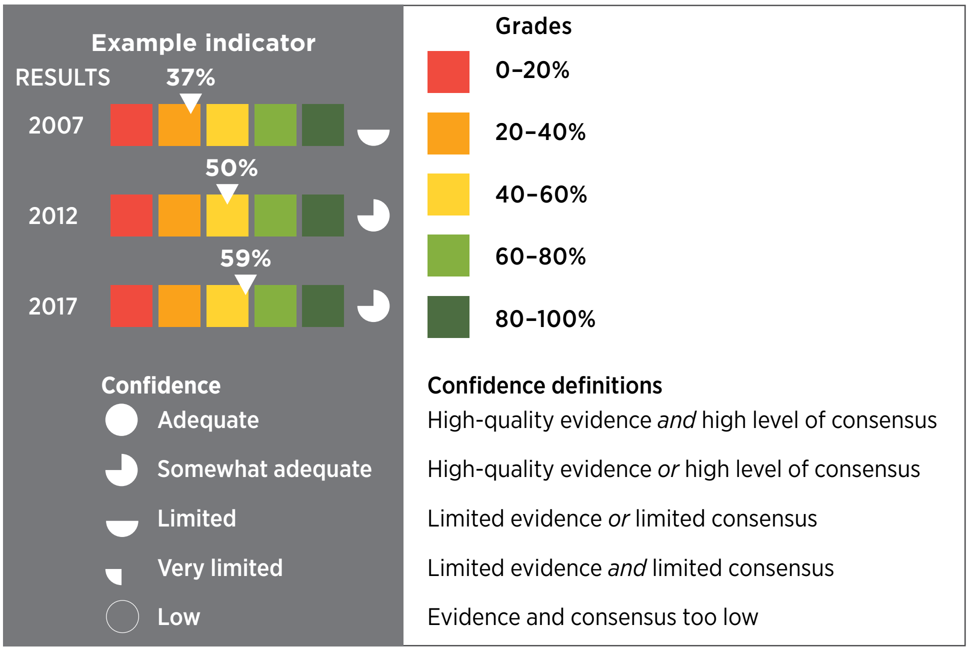


Figure 3 **An example of a summary infographic from a report card with an explanation of terms and symbols.** In the example, the indicator shifted from 37% in 2007 to 50% in 2012 and 59% in 2017. For the 2007 reporting timeframe, the level of confidence in the result was 'limited' in terms of evidence or consensus; and for 2012 and 2017 the level of confidence was 'somewhat adequate'.

Case studies

Indicators that are not assessed here in a report card are in different stages of development. Indicators that are assessed in the future will be included in future outlook reports. For example, indicators in the ecosystem integrity theme require data from the other themes to be ready first.

For indicators that are not assessed in this Outlook Report, case studies that provide a summary of the type of data being gathered have been included.

Time stamping of measurements

This first assessment aims to show changes up to the commencement of the *Biodiversity Conservation Act 2016* (25 August 2017). Where historical data is available, it is used to estimate a trend. Only published data is used to develop the indicators, so different indicators use different types of data, depending on availability. Some indicators calculated using habitat condition, which includes remote-sensing and land-use data, are assessed up to 2013, being the latest published data. Other indicators use more recent data.

The next time indicators are reported, the historical trend will be updated with newly available methods and data.

Scale

The purpose of the Biodiversity Conservation Act includes conserving biodiversity at bioregional and state scales. All indicators are reported at statewide scale. Bioregions, shown in Figure 4, are used to report indicators where location data is available.

Camera monitoring the holly-leaf grevillea. A major pollinator is the white-cheeked honeyeater. Photo: Allan McLean/DPIE

Bioregion code	Bioregion name	Area (ha) in NSW
AUA	Australian Alps	464,305
BBS	Brigalow Belt South	5,624,961
BHC	Broken Hill Complex	3,763,030
CHC	Channel Country	2,340,609
COP	Cobar Peneplain	7,377,221
DRP	Darling Riverine Plains	9,420,085
MDD	Murray Darling Depression	7,935,732
MUL	Mulga Lands	6,591,989
NAN	Nandewar	2,074,646
NET	New England Tablelands	2,860,028
NNC	NSW North Coast	3,994,875
NSS	NSW South Western Slopes	8,103,350
RIV	Riverina	7,019,553
SEC	South East Corner	1,207,807
SEH	South Eastern Highlands	4,942,351
SEQ	South Eastern Queensland	1,661,545
SSD	Simpson Strzelecki Dunefields	1,095,100
SYB	Sydney Basin	3,616,042

Figure 4 **Bioregions of New South Wales and their area.** The bioregions naturally extend across state boundaries and we report only for the area in New South Wales. The largest bioregion in New South Wales is the Darling Riverine Plains and the smallest bioregion is the Australian Alps.

BIODIVERSITY

Expected survival of biodiversity

Theme insights

The Expected survival of biodiversity indicator theme measures the rate of loss of biodiversity. It estimates the survival, in 100 years, of both species and ecological communities that are known to be at risk of extinction, as well as those species whose risk has not been assessed, or species yet to be discovered. It also addresses the possible loss of evolutionary heritage by measuring the phylogenetic diversity of threatened groups of species.

Listed threatened species and ecological communities

This indicator family measures the likely long-term survival of species and ecological communities that have been assessed for risk of extinction by the NSW Threatened Species Scientific Committee.

Key insights

As of 2017 it is estimated that, without concerted investment in management, 50% of listed threatened species in New South Wales are likely to become extinct within the next 100 years.

For species with no close living relatives, extinctions will result in a much greater loss of evolutionary heritage than other species.

The NSW Government's leading threatened species conservation program is *Saving our Species*, which is investing $100 million to save more threatened animals and plants from extinction.

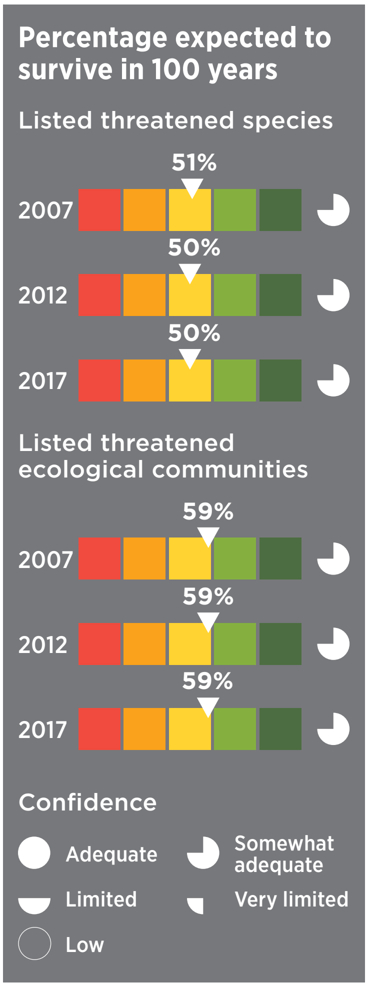
All known and undiscovered species

This indicator family measures the risk of extinction of all known and undiscovered species, including those already formally assessed by the NSW Threatened Species Scientific Committee.

Key insights

Based on a preliminary assessment of extinction risk using location records and habitat condition data up to 2013, about 73% of all NSW vascular plant species are likely to still exist in 100 years and 27% are likely to become extinct within 100 years.

Only about 20% of all plants were categorised as lowest risk, suggesting that many more plant species than are currently listed as threatened may be at risk of extinction.



Report card: Listed threatened species and ecological communities

The Listed threatened species and ecological communities indicator family reports the likely long-term survival of species and ecological communities that have been assessed for risk of extinction by the NSW Threatened Species Scientific Committee. The indicator family also measures the risk of losing NSW evolutionary heritage (phylogenetic diversity).

Three indicators are reported up to 2017:

- **Expected survival of listed threatened species**
  This shows the percentage of listed threatened species expected to survive in 100 years.
- **Expected survival of phylogenetic diversity for listed threatened species**
  This shows the percentage of evolutionary heritage maintained in the species of a biological group that is expected to survive in 100 years.
- **Expected existence of listed threatened ecological communities**
  This shows the percentage of listed threatened ecological communities expected to exist in 100 years.

Listed threatened species

In 2017, 50% of listed threatened species in New South Wales were expected to survive in 100 years.

By 25 August 2017, the NSW Threatened Species Scientific Committee (the Scientific Committee, see Box 1) had listed 991 species and subspecies as threatened (or extinct) under the *Biodiversity Conservation Act 2016*. Of these, 496 (50%) were expected to survive in 100 years (Figure 5). The majority (88%) of listed species belong to well-known groups (birds, mammals and plants) and so patterns in these groups dominate the indicator (Figure 5).

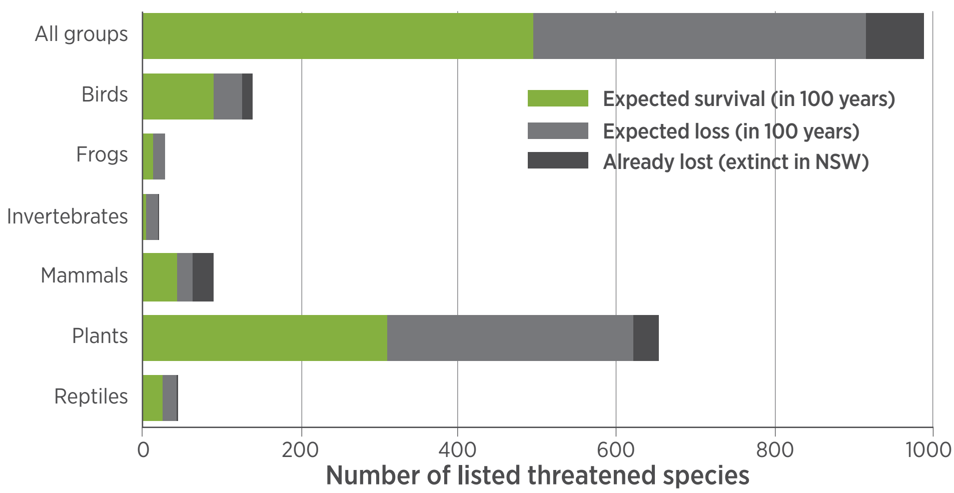


Figure 5 Number of listed threatened species from different biological groups and all groups combined expected to survive in 100 years, from 25 August 2017

The chance of a species surviving in 100 years was determined by the category (vulnerable, endangered, critically endangered or extinct) in which they were listed (see Box 1). The 74 species listed as extinct in New South Wales are very likely to be truly extinct but are included because there is a small chance that one or more will be discovered to still be living within the next 100 years. Some species listed as extinct in New South Wales still occur in other states and could potentially be reintroduced, reducing the expected loss.

The expected survival of listed threatened species in 100 years has clearly declined since 1997.

In the 20 years from 1997 to 2017, the number of threatened species expected to survive in 100 years fell by 19–20 species. In 1997, the number of listed threatened species expected to be surviving in 100 years was 515 (or 52% of the total number of listed threatened species); in 2007 the number expected to be surviving was 503 (51%); in 2012 it was 498 (50%); and in 2017 it was 496 (50%). The historical trend (Figure 6) assumes that each species has stayed in the same category (vulnerable, endangered, critically endangered or extinct) over time, except where the Scientific Committee has reassessed a species to be in a different category. Because species were assumed to be in the same category before they were listed, the historical trend is not due to simple growth in the number of listed species over time. Efforts to secure threatened species from extinction through the *Saving our Species* program (see Box 2) aim to slow, halt or even reverse the historical trend. Outcomes of investment in biodiversity conservation, in addition to new determinations from the Scientific Committee, will be used to update the indicator in the future (Figure 6).

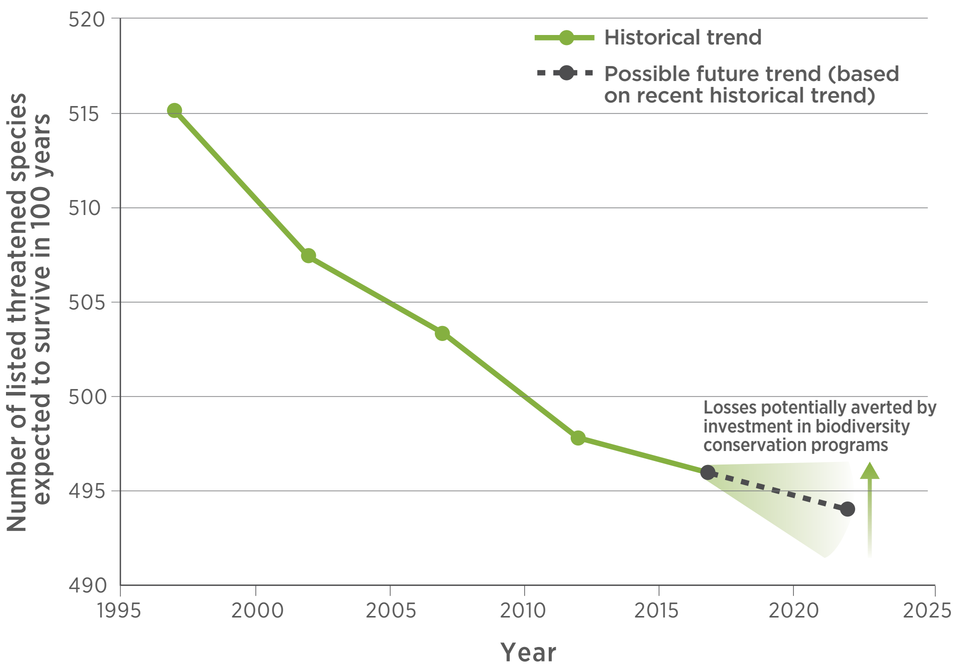


Figure 6 **Historical and possible future trend in the expected survival of listed threatened species.** Historical trend is due to some listed species becoming more threatened over time. Possible trend to 2022 assumes that the recent historical decline (over the last five years) continues. Outcomes of investment in biodiversity conservation may slow, halt or reverse this trend.

Box 1 The NSW Threatened Species Scientific Committee

The Scientific Committee was established in 1995 and continues under the Biodiversity Conservation Act. It is an independent committee of scientists appointed by the Minister for the Environment.

The Scientific Committee assesses the risk of extinction of species, ecological communities and species populations in New South Wales and decides which should be listed. Listing categories for species are: vulnerable, endangered, critically endangered or extinct. Categories for ecological communities are: vulnerable, endangered, critically endangered or collapsed. Threatened fish, marine plants and aquatic ecosystems are listed by the NSW Fisheries Scientific Committee.

The Scientific Committee, the Minister for the Environment or any member of the public may nominate species, species populations or ecological communities for listing. The Scientific Committee assesses risk of extinction using internationally accepted International Union for Conservation of Nature (IUCN) Red List criteria for species and ecosystems. The Scientific Committee may also adopt assessed listings from the Commonwealth, other states or territories where those assessments comply with the nationally agreed common assessment method.

The work reported here focuses on listed threatened species and ecological communities, and in the future, will include listed threatened populations. Prior to commencement of the Biodiversity Conservation Act, 50 endangered populations had been listed: 29 plants, 11 mammals, 7 birds, and one each of a frog, reptile and invertebrate species. A listed threatened population is of significance for its role in the conservation of that species or a number of other species.

Phylogenetic diversity

Australia has many unique species representing many millions of years of independent evolutionary history. Because Australian species are often found nowhere else, this evolutionary heritage is irreplaceable.

In 2017, birds, frogs and mammals were expected to retain, respectively, 92%, 83% and 84% of their original evolutionary heritage in 100 years.

The amount of phylogenetic diversity (evolutionary heritage) expected to survive in 100 years was estimated as the percentage of an evolutionary tree remaining if certain species survived and others were lost (Figure 7). These values are a percentage of the original evolutionary heritage of a group in New South Wales, including species not listed as threatened and species presently listed as extinct. Species not listed as threatened were assumed to be secure, even though some species may be threatened but not yet listed.

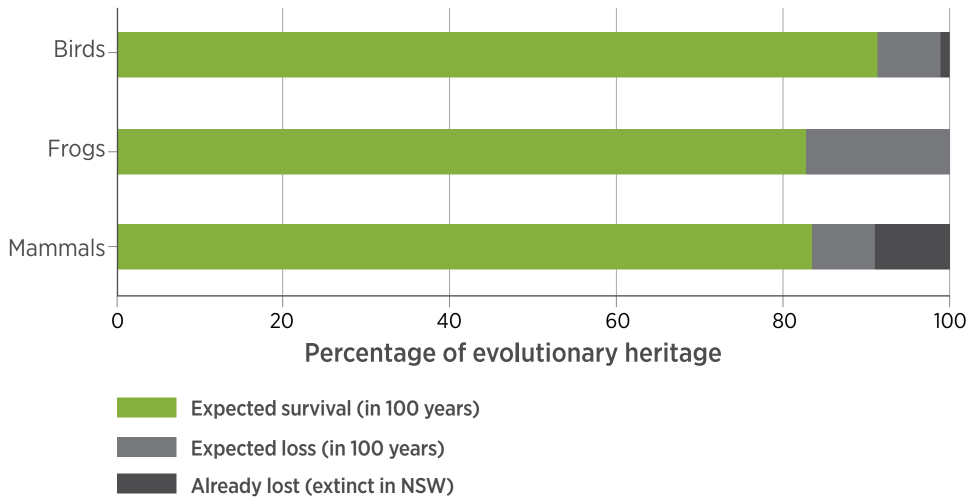


Figure 7 Evolutionary heritage (as a percentage of an evolutionary tree) from different biological groups expected to survive in 100 years, at 25 August 2017

While much evolutionary heritage has already been lost, reintroductions of species extinct in New South Wales (but existing elsewhere) and ongoing management to secure populations could dramatically increase surviving evolutionary heritage for some groups such as bandicoots (see Box 3).

Box 2 *Saving our Species* program

The statewide Saving our Species program aims to reduce the risk of extinction for threatened plants, animals and ecological communities in New South Wales. The program:

- delivers targeted conservation strategies for actions to save specific plants and animals on mapped management sites
- takes a rigorous and transparent approach to prioritising investment to ensure benefit to the maximum number of threatened species and ecological communities
- regularly monitors the effectiveness of strategies so they can be improved over time.

By monitoring and reporting on management effectiveness, the program can identify where conservation strategies have improved the chance of survival of species and ecological communities. These improved chances of survival would, in turn, improve the results for the Expected survival of threatened species and Expected survival of listed threatened ecological communities indicators reported here. Those improvements will be considered in future measurement of these indicators. The annual Saving our Species report cards provide information about actions that have been carried out at key management sites during each financial year.

Box 3 The evolutionary heritage of bandicoots

Greater bilby.
Photo: W Lawler/Australian Wildlife Conservancy

New South Wales has lost four species of bandicoots to extinction over the last two centuries. In 2017, about 48% of the original evolutionary heritage of NSW bandicoots was expected to survive in 100 years (Figure 8a). The continuing existence in New South Wales of an entire group of marsupials is now precarious, relying on the survival of just three species, of which one, the southern brown bandicoot, is endangered.

Fortunately, three of the four species that are extinct in New South Wales (golden bandicoot, western barred bandicoot and greater bilby) still have populations in other states. Successfully reintroducing and securing these species in New South Wales will recover a significant amount of evolutionary heritage historically lost to the state (Figure 8b and c). The NSW Government, partnering with the Australian Wildlife Conservancy and the Wildlife Restoration and Management Partnership, has launched a program to return these irreplaceable species to three national parks in western New South Wales.

Securing the southern brown bandicoot will further increase the expected survival of evolutionary heritage (Figure 8b and c), recovering an additional two million years of heritage. The *Saving our Species* program (see Box 2) has identified three key management sites. At each site, important threats, such as predation by foxes, are targeted. Ongoing monitoring of populations ensures that these management activities will stop the extinction of the species.

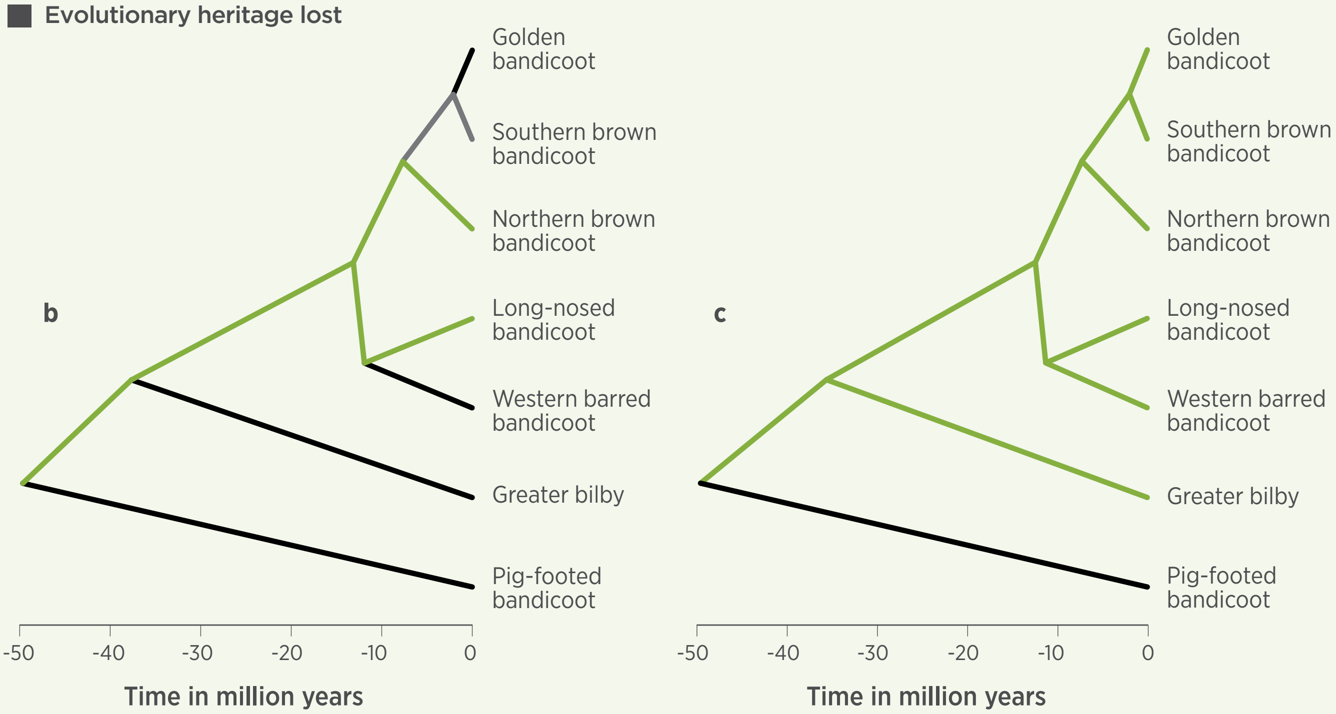


Figure 8 Evolutionary heritage of bandicoots in New South Wales. The original amount of evolutionary heritage represented by bandicoots is the total length of branches in an evolutionary tree. The tree shows how bandicoot species have diverged from each other over the past 50 million years. The expected survival of the evolutionary heritage of bandicoots was 48% in 2017 (see 8a). As of 2017 (see b), black branches are extinct in New South Wales, grey branches are at risk of extinction (30% chance of survival in 100 years) and green branches are secure (≥ 95% chance of survival). If three species (golden bandicoot, western barred bandicoot and greater bilby) are successfully reintroduced to New South Wales and the southern brown bandicoot is secured from extinction, 50 million years of evolutionary heritage will be recovered (see c), increasing expected survival from 48% to 76% (i.e. 48% + 28%) of original (see a).

Listed threatened ecological communities

In 2017, 59% of listed threatened ecological communities in New South Wales were expected to exist in 100 years.

By 25 August 2017, the Scientific Committee (see Box 1) had listed 108 ecological communities as threatened in New South Wales under the Biodiversity Conservation Act. Of these, 64 (59%) were expected to exist in 100 years (Figure 9). The chance of an ecological community existing in 100 years was determined by the category (vulnerable, endangered, critically endangered or collapsed) under which it was listed.

The expected existence of threatened ecological communities in 100 years has remained steady since 1997.

In 2007 and 2012, the expected number of surviving listed threatened ecological communities was estimated as 64 (59%). The historical trend (Figure 9) assumes that each threatened ecological community has stayed in the same category (vulnerable, endangered, critically endangered or collapsed) over time, except where the Scientific Committee has reassessed a threatened ecological community to be in a different category.

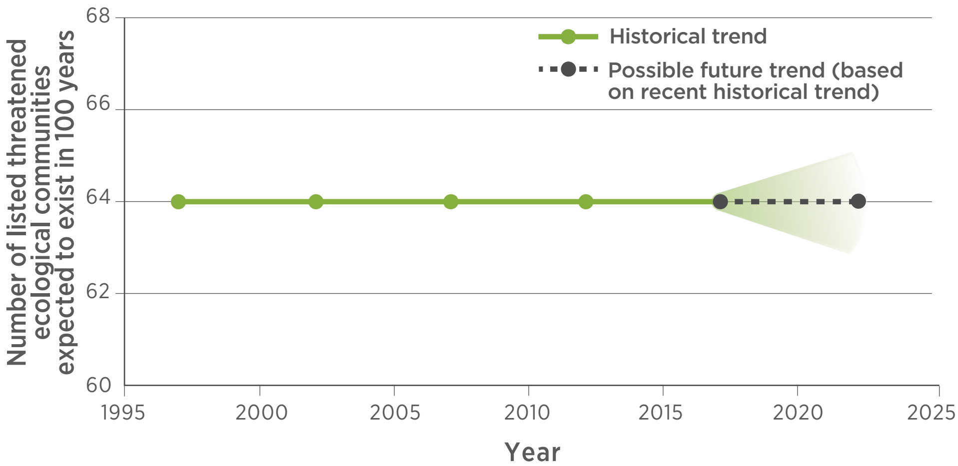


Figure 9 Historical trend and possible future trend in the expected survival of listed threatened ecological communities. Historical trend is due to listed ecological communities not becoming more threatened over time. Possible trend to 2022 assumes that the recent historical trend (over the last five years) continues.

More information

DPIE 2019, *Threatened species*, NSW Department of Planning, Industry and Environment, Sydney, Australia, viewed 12 September 2019, www.environment.nsw.gov.au/topics/animals-and-plants/threatened-species.

Nipperess DA, Faith DP, Auld TD, Brazill-Boast J & Williams KJ 2020, *Expected diversity as an indicator of biodiversity status and trend: A case example using the listed threatened species and ecological communities of New South Wales, Australia*, Biodiversity Indicator Program Implementation Report, Department of Planning, Industry and Environment, Sydney, Australia, www.environment.nsw.gov.au/research-and-publications/publications-search/expected-diversity-as-an-indicator-of-biodiversity-status-and-trend.

Nipperess DA, Faith DP, Auld TD, Brazill-Boast J, Williams KJ & King D 2020, Expected survival of listed and threatened species and ecological communities: Data packages for the Biodiversity Indicator Program, first assessment, *SEED Portal*, datasets.seed.nsw.gov.au/dataset/biodiversity-indicator-program-data-packages.

Percentages for all known species of vascular plants

Expected to survive in 100 years

73%

2013

Remaining amount of original habitat

57%

2013

Remaining original within-species genetic diversity

79–91%

2013

Confidence

Adequate
Somewhat adequate
Limited
Very limited
Low

Report card: All known and undiscovered species

The All known and undiscovered species indicator family measures the risk of extinction of all known and undiscovered species, including those formally assessed by the Scientific Committee (see Box 1). This assessment of extinction risk adapted the habitat-based criterion used by the International Union for Conservation of Nature's Red List. Each assessment applies to a particular biological group.

Three indicators are reported.

One indicator reports the status in 2013 for vascular plants:

- **Expected survival of all known species**
  This shows the percentage of all known species expected to survive in 100 years.

  This indicator was calculated for sets of species found in the full range of habitats for their biological group. Results for these species sets inform the status of all known species in that group, and may also apply to species yet to be discovered. In future assessments we will report on other biological groups (e.g. mammals, frogs, birds).

Two supporting indicators from the related State of all known species indicator family are also presented here:

- **Within-species genetic diversity (all known species)**
  This shows the percentage of within-species genetic diversity of all known species.
- **Extant area occupied (all known species)**
  This shows the average percentage of original habitat presently occupied by all known species.

Another indicator in the Expected survival of all known species indicator family is under development and will be used for future report cards:

- **Expected survival of all known and undiscovered species**
  This is the percentage for all known and undiscovered species expected to survive in 100 years assessed for each biological group (see Box 4).

All known species of vascular plants

In 2013, about 73% of all NSW plant species were expected to survive in 100 years.

This result is a precautionary lower limit for expected survival. This result, and all results reported, were calculated by selecting sets of species found in the full range of habitats for all plants in New South Wales. Each species was assigned a risk category and chance of survival (Figure 10) based on the amount of habitat, and how much of the original habitat has been lost (see Report card: Habitat condition).

About a third (30%) of plant species are in the higher risk category, with half (51%) in the lower risk category, and 19% in the lowest risk category (Table 1). Many more NSW plant species are potentially at risk than have yet been formally assessed (see Report card: Listed threatened species and ecological communities).

Risk categories are defined in the implementation report and shown in Figure 10.

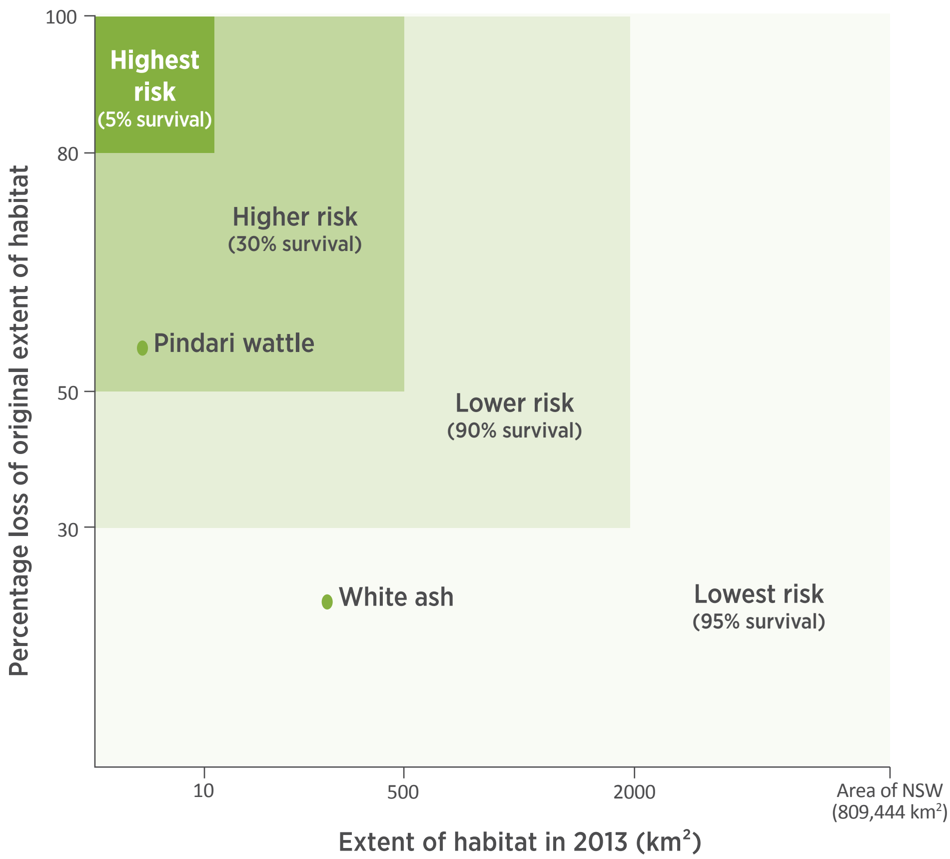


Figure 10 **Criteria for assigning a risk category to a species.** Each species was assigned a chance of survival (in 100 years) based on the amount of habitat and the loss of original habitat. For example, the Pindari wattle (listed as endangered in New South Wales) is in the higher risk category, and the white ash (not listed as threatened) is in the lowest risk category.

Table 1 **Percentage of species surviving in 100 years by risk category**. Percentage of species surviving in 100 years (A x B) is found by multiplying the percentage of species in a risk category (A) by the percentage chance of survival (B) for that category (from Figure 10). The sum of risk categories gives the total percentage of species surviving in 100 years, that is, 73%.

Risk category	Percentage of species in each risk category (A)	Percentage chance of survival (B)	Percentage of species surviving in 100 years (A x B)
Highest risk	<1	5	<1
Higher risk	30	30	9
Lower risk	51	90	46
Lowest risk	19	95	18
Total	**100**	**Not applicable**	**73**

In 2013, for NSW plants, an average of 57% of the original amount of effective habitat, and 79% to 91% of the original within-species genetic diversity remained.

These results for within-species genetic diversity and extant area occupied are an average across all species in all risk categories. There is considerable variation across species. On average, about 57% of NSW plant species' original habitat remains effective, after taking account of ecological condition.

Within-species genetic diversity remaining is estimated from the percentage of original habitat remaining for each species. Genetic diversity is known to decline with shrinking occupied area due to reductions in population size, habitat connectivity and habitat variety.

Species in the highest risk category have retained, on average, 17% of their original habitat, while species in the lowest risk category have retained an average of 75% (Figure 11).

On average, species in the highest risk category have the lowest remaining genetic diversity (49% to 77%). Upper and lower limits are given because each species responds to loss of habitat differently, depending on its ability to move to other environments or adapt to local environmental conditions, which is presently unknown. Species with low genetic diversity are more at risk of extinction because they are less able to adapt to a changing environment.

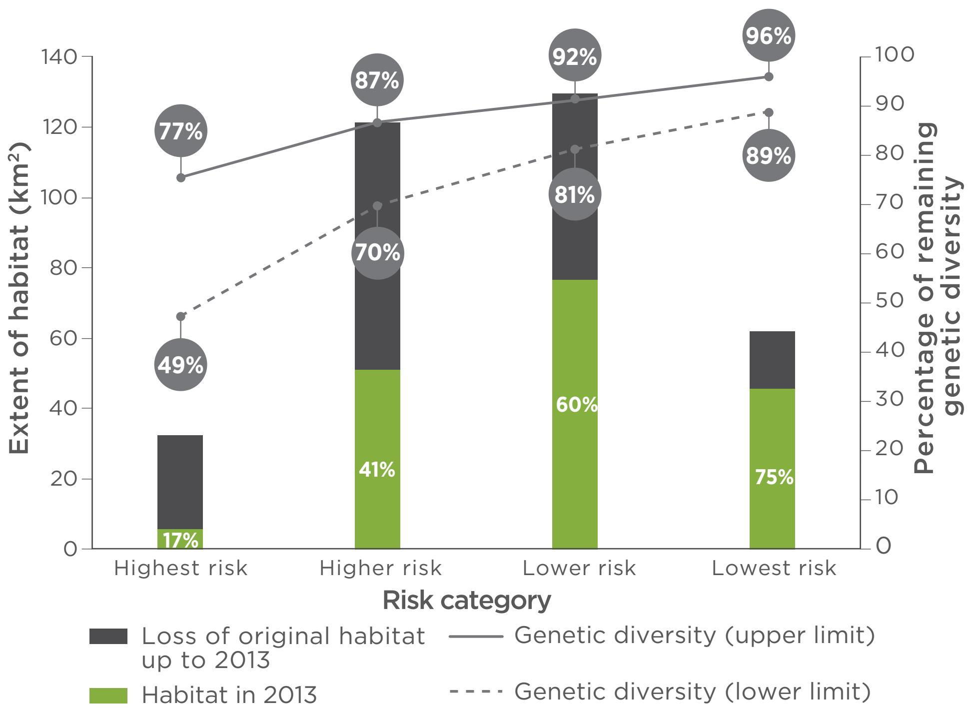
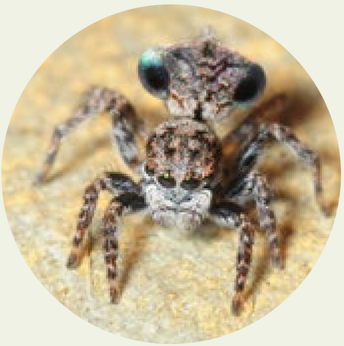


Figure 11 Amount of habitat in 2013, and the loss (up to 2013) of original habitat, averaged over all species in each risk category. The percentage of remaining original habitat is shown in the green bar. Overlaid is the range (upper and lower limit) of within-species genetic diversity that is predicted to remain, averaged over all species in each risk category. The amount of original habitat is equal to the sum of the habitat in 2013 and the lost original habitat.

Box 4 Species discovery over time



The true number of species on Earth, in Australia or in New South Wales, remains unknown. For Australia, about 192,000 species have been described and named, but the *Decadal Plan for Taxonomy and Biosystematics in Australia and New Zealand 2018–2027* estimates there may be more than 500,000. Some groups, such as mammals, are well known, with few or no species left to discover, while others, such as insects, have only a relatively small percentage (about 33%) of species known to science. In the past few decades, more than 1000 new Australian species have been described every year.

A 'discovery curve', which shows the rate over time at which new species are identified, can be used to assess how completely we understand the biodiversity of a biological group. If we are close to discovering all species, fewer and fewer new species will be added each year, and the curve begins to flatten.

Indeed, the rate of discovery of new NSW plant species has been slowing since the 2000s (Figure 12). If the discovery trend continues to slow, despite efforts to find new species, there will be an estimated 7000 species of vascular plants in New South Wales, including about 30 species (less than 1%) that are unknown to science.

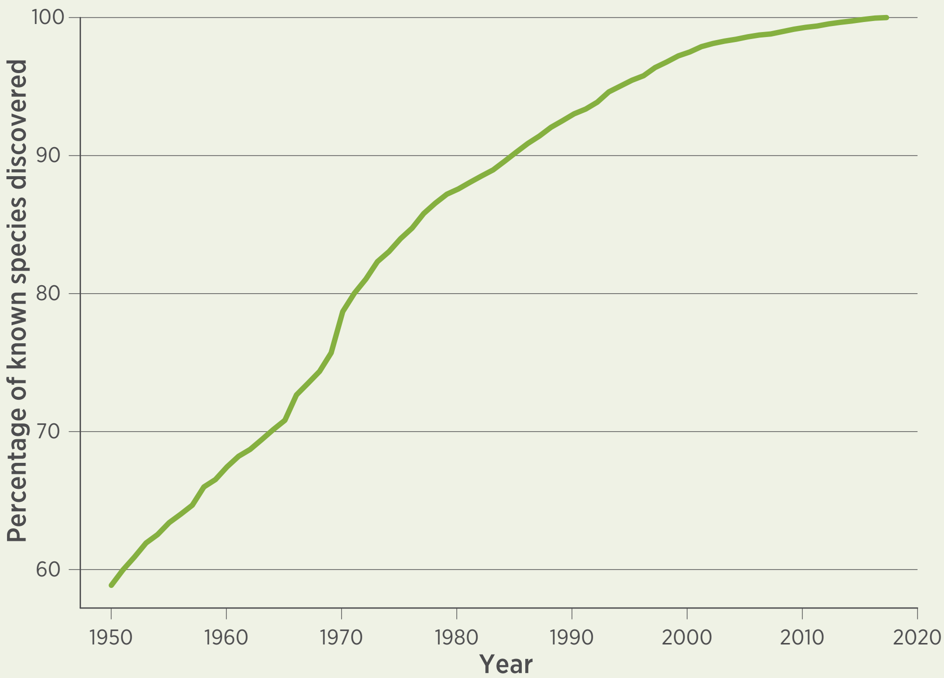


Figure 12 A discovery curve for NSW vascular plant species showing the rate of discovery since 1950

When knowledge of biodiversity is incomplete, patterns must be worked out from what is known. It is well understood that the combination of species found at a location is highly dependent on the physical environment (e.g. temperature, rainfall and soil type). To calculate this indicator, sets of known species of vascular plants were chosen that collectively and uniformly represent the full range of habitats in New South Wales. From these sets, trends for all plant species, including those yet to be discovered, can be figured out. For example, if a known species representing a distinctive environment in New South Wales declines due to habitat loss, other species dependent on that same environment will also decline, even if those species are not currently known to science. The species sets used for these indicators capture the range of habitats important to New South Wales plants. These results may also be representative of other groups that depend on plants, such as butterflies.

Programs like BioBlitz and Bush Blitz improve our understanding of biodiversity by bringing citizen scientists and experts together to record as many species as possible at a location over a short period of time. The more effort expended, the more species are likely to be found, making the contribution of citizen scientists especially important. Locations that have not previously been surveyed are likely to yield many species new to science, especially if they have distinctive physical environments not found elsewhere. By targeting distinctive environments across Australia, Bush Blitz has discovered over 1500 new species of plants and animals since 2010.


Plain tiger butterfly. Photo: R Nicolai

More information

Nipperess DA, Faith DP, Williams KJ, King D, Manion G, Ware C, Schmidt R, Love J, Drielsma M, Allen S, Gallagher R 2020, Expected survival and state of all known species: Data packages for the Biodiversity Indicator Program, first assessment, *SEED Portal*, datasets.seed.nsw.gov.au/dataset/biodiversity-indicator-program-data-packages.

Nipperess DA, Faith DP, Manion G, Williams KJ, King D, Schmidt RK, Gallagher RV, Allen S and Ware C 2020, *Using representative sets of known species and habitat condition to inform change in biodiversity status: A case example for vascular plants,* Biodiversity Indicator Program Implementation Report, Department of Planning, Industry and Environment, Sydney, Australia, www.environment.nsw.gov.au/research-and-publications/publications-search/using-representative-sets-known-species-habitat-condition-inform-change-biodiversity-status.

Decadal Plan Working Group 2018, *Discovering biodiversity: A decadal plan for taxonomy and biosystematics in Australia and New Zealand 2018–2028*, Australian Academy of Science and Royal Society Te Apārangi, Canberra and Wellington, www.science.org.au/support/analysis/decadal-plans-science/discovering-biodiversity-decadal-plan-taxonomy.

BIODIVERSITY

State of biodiversity

Theme insights

The State of biodiversity indicator theme measures the overall amount of biodiversity (genes, species and ecosystems) that currently exists. Where possible, it is expressed as a percentage of biodiversity that existed before the industrial era. Some indicators in this theme also use knowledge of the delay in decline in biodiversity (extinction lag), following loss of high-quality connected habitat, to estimate the amount of biodiversity likely to remain.

The precise status of existing living biodiversity is unknown, but is within a range defined by these measurements.

State of all known species

This indicator family estimates the overall diversity of all species that exist at present, including their genetic diversity, as a proportion of that which originally existed in pre-industrial New South Wales. The Habitat condition indicator family supports this assessment through the measure of ecological carrying capacity.

Indicators in this family are reported in the Report card: All known and undiscovered species. This assessment reports on vascular plants. In future assessments we will report on other biological groups (e.g. mammals, frogs and birds).

Key insights

In 2013, for a representative sample of all NSW vascular plant species, an average of 57% of the original amount of habitat remains effective.

Using the same data, 79% to 91% of original within-species plant genetic diversity is estimated to remain.

This analysis provides a separate line of evidence for the State of biodiversity theme, supporting the estimates derived using models of plant distribution patterns.

State of biodiversity including undiscovered species

This indicator family estimates the overall variety and number of all known and undiscovered genes, species and ecosystems that presently exist and are likely to remain, as a percentage of that which originally existed in New South Wales before any loss, alteration or fragmentation of habitats in the industrial era.

Key insights

In 2013, 80% to 84% of the original diversity of NSW plants were estimated as likely to persist, based on modelled patterns of vascular plant ecosystems and habitat condition data.

The lower estimate includes the effects of fragmentation, because small, isolated patches of habitat are more susceptible to ongoing loss of their original species.

National parks, being larger or more connected with other natural areas, retain more of their original diversity than other tenures.

Field monitoring of species and ecosystems

Long-term and/or wide-ranging field monitoring of species and ecosystems provides useful data and information to inform the status of and trends in biodiversity.

Key insights

Field monitoring programs in New South Wales provide critical data, information and insights for biodiversity conservation management and decision-making. Monitoring data is also used to inform or validate the modelling.

For example, mountain pygmy possums in Kosciuszko National Park are recovering, partly due to management of habitat and feral cat control.

Motion-sensor cameras are monitoring common species across eastern NSW parks and have so far recorded 160 species, including 15 that are threatened.

Long-term monitoring of kangaroos has improved understanding of how the decline and recovery of populations depends on the amount of rainfall.

Percentage of ecosystems persisting

Vascular plant ecosystems

80–84%

2013

Confidence

Adequate | Somewhat adequate | Limited | Very limited | Low

Report card: State of biodiversity including undiscovered species

The State of biodiversity including undiscovered species indicator family estimates the overall variety and extent of all known and undiscovered genes, species and ecosystems that presently exist and are likely to persist as a percentage of that which originally existed in New South Wales prior to any loss, alteration or fragmentation of habitats in the industrial era.

This assessment uses models of biodiversity patterns (see Box 5) to account for the decline in biodiversity based on the Habitat condition family of indicators. Each assessment applies to a particular biological group. Results are reported at three scales: all of New South Wales, bioregions and areas reserved under the *National Parks and Wildlife Act 1974* as of August 2017 (NPW reserves).

One indicator reports the status as at 2013 for vascular plant ecosystems:

- **Persistence of ecosystems (including undiscovered species)**
  This shows the percentage of diversity that exists or is likely to persist, using a classification representing known and undiscovered species.

Results for other biological groups are under development for inclusion in future report cards, as are other indicators in this family:

- **Within-species genetic diversity (including undiscovered species)**
  This shows the existing percentage of within-species genetic diversity of all known and undiscovered species.
- **Persistence of all species (including undiscovered species)**
  This shows the percentage of all species, including known and undiscovered species, that exist or are likely to persist.

All of New South Wales

In 2013, around 80% of the original diversity of vascular plant ecosystems in New South Wales were estimated as likely to persist.

This statewide percentage (Figure 13), was based on modelled patterns of pre-industrial vascular plant ecosystems and the ecological carrying capacity of habitats in 2013 (see Report card: Habitat condition, Figure 24). As part of this assessment of persisting diversity, we estimated the time-delayed effects (i.e. extinction lag) of reduced habitat resources due to fragmentation (see Box 6).

Of the 20% decline in original diversity of vascular plant ecosystems since the pre-industrial era, 16% is due to loss in ecological condition of habitats, and 4% is a further reduction due to fragmentation of remaining habitat (see Report card: Habitat condition, Figure 24 and Figure 25).

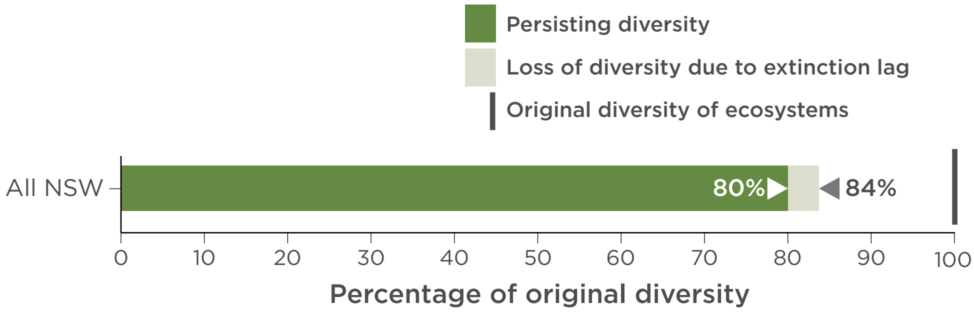


Figure 13 For all New South Wales: persisting diversity of vascular plant ecosystems. This shows the additional loss due to time-delayed effects of fragmentation (extinction lag), all relative to the original diversity of New South Wales since the pre-industrial era.

Bioregions

The diversity of vascular plant ecosystems persists unevenly across bioregions.

Across New South Wales in 2013, the diversity of vascular plant ecosystems persists most in the rugged highlands and coastal bioregions. Both the South East Corner and Australian Alps bioregions have 89% of their original diversity remaining (Figure 14a and Figure 15). However, the South East Corner bioregion originally supported three times the plant diversity of the Australian Alps bioregion (23% compared with 8%) (Figure 14b).

Plant diversity persists least in bioregions in the central wheat-sheep belt, such as the NSW South West Slopes and Riverina bioregions (68% and 70%, respectively, of their original diversity) (Figure 14a and Figure 15). These bioregions were originally characterised by extensive areas of grassy woodlands and many of those ecological communities, such as the White Box – Yellow Box – Blakely's Red Gum Woodlands, are listed as endangered (see Report card: Listed threatened species and ecological communities).

Bioregions such as the South East Corner originally contained more plant diversity (23% of that originally existing in New South Wales: Figure 14b) than western bioregions such as the Darling Riverine Plains (9%). More of that original diversity persists (89% in the South East Corner bioregion compared with 73% in Darling Riverine Plains bioregion).

Note that this indicator focuses on plant diversity. Other aspects of ecosystems, such as their ability to support seasonal migrants and roaming waterbirds, are not considered.

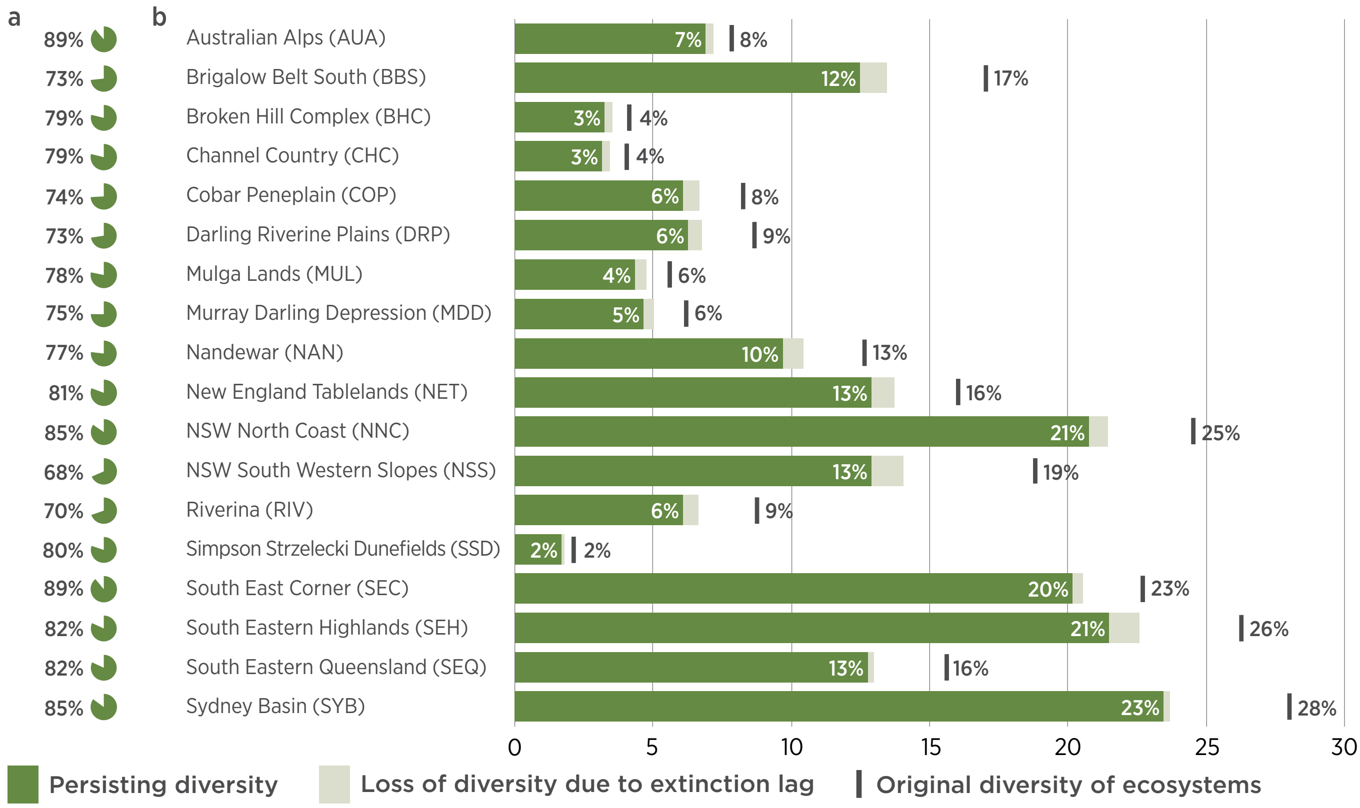


Figure 14 **For each bioregion: vascular plant ecosystem diversity persisting in 2013, loss of diversity due to extinction lag, and original diversity.** (a) Ecosystem diversity persisting in each bioregion in 2013, as a percent of original (pre-industrial) diversity (see Figure 15). (b) Persisting diversity, and the additional loss due to time-delayed effects of fragmentation (extinction lag), all relative to the original diversity of New South Wales. The sum of the percentages across the bioregions exceeds the total for New South Wales because some bioregions share the same ecosystems and their diversity (see Figure 16).

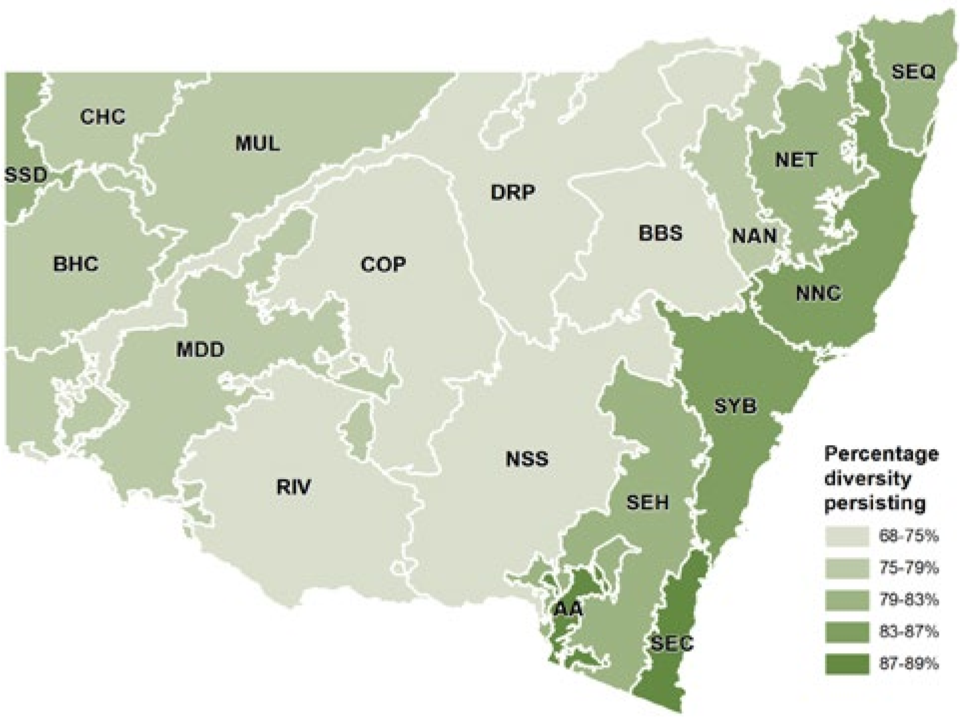


Figure 15 **For each bioregion: vascular plant ecosystem diversity persisting in each bioregion in 2013, as a percent of original (pre-industrial) diversity.** Shortened forms for bioregions are defined in Figure 14.

Areas reserved under the *National Parks and Wildlife Act 1974*

NPW reserves retain more of their original diversity than other tenures.

Within NPW reserves, 90% of the original diversity of vascular plant ecosystems persists (58% originally, 52% in 2013, Figure 16). Original diversity is that which existed in pre-industrial New South Wales.

Declines from the pre-industrial era to 2013 were due to local reductions in the extent and condition of habitat as well as fragmentation in surrounding areas. Across other tenures, 77% of the original diversity persists (92% originally, 71% in 2013).

Tenures other than NPW reserves contain over three times the unique diversity found in NPW reserves, but that diversity is spread over an area that is 10 times larger.

NPW reserves cover an area of about 7.1 million hectares (see Case study: National parks and conservation areas) and other tenures cover about 74 million hectares. Of the 80% total diversity of vascular plant ecosystems that is estimated as likely to persist in 2013 in New South Wales, NPW reserves uniquely contribute 9% and share 43% with areas under other tenures, to total 52% (sum of y and z in Figure 16b). Other tenures uniquely contribute 28% of the state total of 80%. This is about three times more unique diversity than within NPW reserves (28% vs 9%), across an area that is ten times larger (74 million hectares vs 7.2 million hectares). This means that certain types of vascular plant ecosystems are not found in any NPW reserve. These other tenures will continue to have an important role in conserving the diversity of all plants and animals in New South Wales (see Case study: Conservation on private land).

Because some types of plant diversity are now largely only found in NPW reserves, due to clearing and fragmentation in other tenures, the 2013 proportion that uniquely persists in NPW reserves has increased (from 8% to 9%, Figure 16). In other tenures, this proportion has decreased by two-thirds (from 42% to 28%, Figure 16). This loss of persisting diversity across other tenures accounts for the majority of the 20% loss of original plant diversity (80% remaining statewide).

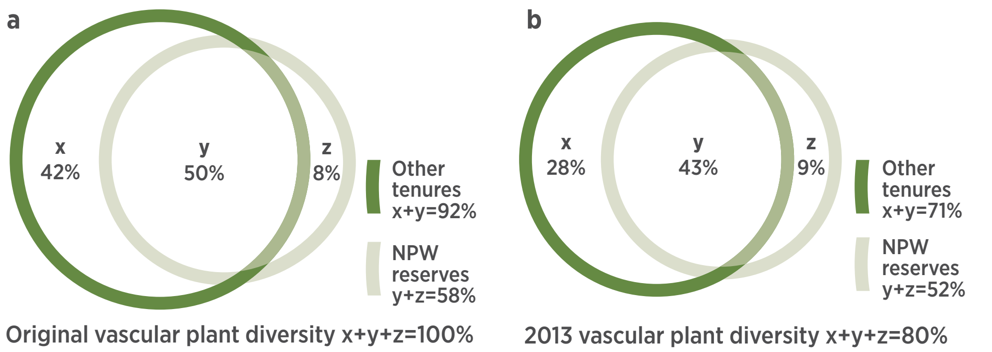


Figure 16 **Diagram showing how the unique and shared contributions of persisting diversity of vascular plant ecosystems are calculated for NPW reserves and other tenures: (a) Original pre-industrial era and (b) 2013.** Total diversity in New South Wales is the sum of x, y and z, where x = other tenures' unique diversity, y = NPW reserves and other tenures' shared diversity, and z = NPW reserves' unique diversity. All percentages are relative to the original (pre-industrial era) diversity of New South Wales.

Box 5 How are patterns of ecosystem diversity modelled and reported?

Diversity of ecosystems was estimated using a generalised dissimilarity model which summarises how the species found at different locations relate to variation in suitable habitats, characterised by climate, soils and landform. The model uses field observations for a particular biological group as an input, such as vascular plants (as used in this indicator), mammals, birds, reptiles, amphibians and certain invertebrate groups, where distributions are adequately known.

The model predicts the proportion of species shared between pairs of locations, varying from 0 (all species are different) to 1 (all species are shared). The results, predicted across New South Wales and neighbouring locations, were classified to represent patterns of variation in ecosystem-level diversity for that biological group, while retaining information about the species shared between those ecosystems.

This approach allows estimates to be made of the contribution that each location makes to the diversity in New South Wales, while also accounting for how ecosystems occurring in different places of similar habitat are related. This so-called 'principle of regional biodiversity complementarity' is used to estimate the degree to which different regions contribute to the full complement of unique ecosystems in New South Wales (for example, as shown for vascular plants for NPW reserves in Figure 16, and in Figure 14 and Figure 15 for bioregions). Complementarity is used to estimate a given ecosystem's unique diversity and how much is shared elsewhere (as shown for a hypothetical reporting region in Figure 17).

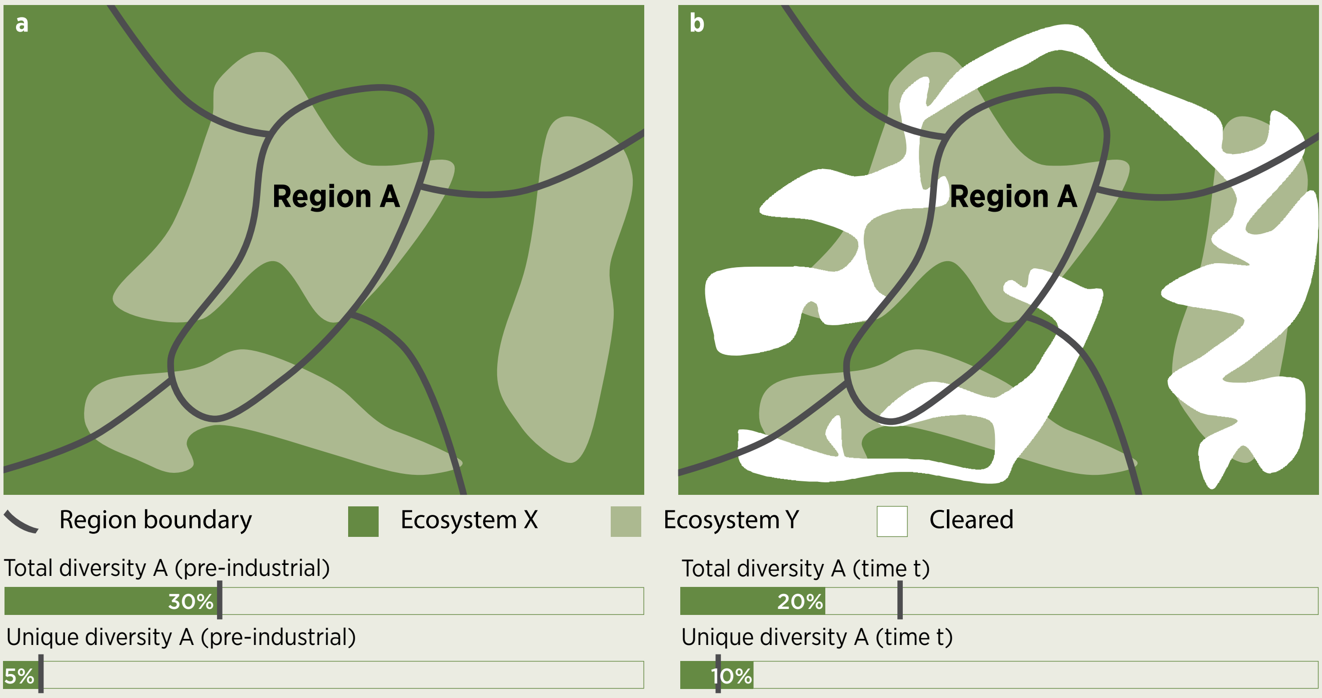


Figure 17 Applying the principle of regional biodiversity complementarity to calculate the total and unique diversity of hypothetical reporting for Region A, which shares amounts of two imaginary ecosystems (X and Y) with four other adjacent regions within a jurisdiction (as the bounding box). Originally (see a), the total diversity of Region A was at its maximum (30% of the total diversity of all regions combined) and its unique contribution to diversity was 5%, as its ecosystems were also represented in other regions. At time t (see b), clearing of habitat (shown as white), especially of ecosystem Y, left Region A relatively intact with more clearing in the other four regions. Region A's total diversity was reduced to 20% of that originally found there, but its overall unique contribution to the diversity that remains increases to 10%, as some of the diversity shared with neighbouring regions was removed.

Box 6 Using extinction lag of fragmented areas to estimate persisting diversity

Following clearing and fragmentation, remaining areas of habitat are susceptible to local species extinctions leading to ongoing loss of some or all of their original diversity. A time lag often follows before diversity stabilises at levels that can be supported by the reduced habitat resources, and therefore determines its carrying capacity. This extinction lag is defined as the time-delayed loss of sensitive species in remnant natural areas following clearing.

In fragmented habitats (see Box 7), sensitive individuals and populations of species become isolated and succumb over time to inadequate resources, reduced colonisation and dispersal abilities, reduced mating or pollination opportunities and a diminished gene pool.

The precise status of existing living diversity in fragmented habitats is unknown, but is within a range of values depending on whether the lag effects of extinction have stabilised:

- The maximum value of persisting diversity is calculated using ecological condition (see Report card: Habitat condition), which accounts for local clearing and loss of condition, but not the extinction lag.
- The minimum value of persisting diversity is calculated using ecological carrying capacity (see Report card: Habitat condition), which accounts for local clearing, loss of condition, and extinction lag through processes related to habitat fragmentation.

Some local extinctions may be averted through targeted management responses that supplement the available habitat resources or facilitate dispersal.

The relationship with persistence is inferred from how much effective habitat remains for each ecosystem as a proportion of its original capacity. Effective habitat is the measure we use to report on ecological carrying capacity (see Report card: Habitat condition). As this effective habitat area declines, the proportion of diversity persisting also declines. Initially, loss in diversity is not as fast as expected because of alternative locations for species to persist. Effective habitat is the measure we use to report on ecological carrying capacity (see Report card: Habitat condition). As these alternatives disappear, the rate of diversity loss increases until it is faster than the rate of loss of effective habitat. Figure 18 shows where each bioregion is positioned along this theoretical curve. Several bioregions are close to a point of accelerating diversity loss.

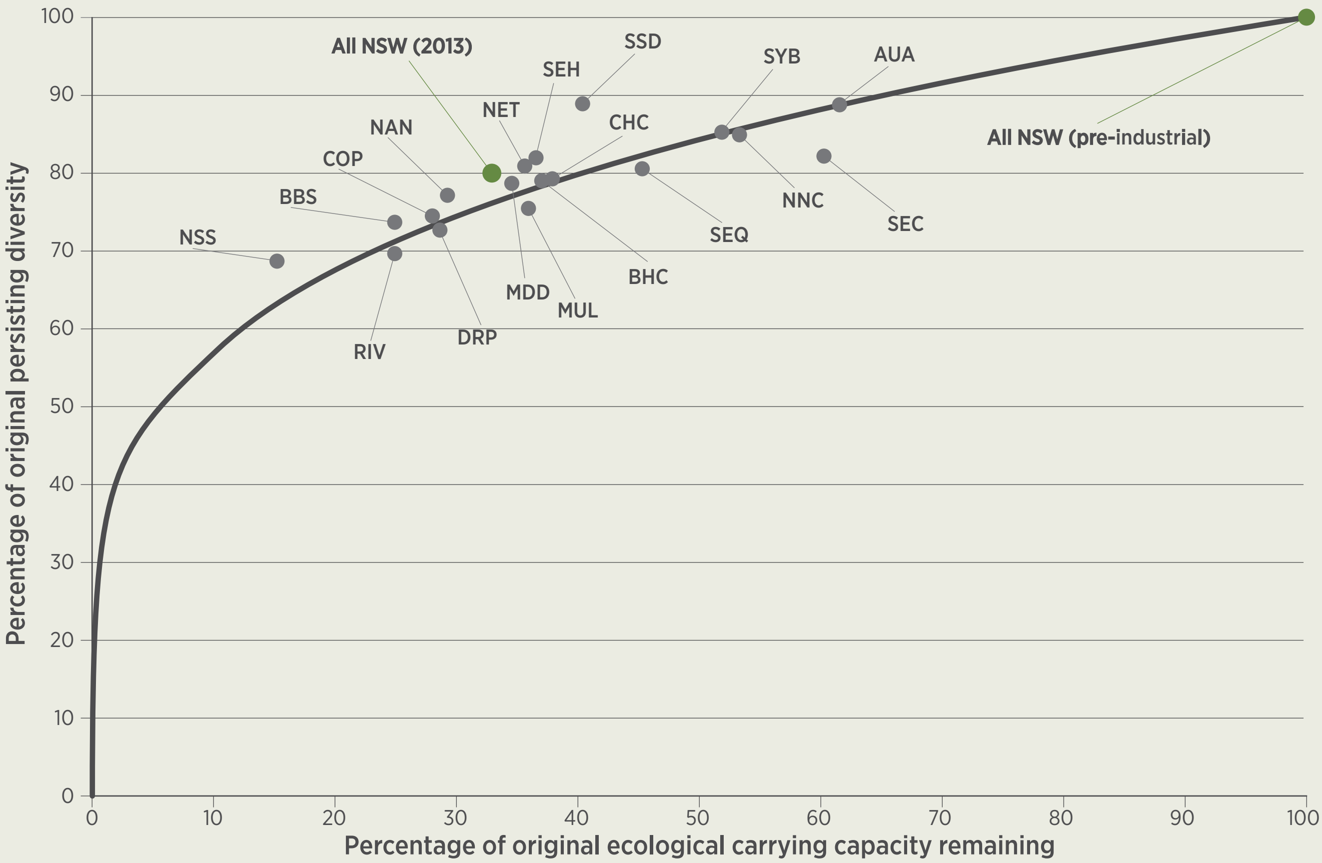


Figure 18 Percentage of persisting diversity of vascular plant ecosystems for each bioregion, plotted against percentage of ecological carrying capacity remaining. The line shows the theoretical relationship between effective habitat and persisting diversity. Shortened forms for bioregions are defined in Figure 4.

More information

Drielsma M, Love J, Williams K, White M & Ferrier S 2020, *A model-based indicator of capacity for biodiversity persistence using vascular plant records and habitat condition,* Biodiversity Indicator Program Implementation Report, Department of Planning, Industry and Environment, Sydney, Australia, www.environment.nsw.gov.au/research-and-publications/publications-search/modelbased-indicator-capacity-biodiversity-persistence-using-vascular-plant-record-habitat-condition.

Drielsma M, Love J, Williams K, White M & Ferrier S 2020, Persistence of ecosystems (including undiscovered species) (vascular plants): Data packages for the Biodiversity Indicator Program, first assessment, *SEED Portal*, datasets.seed.nsw.gov.au/dataset/biodiversity-indicator-program-data-packages.

Field monitoring of species and ecosystems

Long-term and/or wide-ranging field monitoring of species and ecosystems provides useful and complementary measures of the status of and trends in biodiversity. Other indicators that rely on indirect measures of biodiversity (such as from remote sensing and modelling) use field-based observations of biodiversity from sites with relatively intact and natural vegetation to complement the indirect measures.

These indicators are under development:

- **Species trends**
  This shows trends in the extent, abundance or number of native species measured from long-term or wide-ranging field monitoring programs.
- **Ecosystem trends**
  This shows trends in the extent, abundance or number of native ecosystems.

In this first *NSW Biodiversity Outlook Report,* case studies are reported for this indicator family.

Malleefowl, a threatened, large ground-dwelling native bird. Photo: Dave Curtis

Species trends

Case study: Mountain pygmy-possum

Numbers of mountain pygmy-possums at cat-controlled sites are higher than they were before the drought.

The endangered mountain pygmy-possum.
Photo: Linda Broome/DPIE

Populations of the endangered mountain pygmy-possum have been monitored every spring at Mt Blue Cow ski resort in Kosciuszko National Park since the time the site was developed in 1986.

The average population at Mt Blue Cow from 1986 to 1999 was 39. Numbers declined sharply from 1999 to 2000 and remained low during the Millennium Drought (1997 to 2009). A wildfire burnt 80% of vegetation cover on the site in 2003.

The population has recovered due to:

- the Millennium Drought breaking in 2010
- vegetation cover re-establishing on the site after the fire
- additional movement corridors being installed
- feral cat control being increased since December 2010 to include summer as well as winter trapping (Figure 19).

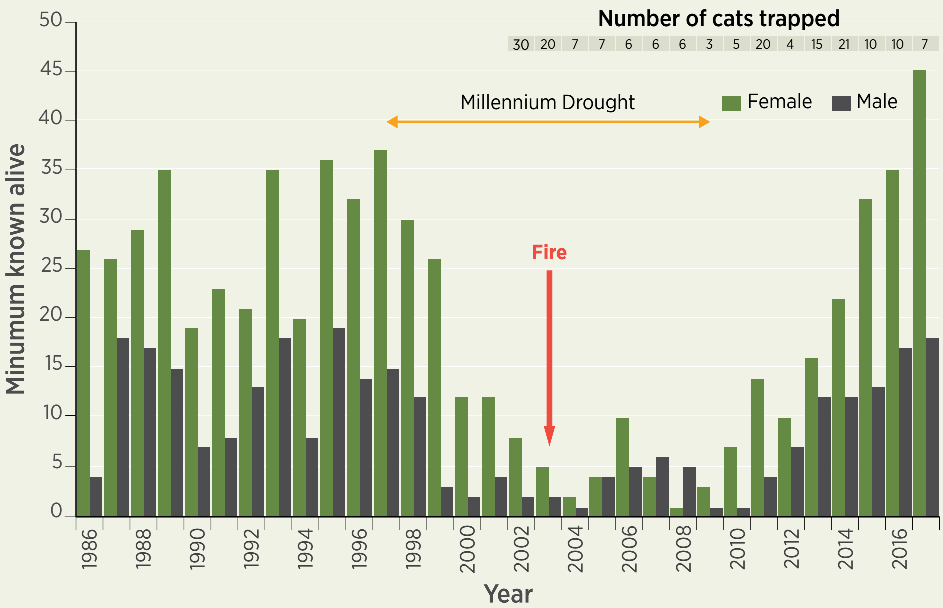


Figure 19 Abundance of mountain pygmy-possum at Mt Blue Cow from 1986 to 2017

Population sizes, diet and genetics are monitored annually at six sites in Kosciuszko National Park, snow duration at eight sites, and the relative abundance of bogong moths at three sites.

More information

OEH 2017, *Mountain pygmy-possum profile*, NSW Office of Environment and Heritage, Sydney, Australia, viewed 12 September 2019, www.environment.nsw.gov.au/threatenedSpeciesApp/profile.aspx?id=10114.

Case study: WildCount 2012 to 2016

WildCount can confidently detect changes in the occurrence of species over a 10-year period.

Long-nosed bandicoot captured by a WildCount camera.
Photo: WildCount/DPIE

WildCount is a terrestrial animal monitoring program that uses 'camera trap' technology. The program is monitoring species trends for a range of widespread, common species in eastern NSW parks over a 10-year period.

About 160 animal species have been recorded and new locations have been identified for more than 15 threatened species.

Occupancy models, which have been developed for 39 species, indicate that two species are likely to be declining (long-nosed bandicoot and rabbit), and five species are likely to be increasing (mountain brushtail possum, satin bowerbird, spotted quail-thrush, wonga pigeon and feral pig). The other 32 appear to be stable.

Through rigorous survey design and sampling efforts, the Department can identify broad species trends that are of conservation significance, such as increases in pest species and declines in native species (Figure 20). Understanding these changes will help the National Parks and Wildlife Service (NPWS) manage parks.

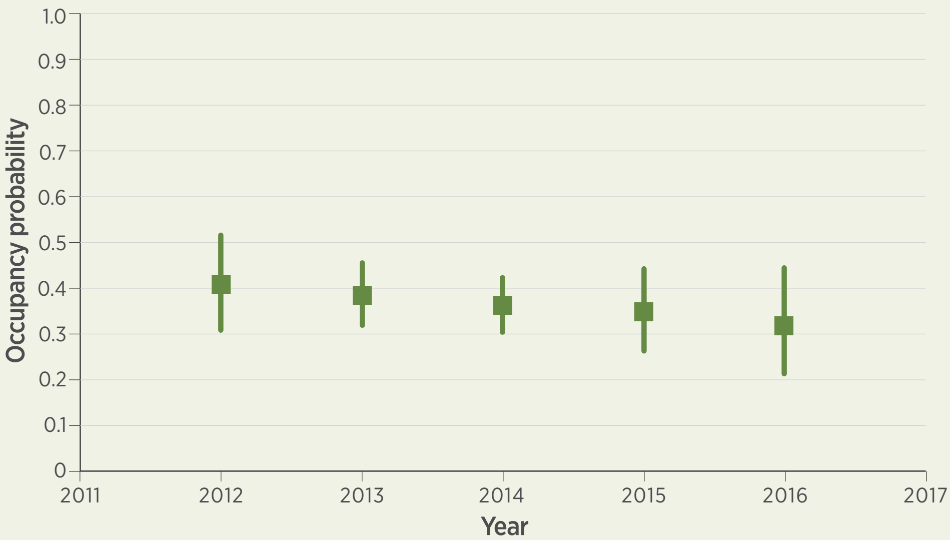


Figure 20 Occupancy model for long-nosed bandicoot showing a likely decline in occupancy between 2012 and 2016. Occupancy models have been modelled for 38 other species. These models show the proportion of sites occupied by the species. An occupancy of 1 would mean that every site is occupied. There is a 95% chance that the true value is within the range shown by the green vertical line. The point on the line shown by the green square is the most likely value.

Annual surveys will continue until 2021. Analyses using additional environmental data are likely to improve our understanding of species trends.

More information

DPIE 2019, *WildCount*, NSW Department of Planning, Industry and Environment, Sydney, Australia, viewed 12 September 2019, www.environment.nsw.gov.au/topics/animals-and-plants/surveys-monitoring-and-records/native-animal-monitoring.

Case study: Monitoring kangaroos

Repeatable surveys help identify population trends and improve our understanding of how kangaroos respond to conditions.

Red kangaroo, Willandra National Park. For more than 42 years, the Department has estimated population size of kangaroos in NSW commercial harvesting zones.

Photo: John Spencer/DPIE

The three largest kangaroo species in New South Wales (red kangaroo, western grey kangaroo and eastern grey kangaroo) are among the most abundant mammals in the state.

Kangaroo research, monitoring and management has been conducted under the NSW Kangaroo Management Program since the 1970s. Population sizes have been estimated in NSW commercial harvesting zones as follows:

- New South Wales Western Division since before 1975
- Northern Tablelands since 2001
- South-east New South Wales since 2003
- Central Tablelands since 2010.

This is the longest running field monitoring study of wildlife in Australia, and possibly one of the longest running terrestrial wildlife monitoring programs in the world.

Aerial survey methods have improved over time to increase the precision and accuracy of population estimates.

Figure 21 Changes in the estimated population size of kangaroos in NSW commercial harvesting zones over 42 years. Population declines are consistent with drought periods and population recoveries are consistent with increased rainfall.

The Western Division is surveyed every year (July to June) and the tablelands regions are monitored on rotation, once every three years (August to September).

More information

DPIE 2019, *Kangaroo management*, NSW Department of Planning, Industry and Environment, Sydney, Australia, viewed 12 September 2019, www.environment.nsw.gov.au/topics/animals-and-plants/wildlife-management/kangaroo-management.

DPIE 2019, *Kangaroo population monitoring and reporting*, NSW Department of Planning, Industry and Environment, Sydney, Australia, viewed 12 September 2019, www.environment.nsw.gov.au/topics/animals-and-plants/wildlife-management/kangaroo-management/kangaroo-population-monitoring-and-reporting.

OEH 2017, *NSW Commercial kangaroo harvest management plan 2017–21*, NSW Office of Environment and Heritage, Sydney, Australia, www.environment.nsw.gov.au/research-and-publications/publications-search/nsw-commercial-kangaroo-harvest-management-plan-2017-2021.

Ecosystem trends

Case study: Spinifex–mallee ecosystem trends

During the last five years, some mallee components were stable and others declined slightly.

Hakea shrubs in the spinifex–mallee ecosystem had large declines (22%) due to goats and rabbits eating young plants.
Photo: Mark Tozer/DPIE

The biodiversity within a semi-arid spinifex–mallee ecosystem in two protected areas, Tarawi Nature Reserve and Scotia Sanctuary, has been monitored since 1998. This case study outlines trends for the last five years (2012 to 2017). The trends do not represent those in spinifex–mallee outside reserves.

The dominant mallee eucalypts, which provide shelter and food for birds, mammals, reptiles and invertebrates, were essentially stable. There were small declines in small burnt areas.

Hummock grasses (spinifex), critical for ground fauna and seed-eaters, were stable, but declined in small areas treated with planned fires.

The number of malleefowl mounds occupied was low, but no trend relative to numbers in other years was observed. Over the last 20 years, the number of mounds occupied each year has fluctuated between zero and eight. Ground fauna (especially mammals) had large declines in young mallee (burnt in last 35 years), but not in old mallee (unburnt for more than 90 years). Declines may have been due to increased predator activity. Changes in species richness in young and old mallee were broadly similar. The trends in these managed reserves are unlikely to represent trends in the broader landscape. The broader landscape is subject to greater threats from more intense land use, overgrazing and feral animal activity.

Spinifex–mallee vegetation.
Photo: Mark Tozer/DPIE

Surveys of the five ecosystem components will continue until 2021.

More information

DPIE 2019, *Malleefowl native animal facts*, NSW Department of Planning, Industry and Environment, Sydney, Australia, viewed 12 September 2019, www.environment.nsw.gov.au/topics/animals-and-plants/native-animals/native-animal-facts/malleefowl.

OEH 2017, *Malleefowl profile*, NSW Office of Environment and Heritage, Sydney, Australia, viewed 12 September 2019, www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10459.

University of New South Wales n.d., *Mallee ecosystem dynamics*, UNSW, viewed 12 September 2019, www.ecosystem.unsw.edu.au/research-projects/terrestrial-ecosystems/ecosystem-dynamics/mallee-ecosystem-dynamics.

ECOLOGICAL INTEGRITY

Ecosystem quality

Theme insights

The Ecosystem quality indicator theme measures habitat condition, showing the capacity to maintain natural functions and processes that support terrestrial species and ecosystems in New South Wales. It also measures pressures that threaten habitat condition or biodiversity, which are needed to understand change in the status of ecosystem quality.

Habitat condition

This indicator family measures habitat condition, showing the capacity to maintain natural functions and processes that support terrestrial species and ecosystems in New South Wales.

Key insights

Using remote-sensing and land-use data to track change, about one-third (33%) of habitats' original effectiveness for supporting native species in New South Wales remained in 2013.

Fragmentation — which affects the ability of species to forage easily for food and shelter, find mates, disperse and migrate — has reduced the effectiveness of remaining habitat by 25%.

Nearly two-thirds (62%) of the area covered by NPW reserves retain at least 60% of original ecological carrying capacity, whereas only 2% of the total area of other tenures have that level of habitat condition.

Other tenures are Crown reserves, forest reserves, private land, vegetation management areas and other lands that provide important supporting habitat for biodiversity.

Further development of our indicators in New South Wales will better represent the conditions outlined above.

Pressures

This indicator family measures major known pressures that cause biodiversity loss or threaten the quality of ecosystems and, therefore, affect the survival of many species or entire ecological communities.

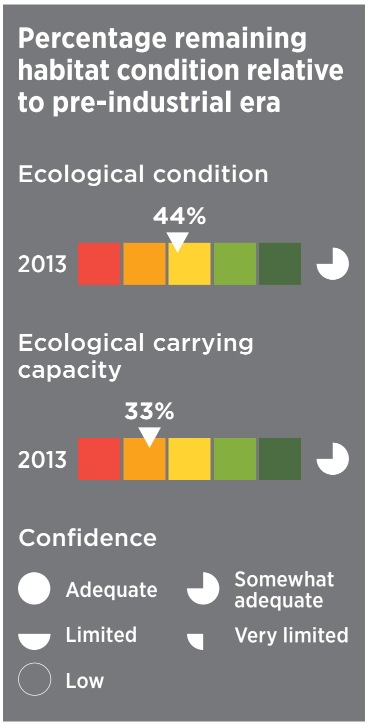
Key insights

Biodiversity is threatened by a range of pressures, such as habitat loss, climate change and pests and weeds. Monitoring of these pressures and their impacts on species and ecosystem trends is critical to understanding how to respond.

In national parks, specific plans of management focus on strategies for controlling pest animals and weeds, and inappropriate hydrological regimes.

Recent successes include:

- New South Wales being on track to reach the goal of eradicating hawkweed by 2025
- environmental water extending the duration of natural flood events and supporting large-scale waterbird breeding.



Report card: Habitat condition

The Habitat condition indicator family measures the capacity of habitat to support native plants, animals and ecosystems in New South Wales, and considers both its condition and connectivity.

Three indicators report the status at 2013 as a percentage relative to that in the pre-industrial era:

- **Ecological condition of terrestrial habitat**
  This shows the quality of terrestrial habitat at each location, estimating its intactness and naturalness without considering the indirect effects of surrounding habitat loss and fragmentation.
- **Ecological connectivity of terrestrial habitat**
  This shows the contribution each location makes to the connectivity of terrestrial habitat by way of its ecological condition and relative position in the landscape (e.g. as part of a habitat corridor or as a stepping stone).
- **Ecological carrying capacity of terrestrial habitat**
  This shows the effectiveness of habitat at each location to support native species and ecosystems, considering its ecological condition and the effect of surrounding habitat loss and fragmentation on biological movement such as foraging, dispersal and migration.

Results are reported at three scales: all of New South Wales, bioregions and NPW reserves.

Ecological condition and ecological carrying capacity were used to estimate the State of biodiversity including undiscovered species indicator family, and ecological condition was used to estimate Expected survival of all known and undiscovered species indicator family. See separate report cards.

The following indicator is under development: Ecosystem function of terrestrial vegetation.

All of New South Wales

33% of NSW's original habitat effectiveness for supporting native species remained in 2013.

Since the pre-industrial era, the loss and alteration of habitat up to 2013 has directly reduced the ecological condition of habitat in New South Wales from its original of 100% to 44% (Figure 22 and Figure 23). The ongoing, indirect effects of loss, alteration and fragmentation of habitat (see Box 7), have reduced the average ecological carrying capacity of remaining habitats in New South Wales by 25% (to 33%). In 2013, approximately one-third of the original capacity of habitat in the pre-industrial era remains (see Figure 22 and Figure 23).

Other processes not considered here may also affect the capacity of habitats to support their native species (see case studies included in the Pressures section).

Results for ecological condition and ecological carrying capacity presented here are based on 2013 data. The status for 2017 will be estimated when required datasets become available, including remotely sensed vegetation cover and vegetation integrity scores currently under development (see Box 8).

Bioregions

The pattern of habitat loss and degradation varies between bioregions.

The amount of effective habitat remaining in each bioregion has implications for its diversity of species and ecosystems, and their ability to persist (see Report card: State of biodiversity including undiscovered species and Report card: All known and undiscovered species).

Habitat in the Australian Alps, South East Corner and NSW North Coast bioregions has remained the most intact relative to other bioregions with 53% to 62% of their original ecological carrying capacity remaining (Figure 23).

Land has been used more intensively in the NSW South Western Slopes, Brigalow Belt South and Riverina bioregions, resulting in less remaining and more fragmented habitat relative to other bioregions, and therefore, less remaining ecological carrying capacity overall (15% to 25%).

Areas reserved under the *National Parks and Wildlife Act 1974*

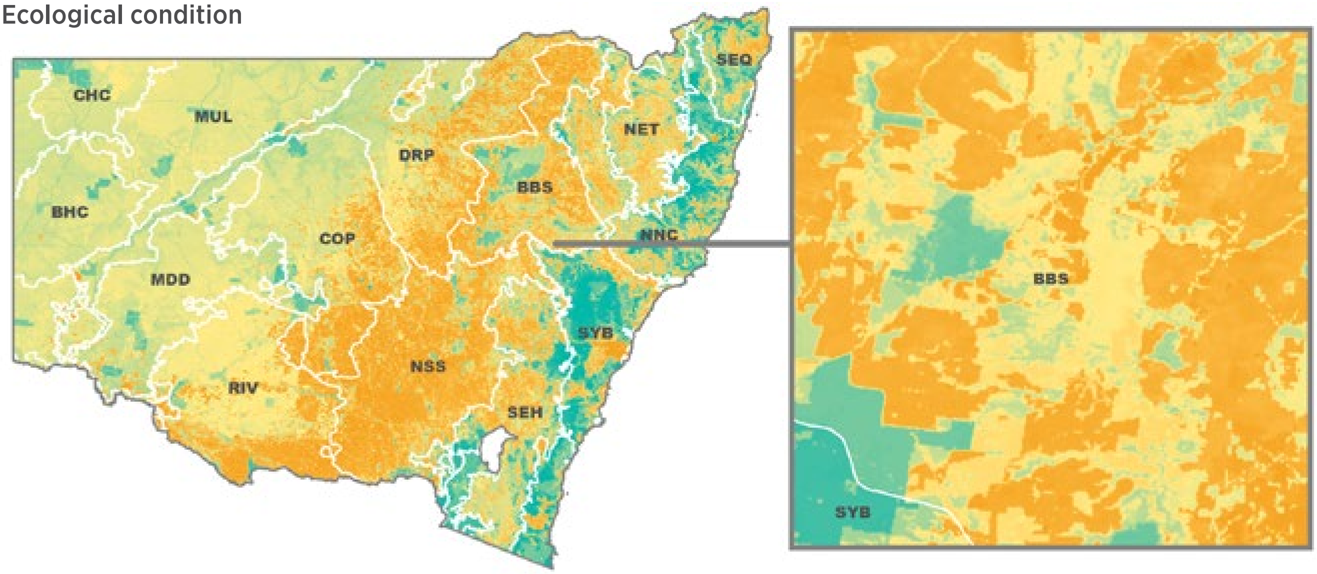
62% of the area of NPW reserves — and 2% of the area of other tenures — have an ecological carrying capacity of at least 60%.

Areas of high ecological carrying capacity (at least 60%) occur both inside and outside of NPW reserves (Figure 25). NPW reserves as of August 2017 comprised about 7.1 million hectares that were primarily managed for conservation, of which over 4.4 million hectares (just under 62% of their total area) had an ecological carrying capacity of at least 60% (shown as a brown vertical line in Figure 25).

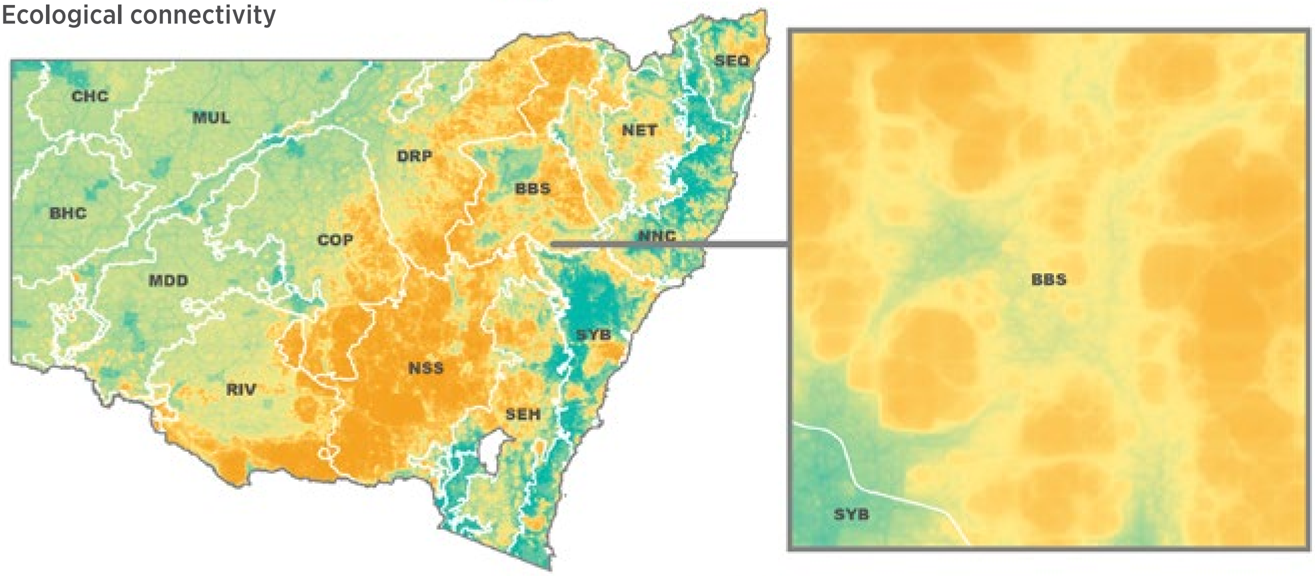
Around 1.7 million hectares of land on other tenures has an ecological carrying capacity of at least 60% (Figure 25). While this is only 2% of the total area of other tenures (approximately 73.9 million hectares), it represents over one-quarter (28%) of all lands with an ecological carrying capacity of at least 60% (that is, 1.7 million of 6.1 million hectares). Some of these lands are perpetual conservation areas such as forest reserves (see Case study: National parks and conservation areas). Other tenures also include Crown reserves, private land conservation and vegetation management areas.

The unique contribution that each area makes to diversity, or shares with other areas, can be estimated (see Box 5). This estimation, together with its ecological condition and carrying capacity, can be used to measure the persistence of biodiversity (see Report card: State of biodiversity including undiscovered species) or to help inform conservation assessments.

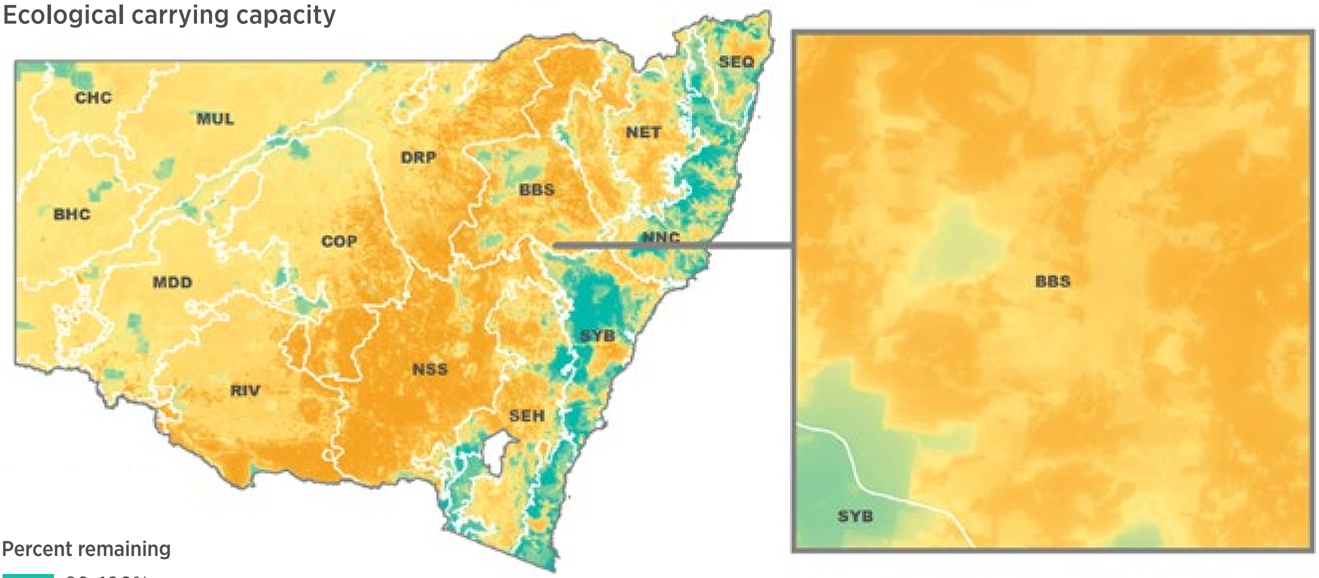
a Ecological condition



b Ecological connectivity



c Ecological carrying capacity



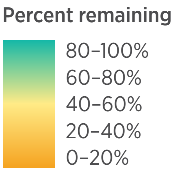


Figure 22 Ecological condition, ecological connectivity and ecological carrying capacity of terrestrial habitat in New South Wales (left) and for part of the Brigalow Belt South bioregion, adjacent to the Sydney Basin bioregion (right) at 2013. Results are a percentage relative to that of the pre-industrial era (which by definition equals 100%). Results are given in Figure 23. Results represent habitat as of 2013.

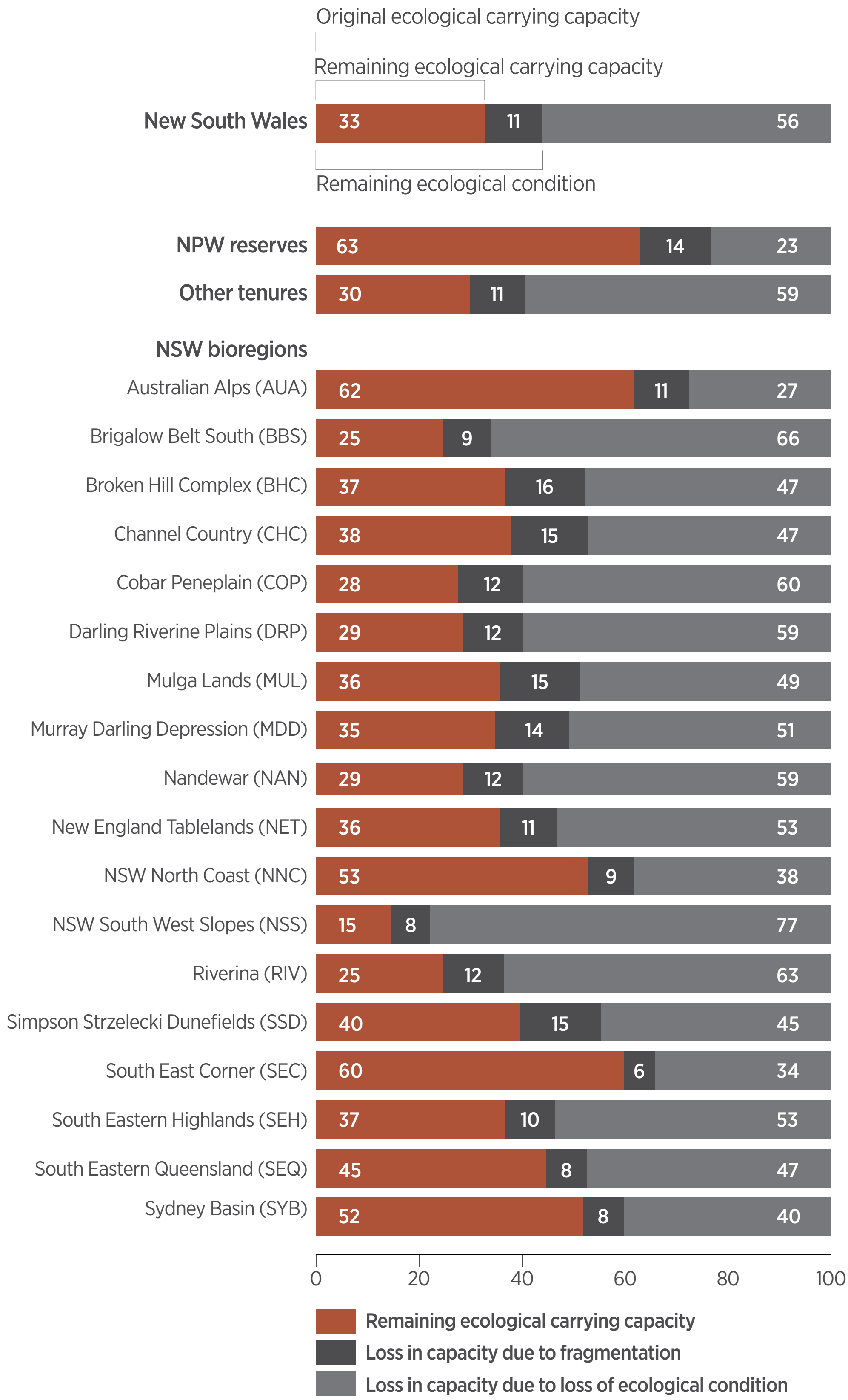


Figure 23 Remaining ecological carrying capacity (brown) due to loss of ecological condition (light grey), and additional loss of capacity due to fragmentation (dark grey), for all New South Wales, NPW reserves, other tenures, and bioregions. Locations of bioregions are shown in Figure 22. Results use ecological condition as of 2013. NPW reserves are as of August 2017.

Box 7 Ecological condition, connectivity and carrying capacity

Habitat supports native plants, animals, populations and ecological communities by providing the resources they need as individuals and in groups. Habitat that is in better condition is more capable of supporting healthy ecosystems and a wider range of native species.

Ecological carrying capacity accounts for the quality and connectivity of habitat. Well-functioning connectivity allows species to forage easily for food and shelter, find mates, disperse (both fauna and flora) and migrate. The ecological condition of the hypothetical habitat in the circle in both landscapes shown in Figure 24 might be the same, but habitat in Landscape a is better connected to neighbouring habitats than that shown in Landscape b, and therefore, is more effective in supporting its native plants, animals and ecosystems.

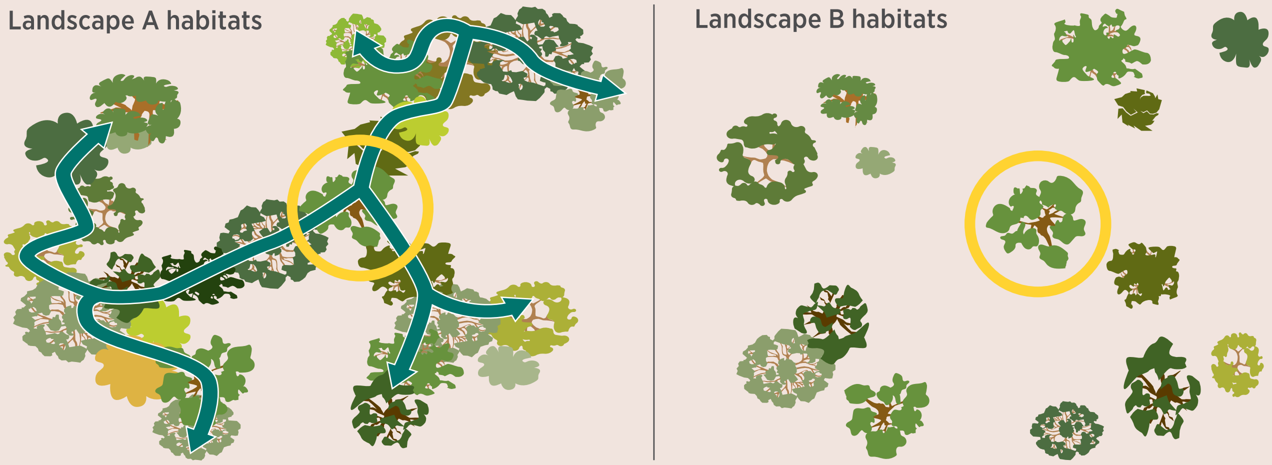


Figure 24 Two hypothetical habitat configurations, Landscape A and Landscape B, with different connectivity to surrounding habitats

Habitat with high ecological condition may not have high ecological connectivity or ecological carrying capacity if its surrounding habitat is highly fragmented. However, habitat with low to moderate ecological condition or ecological carrying capacity may have high ecological connectivity if it contributes to important connections (corridors or stepping stones) between other habitats. Examples of these differences due to fragmentation are shown for part of the Brigalow Belt South bioregion, adjacent to the Sydney Basin bioregion (Figure 22).

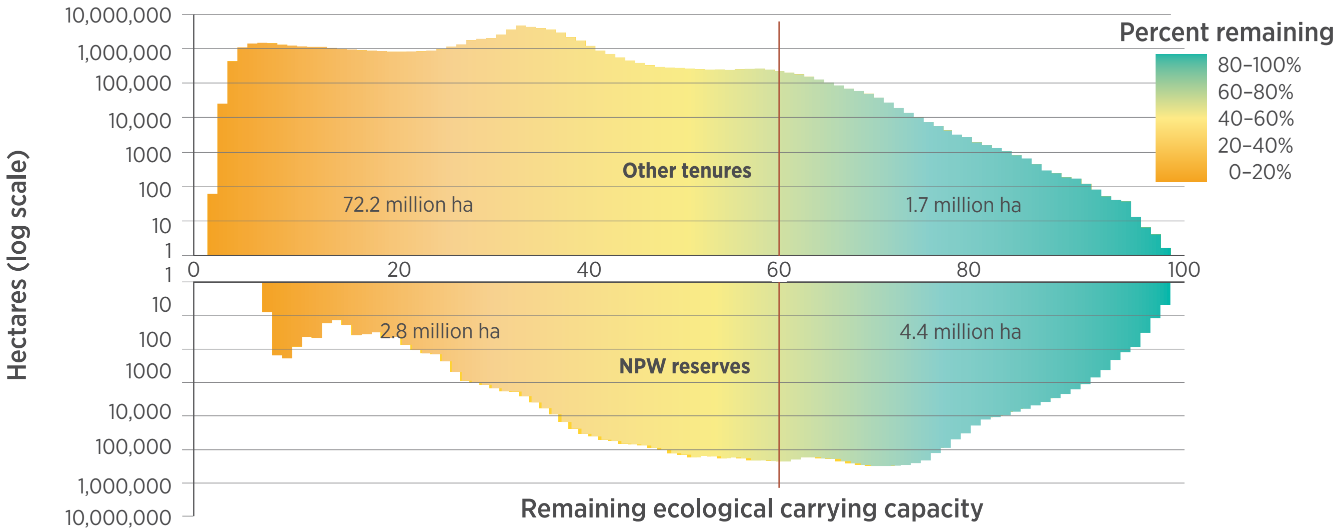


Figure 25 Histogram showing the distribution of remaining ecological carrying capacity values in NPW reserves (bottom) and other tenures (top). Area on the vertical axis is in log 10 scale and percent remaining ecological carrying capacity on the horizontal axis. NPW reserves are as of August 2017. (The total area of NPW reserves in this figure is calculated using GIS data and differs slightly from the area calculated using finer-scale, gazette notice information.)

Box 8 Calculating vegetation integrity scores to inform ecological condition

The New South Wales Biodiversity Assessment Method (BAM) has developed an on-ground approach to assess the structure, composition and function of vegetation which is used to calculate a vegetation integrity score.

Individual sites can be assessed and then scored relative to the remaining 'best-on-offer' habitats. These best-on-offer sites — and the benchmarks that underpin them — are those sites within the landscape with higher numbers of native plant species, and greater structural complexity and functional components relative to other sites of the same vegetation type.

Using these data-driven benchmarks, we can retrospectively calculate (using, for example, the BAM Calculator) structural and compositional components of the vegetation integrity score for over 35,000 sites stored in the NSW BioNet system. These data were not complete at the time this indicator was being developed. However, they will be used in future assessments to train, calibrate and validate ecological condition where remote-sensing imagery shows no significant change has occurred.

More information

Love J, Drielsma MJ, Williams KJ & Thapa R 2020, *Integrated model–data fusion approach to measuring habitat condition for ecological integrity reporting: Implementation for habitat condition indicators*, Biodiversity Indicator Program Implementation Report, NSW Department of Planning, Industry and Environment, Sydney, Australia, www.environment.nsw.gov.au/research-and-publications/publications-search/integrated-model-data-fusion-approach-measuring-habitat-condition-ecological-integrity-reporting.

Love J, Drielsma MJ, Williams KJ & Thapa R 2020, Habitat condition: Data packages for the Biodiversity Indicator Program, first assessment, *SEED Portal*, datasets.seed.nsw.gov.au/dataset/biodiversity-indicator-program-data-packages.

OEH 2017, *Native vegetation integrity benchmarks: An information sheet*, NSW Office of Environment and Heritage, Sydney, Australia, www.environment.nsw.gov.au/research-and-publications/publications-search/native-vegetation-integrity-benchmarks.

Pressures

The Pressures indicator family identifies pressures which degrade the quality of ecosystems or the survival of species or ecological communities. The impact of a pressure will depend on the current state, resilience and sensitivity of the species, ecological community or ecosystem it is acting on. Information about pressures and threatening processes helps develop the Ecological condition of terrestrial habitat indicator, and provides a basis for identifying cause of changes in condition.

These indicators are under development:

- **Land-use and management practices**
  This indicator monitors the area of, and trends in, land use, ordered by the potential degree of modification from a nominated 'natural state'. The mapping of land use does not necessarily depict impact, since the land classification may indicate potential to modify rather than actual modification.
- **Native vegetation extent**
  This indicator monitors the extent of native woody and non-woody vegetation cover based on remote sensing and other data supporting detection of natural areas.
- **Inappropriate fire regimes**
  This shows the extent and impact of altered fire regimes on sensitive ecosystems.
- **Inappropriate hydrological regimes**
  This shows the extent and impact of altered hydrological regimes on sensitive ecosystems.
- **Invasive species (pests, weeds, disease)**
  Invasive species are known to be threats to many species and ecological communities.
- **Altered climatic regimes, variability and extremes**
  The indicator is the mapped extent, frequency and intensity of physiological stress predicted for plants and/or animals due to climatic extremes, and how much these vary from the usual climate in pre-industrial times, assessed for sensitive species and ecosystems. This indicator will evolve as methods for modelling and monitoring climate change impacts on biodiversity are further developed.

In this first *NSW Biodiversity Outlook Report*, case studies are reported for this indicator family.

Land-use and management practices

Case study: Horticultural land-use mapping

Mapping land use will improve understanding of how patterns in land use affect the natural environment.

Blueberries are an important horticultural industry on the Coffs Coast.
Photo: David Nowell

Area and trends in land use inform the status and trends of biodiversity and ecological integrity.

Different types of land use and land management have different impacts on biodiversity. By tracking land use across the state, it is possible to track impacts on biodiversity at a local or regional scale.

After an outbreak of Panama disease TR4 in Queensland, the former Office of Environment and Heritage received a grant from the Commonwealth to update mapping of banana production and other horticultural operations along the NSW mid to north coast.

When mapping the extent of banana production, the expansion of blueberry production was clearly visible as a rapidly emerging horticultural industry (Figure 26).

On the Coffs Coast, available aerial imagery shows that banana plantations are being converted to blueberries. Approximately 400 hectares of land mapped as bananas in 2000 was mapped as blueberries in 2016. The concentration of blueberry farms in the Coffs Coast area is shown in Figure 27.

Banana and blueberry plantations provide habitat for insects and attract pollinators, such as bees and bats. Rapid changes like the ones seen in this project can change the biodiversity and ecological integrity of these sites.

Management activities associated with horticulture may have an impact on the surrounding biodiversity. Impacts could be associated with seasonal management activities, such as the use of pesticides, herbicides, fertilisers and netting. Alternatively, impacts could result from more permanent activities, such as tree clearing to support the drive towards automated and larger machinery.

Land-use mapping can be used to monitor the impact of urban and industrial development for major and regional centres. Urban expansion is impacting on both agricultural production and the environment. The Australian Bureau of Statistics recorded Coffs Harbour Local Government Area population as increasing at around 1% per annum since 2011. This expansion is evident in the number of new housing subdivisions identified in the land-use mapping.

The NSW land-use maps contribute to the Australian Collaborative Land Use Mapping Program. This national dataset is available to Commonwealth and NSW governments, industry, growers and the public.

National land-use mapping has been used in the Rural Research for Development and Profit–Horticulture Innovation Australia: National Tree Project for Australia. This project links growers, industry, research institutions and government to deliver best practice science for tree crop production, minimising the impacts on natural resources and the environment.

Having access to up-to-date land-use information gives government and stakeholders the ability to understand how different land uses impact on natural resources and the environment. Land-use mapping supports rapid and strategic deployment of resources to deal with a biosecurity issue or natural disaster.

Figure 26 Rapid changes in land use — bananas to blueberries. Comparison of commercial aerial imagery shows bananas (left) converted to blueberries (right) within seven months of field verification of banana crop. Photo: Nearmap (2015, 2016).

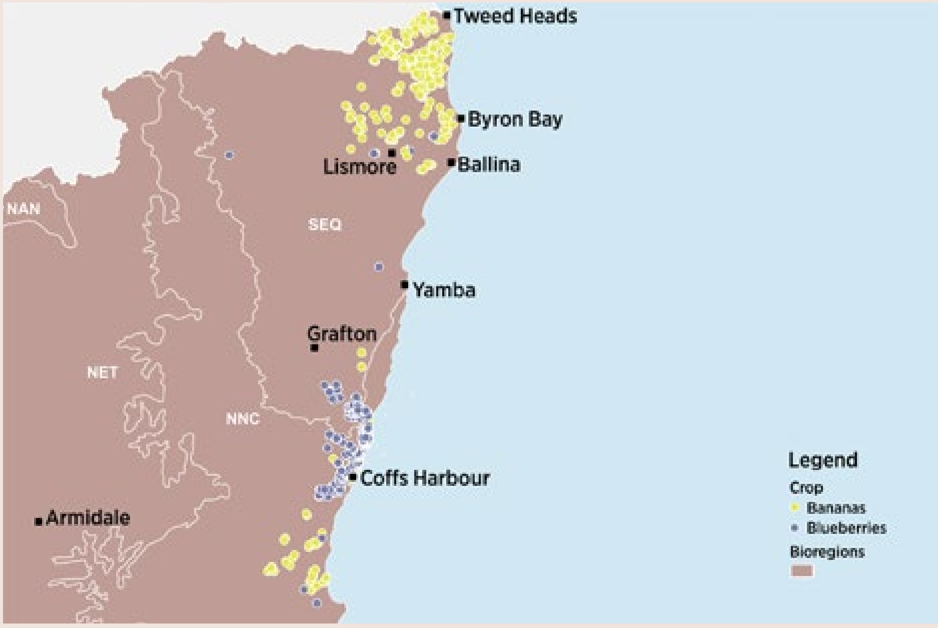


Figure 27 Banana and blueberry crops in the NSW mid to north coast. See Figure 23 for bioregion code descriptions.

Land-use mapping for New South Wales will be updated on a regular basis as part of the Land Management Framework. This will include land acquired for conservation, through reserve establishment, publicly funded environmental works, stewardship programs and set aside areas under the Land Management Framework. It will also identify changes in agricultural production.

More information

Australian Collaborative Land Use and Management Program 2018, *Land use and management information for Australia*, Department of Agriculture, viewed 12 September 2019, www.agriculture.gov.au/abares/aclump.

OEH 2017, NSW Landuse 2013, *SEED Portal*, available at https://datasets.seed.nsw.gov.au/dataset/nsw-landuse-2013.

University of New England n.d., National Tree Project: Multi-scale monitoring tools for managing Australian tree crops – industry meets innovation, UNE, viewed 12 September 2019, www.une.edu.au/about-une/faculty-of-science-agriculture-business-and-law/school-of-science-and-technology/research/parg/research-areas-and-current-projects/national-tree-project.

Inappropriate fire regimes

Case study: Fire thresholds

The percentage of dry vegetation formations within fire thresholds in New South Wales fell from 15% in 2011 to 12% in 2016.

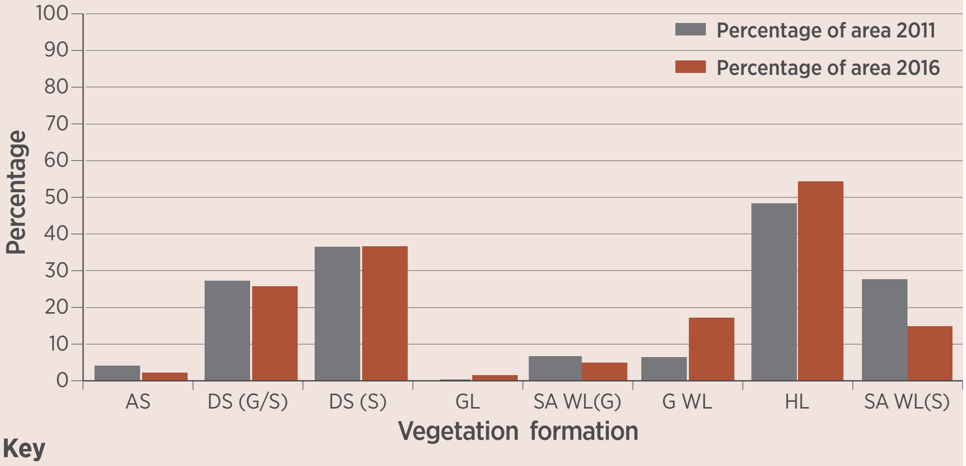
Smoke plumes at Diggers Camp.
Photo: John Lugg/DPIE

Fire thresholds are set for each broad vegetation type (formation) in New South Wales. These thresholds give the minimum and maximum number of years between fires that are compatible with conserving a range of biodiversity. At a landscape scale, it is recommended that 50% of each vegetation formation is within thresholds.

Figure 28 shows the percentage of each of the dry vegetation formations in New South Wales (total area of 42.6 million hectares) that were within fire thresholds in 2011 and 2016.

In 2016, the recommended target was achieved for Heathlands, with 54% within fire thresholds. The next closest to meeting the target was Dry Sclerophyll (Shrubby) vegetation, with 37% within thresholds (Figure 28).

More of each dry vegetation formation may be within fire thresholds, but no fires have been recorded in 79% of the area of this vegetation. If fires within the last 30 to 50 years had been recorded, the amount of dry vegetation formations within fire thresholds would be greater.



Key
AS = Arid Shrublands
GL = Grasslands
HL = Heathlands
DS (G/S) = Dry Sclerophyll (Grass/Shrub)
SA WL(G) = Semi-arid Woodlands (Grassy)
SA WL(S) = Semi-arid Woodlands (Shrubby).
DS (S) = Dry Sclerophyll (Shrubby)
G WL = Grassy Woodlands

Figure 28 Percentage of dry vegetation formations within fire thresholds in New South Wales, 2011 and 2016. Source: Rural Fire Service and data from the former OEH.

These results will be recalculated with the 2020–21 fire season data. Consistent record keeping and more accurate data will increase the confidence in the results.

More information

OEH 2012, *Living with fire in NSW national parks: A strategy for managing bushfires in national parks and reserves 2012–2021*, NSW Office of Environment and Heritage, Sydney, Australia, www.environment.nsw.gov.au/research-and-publications/publications-search/living-with-fire-in-nsw-national-parks.

NPWS 2004, *Guidelines for ecologically sustainable fire management*, NSW National Parks and Wildlife Service, Sydney, www.environment.nsw.gov.au/resources/biodiversity/FireGuidelinesReport.pdf.

Inappropriate hydrological regimes

Case study: Waterbirds and wetland health

Environmental water has been used to make natural flood events last longer and support waterbird breeding.

The royal spoonbill is one of the waterbird species that benefits from flooding of wetlands.
Photo: John Spencer/DPIE

Waterbirds are useful indicators of wetland health. Colonial-nesting waterbirds include pelicans, ibis, spoonbills, herons and egrets. These waterbirds can nest in large numbers in response to the flooding of inland wetlands. Figure 29 shows aerial estimates of waterbird numbers fluctuating with the size of the wetland.

Each year, surveys are conducted to document waterbird diversity, numbers and breeding activity in the NSW Murray–Darling Basin. Ground surveys complement long-term aerial surveys. Survey results direct management of wetlands as well as environmental water delivery, which is a supplement to natural flooding events, to maintain waterbird feeding and breeding habitats.

Environmental water was delivered by the former NSW Government and the Commonwealth Environmental Water Office to boost flood events in 2016–17. This supported large-scale waterbird breeding in the Macquarie, Lachlan and Murrumbidgee catchments.

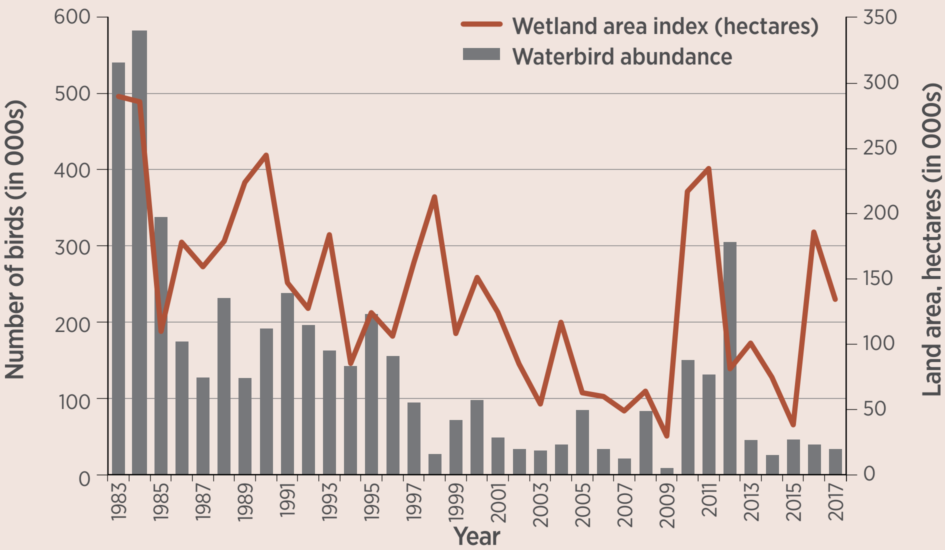


Figure 29 Waterbird numbers and wetland area index (hectares) in New South Wales

Annual aerial and ground-based surveys will continue.

More information

DPIE 2019, *Water for the environment*, NSW Department of Planning, Industry and Environment, Sydney, Australia, viewed 12 September 2019, www.environment.nsw.gov.au/topics/water/water-for-the-environment.

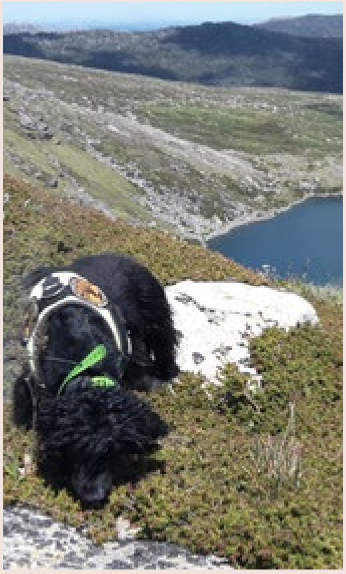
University of NSW, *Eastern Australian Waterbird Survey*, UNSW, Sydney, viewed 12 September 2019, www.ecosystem.unsw.edu.au/content/rivers-and-wetlands/waterbirds/eastern-australian-waterbird-survey.

Commonwealth Environmental Water Office n.d., *Monitoring, evaluation and research*, Department of the Environment and Energy, Parkes, Australia, viewed 12 September 2019, www.environment.gov.au/water/cewo/monitoring.

Invasive species

Case study: Controlling hawkweed

With continued effort, New South Wales is on track to reach the goal of eradicating hawkweed by 2025.



Sally, a specially trained hawkweed detection dog, searching for mouse-ear hawkweed above Blue Lake.
Photo: Hillary Cherry/DPIE

Hawkweeds are perennial herbs that are serious weeds in many parts of the world. The NSW Hawkweed Eradication Program targets orange hawkweed and mouse-ear hawkweed in Kosciuszko National Park and the southern Snowy Plains.

Traditional ground-based searching techniques, involving over 200 volunteers, have been used since 2011. To complement these efforts and increase early detection, unique surveillance tools are being used: dogs have been specially trained to detect hawkweed at low densities; and drones are being flown in remote areas to collect imagery that is analysed to detect bright orange hawkweed flowers among native vegetation.

The program is making good progress. The infested area has been significantly reduced and all known plants controlled. There is also a clear downward trend in the total area needing treatment each year (Figure 30), despite an increase in the area searched.

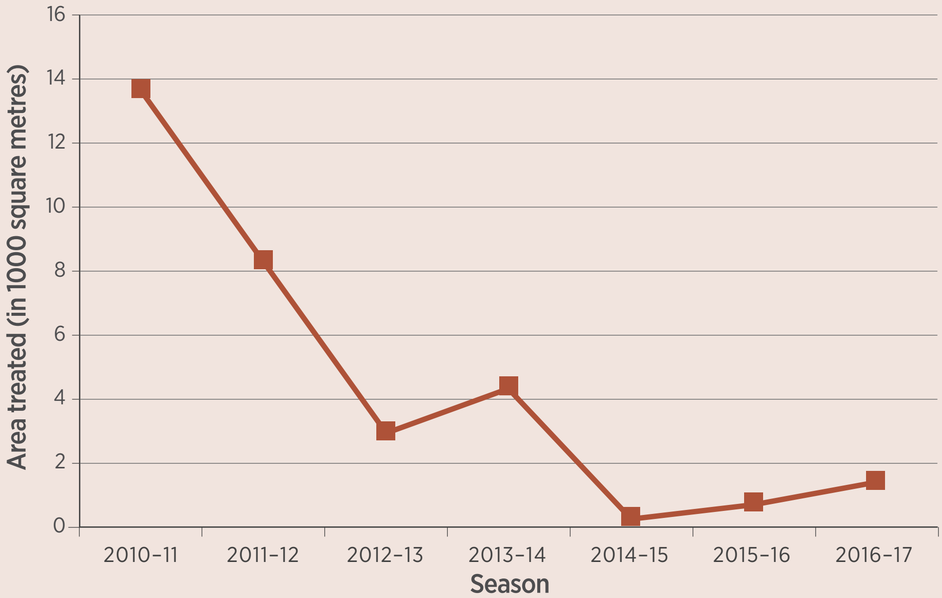


Figure 30 Area of hawkweed treated at known sites each season (Oct–April)

Measurements will continue until 2025. Staff will measure total area searched, and total area and number of plants detected and controlled.

More information

DPIE 2019, *Orange hawkweed*, NSW Department of Planning, Industry and Environment, Sydney, Australia, viewed 12 September 2019, www.environment.nsw.gov.au/topics/animals-and-plants/pest-animals-and-weeds/weeds/new-and-emerging-weeds/orange-hawkweed.

ECOLOGICAL INTEGRITY

Ecosystem management

Theme insights

The Ecosystem management indicator theme measures the actions intended to stop or reduce biodiversity loss, how well these actions work and the ability of management to maintain or improve ecosystem quality. It allows for consideration of all types of management across all land sectors that collectively influence outcomes for biodiversity and ecological integrity.

In this indicator theme, management responses are the supporting information needed to report on the status and trends of biodiversity that give context for measuring the performance of the *Biodiversity Conservation Act 2016* and enforcement mechanisms and regulations. Management effectiveness measures the success of these responses.

Management responses

This indicator family provides information about what land-use policies or actions are implemented and how they will prevent or reduce biodiversity loss.

Key insights

Conservation on public and private lands is a key part of strategies for maintaining biodiversity in New South Wales.

Presently, 9% of land in New South Wales, such as national parks and flora reserves, is conserved in perpetuity.

The Biodiversity Conservation Trust is helping by managing private land agreements, with 1665 agreements presently covering 270,712 hectares.

The 2015 'Who Cares About the Environment?' survey showed there is widespread awareness of the term 'biodiversity' and the importance of its protection.

The *NSW Biodiversity Outlook Report* will support an increased understanding of the status and trend in biodiversity conservation.

Management effectiveness

This indicator family measures the effectiveness of implemented policies or actions in reducing the rate of biodiversity loss, including:

- societal attitudes leading to actions (e.g. volunteer engagement in on-ground programs)
- planning for adaptation under climate change that is being implemented to support ecosystems.

Key insights

Monitoring of the effectiveness of on-ground management is critical to ensuring the right type of conservation in the right place.

- For example, critical knowledge about why the Gould's petrel was declining led to specific management actions to mitigate threats on Cabbage Tree Island resulting in rapid population recovery.

Community volunteers are critical to the maintenance of local biodiversity values.

- For example, collection of water quality data at more than 15 sites by citizen scientists has helped identify the best time for release of captive-bred threatened Bellinger River snapping turtles back into the wild following a disease outbreak.

Capacity to sustain ecosystem quality

This indicator family measures the change in adaptive management capacity to maintain or enhance ecosystem quality and so improve the longer-term outlook for sustaining biodiversity. All types of information influencing biodiversity outcomes are incorporated, including land management that moves toward ecologically sustainable development.

Indicators in this family are under development for future reporting.

Management responses

The Management responses indicator family provides information about what land-use policies or actions are implemented and how they will prevent or reduce biodiversity loss. The indicators assess changes in management responses and potential implications for biodiversity.

These indicators are under development:

- **Areas managed for conservation in perpetuity**
  This shows the extent of areas that are designated for long-term biodiversity conservation outcomes.
- **Areas managed for conservation under formal or informal agreements**
  The indicator covers the extent of areas managed for biodiversity conservation under agreements including private land conservation agreements under the Biodiversity Conservation Act (e.g. biodiversity stewardship agreements, conservation agreements).
- **Community appreciation of biodiversity**
  This shows the level of community understanding of and support for biodiversity conservation.

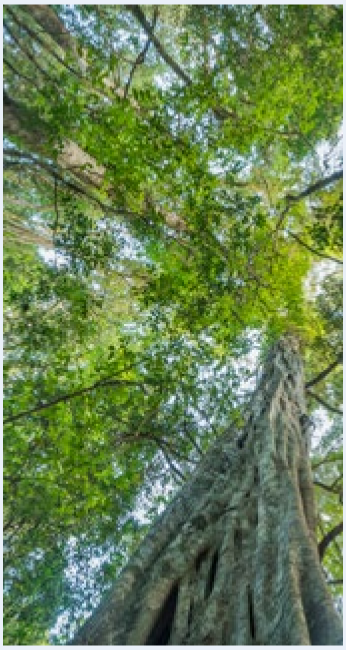
In this first *NSW Biodiversity Outlook Report*, case studies are reported for this indicator family.

Govetts Leap Lookout, Blue Mountains National Park.
Photo: S Cottrell/DPIE

Areas managed for conservation in perpetuity

Case study: National parks and conservation areas

9% of land in New South Wales is conserved in perpetuity.



Tooloom National Park.
Photo: John Spencer/DPIE

As of 1 January 2018, areas managed for conservation in perpetuity in New South Wales comprised 9% of the state, and included:

- 872 parks totalling 7,142,675 hectares managed by the National Parks and Wildlife Service (NPWS)
- 40,696 hectares of flora reserve managed by Forestry Corporation of NSW.

The different categories of parks and their extent are summarised in Table 2 and illustrated in Figure 31.

Table 2 Extent and types of terrestrial protected areas in New South Wales

Type of protected area	Total number	Area (ha)
NSW national parks and reserves [A]		
National parks [B]	239	5,394,344
Nature reserves	426	955,976
Aboriginal areas [B]	24	35,859
Historic sites	16	3,023
State conservation areas [B]	142	727,207
Regional parks	21	21,038
Karst conservation reserves	4	5,228
Total		**7,142,675**
Reserved areas in state forests [C]		
Flora reserves	Not reported	40,696

[A] Reserved under the *National Parks and Wildlife Act 1974*.
[B] Includes community conservation areas.
[C] Reserved under the *Forestry Act 2012*.

Source: NPWS data 2018 and Forestry Corp NSW data 2018 (up to and including 1 January 2018).

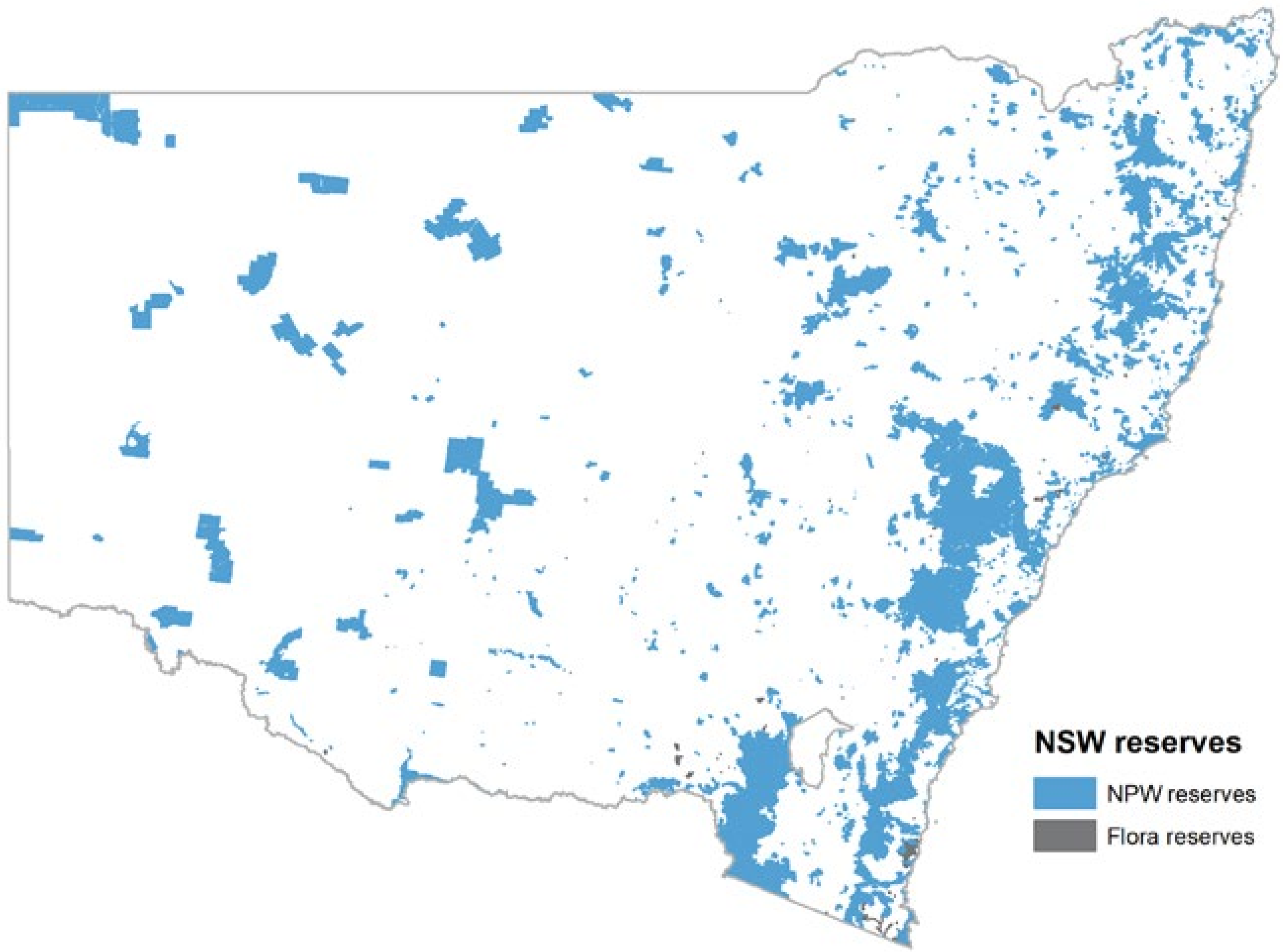


Figure 31 NPW reserves and state forest flora reserves. Data current as of 1 January 2018.

These protected areas play a critical role in conserving biodiversity. State conservation areas allow for dual uses, allowing resource exploration and mining as well as protecting natural and cultural values. Aboriginal areas and historic sites are mainly conserved for their cultural values; however, many of these areas contain important biodiversity values.

The area reserved is measured every year.

More information

DPIE 2019, *New parks, additions, acquisitions and revocations*, NSW Department of Planning, Industry and Environment, Sydney, Australia, viewed 12 September 2019, www.environment.nsw.gov.au/topics/parks-reserves-and-protected-areas/establishing-new-parks-and-protected-areas/new-parks-and-changes-to-parks.

NPWS 2019, *Our parks*, NSW National Parks and Wildlife Service, Sydney, Australia, viewed 12 September 2019, www.nationalparks.nsw.gov.au/conservation-and-heritage/our-parks.

NPWS 2019, *Protecting biodiversity*, NSW National Parks and Wildlife Service, Sydney, Australia, viewed 12 September 2019, www.nationalparks.nsw.gov.au/conservation-and-heritage/protecting-biodiversity.

Areas managed for conservation under formal or informal agreements

Case study: Conservation on private land

The Biodiversity Conservation Trust is managing 1665 agreements covering 270,712 hectares.

Private landholders can establish protected areas on their land to manage and improve biodiversity on their properties.
Photo: Scott Hartvigsen

The Biodiversity Conservation Trust (BCT), established on 25 August 2017, works in partnership with landholders to establish private land conservation agreements to conserve and manage high-value biodiversity on private land. The BCT manages three types of agreements:

- biodiversity stewardship agreements
- conservation agreements
- wildlife refuges.

The BCT Business Plan outlines measures to conserve biodiversity, including those related to land protected in new biodiversity stewardship agreements and conservation agreements (including set term and in-perpetuity).

This case study reports a baseline as of 25 August 2017 for those areas that are covered by agreements managed by the BCT and its predecessors (Table 3). This information will be reported annually. The case study does not consider which environmental assets are conserved and their ecological condition — this information is available in the BCT's annual report.

Table 3 Private land conservation agreements (as of 25 August 2017)

Agreement type	Number	Area (ha)
Conservation agreement	466	156,481
Wildlife refuge	687	n/a [1]
Nature Conservation Trust agreement	131	56,439
Registered property agreement and management contracts (in perpetuity)	237	44,149
Registered property agreement (termed)	80	6,486
Biobanking agreement	64	7,157
Total	**1,665**	**270,712**

[1] This figure was not included because a refuge usually covers the whole of a property, rather than the area of conservation.

More information

BCT 2018, *Biodiversity Conservation Trust*, Sydney, Australia, viewed 12 September 2019, www.bct.nsw.gov.au.
BCT 2018, *Biodiversity Conservation Trust 2017–18 to 2020–21 business plan*, Biodiversity Conservation Trust, Sydney, Australia, viewed 12 September 2019, www.bct.nsw.gov.au/sites/default/files/2018-03/BCT-Business-Plan.pdf.

Community appreciation of biodiversity

Case study: Who cares about the environment? survey

The survey showed there is widespread awareness of the term 'biodiversity', but relatively low understanding of its meaning.

Fungi growing in South East Forests National Park.

Photo: John Spencer/DPIE

The information presented here is from a 2015 general population survey of a representative sample of 2000 NSW residents. It provides a limited partial measure of community understanding and support for biodiversity conservation in New South Wales (Figure 32). In the future, this indicator will further define and measure 'community appreciation of biodiversity' in a way that recognises the breadth of members of the NSW community and their different values, associations and understanding of biodiversity.

The 2015 survey showed there is widespread awareness of the term 'biodiversity', but relatively low understanding of its meaning. Of the 2000 people surveyed, 83% had heard of the term, but only 30% understood what it means.

After explaining biodiversity to survey participants, they were asked about their views on the role of nature and biodiversity. There was widespread agreement on the importance of protecting nature and biodiversity for a broad range of reasons, including for future generations; its role in providing food, clean air and water, medicines, and in tackling climate change; and for its recreational benefits.

Only 46% of survey respondents were aware that threatened plant species exist in New South Wales. Of these, 53% were aware the number of threatened plant species in the state had increased over the past decade. Of the 61% aware that threatened animal species exist in New South Wales, only 45% knew the number of threatened animal species in this state had increased over the past decade. Despite the relatively low levels of awareness shown by the survey, discussion groups had a general familiarity with the concept and the causes of species loss, but did not associate it with New South Wales.

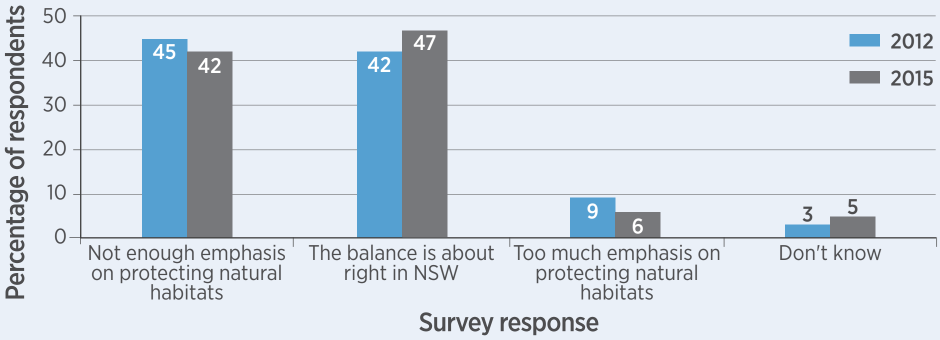


Figure 32 Responses to a question on attitudes towards protecting natural habitats for native plants and animals. Almost half (47%) of all survey respondents in 2015 thought that the balance between protecting natural habitats for native plant and animal species in New South Wales and using the land for other purposes was about right. In 2015, 42% thought there was not enough emphasis on protecting native plants and animals, and only 6% thought there was too much emphasis.

More information

DPIE 2019, *Who cares about the environment?*, NSW Department of Planning, Industry and Environment, Sydney, Australia, viewed 12 September 2019, www.environment.nsw.gov.au/research-and-publications/our-science-and-research/our-research/social-and-economic/%20sustainability/who-cares-about-the-environment.

Management effectiveness

The Management effectiveness indicator family measures the effectiveness of implemented policies or actions in reducing the rate of biodiversity loss, including:

- social attitudes leading to actions (e.g. volunteer engagement in on-ground programs)
- planning for adaptation under climate change that is being implemented to support ecosystems.

The indicators in this family build on data collected through the Management responses indicator family and provide a basis for improving predictions of biodiversity persistence across whole landscapes (through the Capacity to sustain ecosystem quality indicator family).

These indicators are under development:

- **Effectiveness of on-ground biodiversity conservation programs**
  This shows the individual and collective effectiveness of programs delivering conservation outcomes on the ground.
- **Community-based maintenance of biodiversity values**
  This shows the collective effectiveness of voluntary community-based management.
- **Implemented climate-adapted conservation planning and management**
  This shows the effectiveness of management actions in helping biodiversity adapt to climate change.

In this first *NSW Biodiversity Outlook Report*, case studies are reported for this indicator family.

Children participating in Wilderquest, Dorrigo National Park.
Photo: DPIE

Effectiveness of on-ground biodiversity conservation programs

Case study: Gould's petrel

Addressing threats has improved the breeding success of Gould's petrel in New South Wales.

Adult Gould's petrel on the forest floor of Cabbage Tree Island, off Port Stephens, New South Wales, principal nesting site of this vulnerable species.

Photo: Nicholas Carlile/DPIE

Between 1970 and 1992, the total population of Gould's petrel declined by more than 26%. In the early 1990s, there were less than 250 breeding pairs on Cabbage Tree Island, off Port Stephens. Each year, adult mortality exceeded the number of young produced on the island.

Since 1993, a recovery program has been effective in improving breeding success. The number of breeding pairs has increased to more than 600 pairs. The number of fledglings produced has also improved, from less than 60 to more than 300 in most years (Figure 33).

These increases are a result of:

- removing native birdlime trees from the petrels' breeding habitat to reduce entanglement in the sticky fruits
- culling predatory pied currawongs
- removing rabbits to allow understorey vegetation to recover, which in turn reduces fruit-fall and predation.

The reductions in 2014 and 2015 were part of a moderate (almost one-third) decline in the number of breeding birds and breeding success. The cause of this decline is not well understood, but may be related to limited food availability in the breeding and non-breeding seasons.

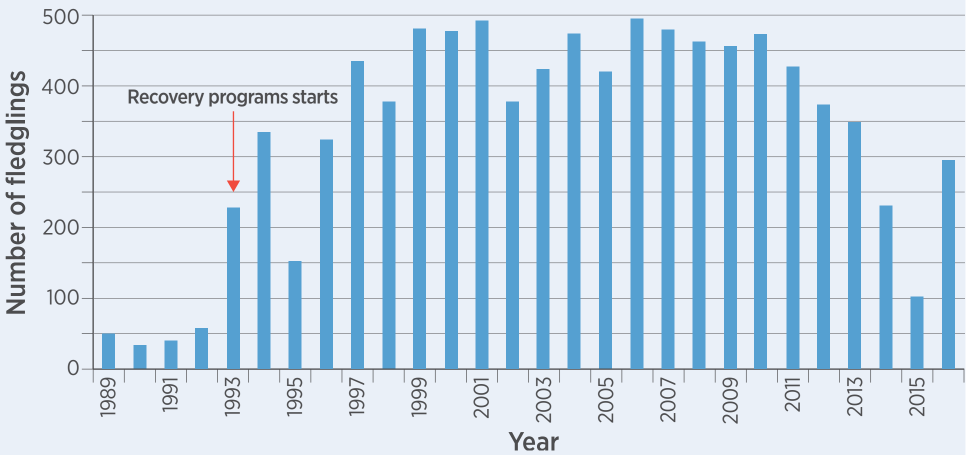


Figure 33 Number of Gould's petrel fledglings produced on Cabbage Tree Island

Annual surveys will continue over the next decades.

More information

OEH 2017, *Gould's petrel profile*, NSW Office of Environment and Heritage, Sydney, Australia, viewed 12 September 2019, www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10917

OEH 2006, *Gould's petrel* (Pterodroma leucoptera leucoptera) *recovery plan*, NSW Office of Environment and Heritage, Sydney, Australia, www.environment.nsw.gov.au/research-and-publications/publications-search/goulds-petrel-pterodroma-leucoptera-leucoptera-recovery-plan.

Community-based maintenance of biodiversity values

Case study: Citizen science programs for restoration

Water quality data has been consistently collected at more than 15 sites by a dedicated group of citizen scientists.

Citizen scientists from local schools undertaking water quality monitoring.
Photo: Geetha Ortac/DPIE

A disease outbreak in February 2015 in northern New South Wales caused the death of a large number of Bellinger River snapping turtles.

Scientists and researchers investigating the virus outbreak found that there was no consistent and robust water quality data. The Bellingen Riverwatch project was established to gather this data and act as a starting point to improve our understanding of overall river health across Bellingen Shire.

Since the project began in May 2017, the community's citizen scientists have been the backbone of the project, with over 20 people and five schools monitoring more than 15 sites across Bellingen Shire every month. Water quality data has been verified and uploaded to the Atlas of Living Australia.

Positive behaviour change through community-based projects will ultimately contribute to a healthier river system.

A threatened Bellinger River snapping turtle. Water quality monitoring results will help researchers make decisions about when to release captive-bred turtles back into the river.
Photo: Ricky Spencer/Western Sydney University

Monthly citizen science surveys will continue until the program's 10-year review in 2027.

More information

DPIE 2019, *Bellinger Riverwatch: Our rivers, our future*, NSW Department of Planning, Industry and Environment, Sydney, Australia, viewed 12 September 2019, www.environment.nsw.gov.au/research-and-publications/your-research/citizen-science/threatened-species-projects/bellingen-riverwatch.

DPIE 2019, *Bellinger River snapping turtle profile*, NSW Department of Planning, Industry and Environment, Sydney, Australia, viewed 12 September 2019, www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=20301.

OEH 2016, *Citizen science strategy 2016–18*, NSW Office of Environment and Heritage, Sydney, Australia, www.environment.nsw.gov.au/resources/research/150859-citizen-science-strategy.pdf.

ECOLOGICAL INTEGRITY

Ecosystem integrity

Ecosystem integrity

The Ecosystem integrity indicator theme considers the ability of ecosystems to retain their biodiversity and ecological functions in the face of ongoing, yet uncertain, environmental change, including both climate change and land-use change. It measures the capacity of ecosystems to adapt to change (and so provide for the needs of future generations), which is a key purpose of the *Biodiversity Conservation Act 2016*.

Methods are being developed for both indicator families in this theme.

Capacity to retain biological diversity

This indicator family measures the capacity of ecosystems to retain biodiversity in the face of ongoing, and uncertain, environmental change, including climate change and land-use change. It aims for the integration and synthesis across other themes of biodiversity and ecological integrity and introduces the concept of ecosystem resilience.

Capacity to retain ecological functions

This indicator family mirrors the family above, but relates to ecological functions.

NEXT STEPS

The indicators will be measured in a staged approach.

We are measuring and reporting some indicators now because we have the necessary data and analysis techniques. In the future, these indicators will be measured again with new data to help us track our progress in managing biodiversity in New South Wales.

For other indicators, we need to collect additional data and further develop methods. This work is underway, guided by the technical method report, which defines a program to further develop and refine indicators for future reporting. Crucial data gaps will be identified, which can be filled by research or data collection.

To subscribe to Biodiversity Indicator Program updates, go to the Department's Biodiversity Indicator Program webpage.

Thredbo to Mount Kosciuszko walking track,
Kosciuszko National Park.
Photo: E Sheargold/DPIE

Glossary

Animal: any animal, whether vertebrate or invertebrate and in any stage of biological development, in the taxonomic kingdom of Animalia.

Biodiversity (biological diversity): variety of living animal and plant life from all sources (including terrestrial, aquatic, marine and other ecosystems and ecological complexes of which they are a part). It includes genetic diversity, species diversity and ecosystems diversity. Biodiversity includes plants, animals, fungi, lichen, invertebrates and microorganisms.

Biodiversity Conservation Trust (BCT) of New South Wales: a statutory not-for-profit body established under the *Biodiversity Conservation Act 2016* to work with landholders to establish private land conservation agreements. The BCT also seeks strategic biodiversity offset outcomes to compensate for the loss of biodiversity due to development and other activities.

Disturbance: any process or event which disrupts ecosystem structure and resource availability.

The Department: Department of Planning, Industry and Environment.

Ecological carrying capacity: the ability of an area to maintain self-sustaining and interacting populations of all species naturally expected to occur there, given the effectiveness of habitat, including its resources (such as shelter, food and water), and connections to other habitat needed for persistence.

Ecological community: an assemblage of species occupying a particular area at a particular time.

Ecological condition: the intactness and naturalness of habitat to support biodiversity, without considering the indirect effects of fragmentation or connections with surrounding suitable habitat.

Ecological connectivity: accounts for the generalised quality of habitats supporting biodiversity at each location, the fragmentation of habitat within its neighbourhood and its position in the landscape (e.g. as part of a habitat corridor or as a stepping stone).

Ecological integrity: is about maintaining the diversity and quality of ecosystems and enhancing their capacity to adapt to change and provide for the needs of future generations.

Ecosystem: a group of plant, animal and microorganism communities and their nonliving environment (e.g. terrain or climate) that interact as a functional unit. Ecosystems may be small and simple, such as an isolated pond, or large and complex, such as a specific tropical rainforest or a coral reef.

Ecosystem diversity: The number and variety of ecosystem types present within a region. Different ecosystem types provide different habitats for species and are distinguished from one another by the different combinations of species found in them. Ecosystem types may also differ in a variety of other attributes such as vegetation structure (e.g. forest versus grassland), the natural frequency of fires, and the rate at which nutrients are recycled. The type of ecosystem that will occur will depend on the local environmental conditions (e.g. temperature, rainfall, soil type) and history of disturbance (e.g. fire).

EES: the Environment, Energy and Science Group of the Department of Planning, Industry and Environment; formerly known as the Office of Environment and Heritage (OEH).

Effective habitat or habitat effectiveness: the proportion of residual habitat quality at a site which remains effective in supporting native plants and animals following the impacts of clearing, degradation and fragmentation at that site and in its neighbourhood. Used to report ecological carrying capacity.

Expected survival: number or percentage of species or ecological communities likely (with a high probability) to persist over some timeframe (e.g. 100 years).

Extinction lag: the irreversible and time-delayed loss of sensitive species in remnant natural areas following clearing.

Fungi: a diverse group of microorganisms in the taxonomic kingdom of Fungi, including mushrooms, moulds, mildews, smuts, rusts and yeasts.

Genetic diversity: the range of intrinsic differences in genes among individual organisms within a species, or among different species within a taxonomic group.

Habitat: an area or areas occupied, or periodically or occasionally occupied, by a species, population or ecological community, including any biotic or abiotic component.

Habitat condition: the capacity of an area to provide the structures and functions necessary for the persistence of all species naturally expected to occur there in an intact state.

Habitat fragmentation: the emergence of gaps (fragmentation) in an organism's preferred environment (habitat), causing population fragmentation and ecosystem decay.

Indicator: something that shows what a situation is like or measures the status or level of something.

Likely: expected (with a high probability) to be true.

Listed threatened species and ecological communities: species or ecological communities listed as threatened in the *Biodiversity Conservation Act 2016.*

Modelling: computational simulation of a process, concept or the operation of a system.

National parks: lands reserved under the *National Parks and Wildlife Act 1974*. It includes areas classified as national parks, nature reserves, state conservation areas, regional parks, Aboriginal areas, historic sites or karst conservation reserves. The gazetted area of national parks, as of 1 January 2018, was 7,142,675 hectares or 9% of New South Wales.

NPW reserves: lands reserved under the *National Parks and Wildlife Act 1974* as of August 2017 covering an area of 7,179,788 hectares. This figure is calculated using GIS data and differs slightly from the gazetted area.

Other tenures: lands outside of NPW reserves.

Plant: any plant, whether vascular or non-vascular and in any stage of biological development in the taxonomic kingdom of Plantae. Note that under NSW biodiversity legislation, 'plant' includes fungi and lichens but not marine vegetation.

Power curve: in ecology, a power curve describes the nonlinear relationship between an increasing number of biodiversity features (genes, species or ecosystems) and increasing area sampled (or number of locations).

Pre-industrial era: the time period prior to the Industrial Revolution and thus before the significant changes in human population density and land use that have occurred globally since. The Industrial Revolution is commonly considered to have begun around 1750 CE but the beginning of the population and land use changes associated with the period varies across the globe and across New South Wales.

Remote sensing: a means of acquiring information using airborne or satellite equipment and techniques to determine the characteristics of an area; most commonly using imagery from aircraft and images from satellites.

SEED: the NSW Government's Sharing and Enabling Environmental Data (SEED) platform.

Spatial modelling: a set of analytical procedures used to figure out information about the spatial relationships between location-based features (e.g. the relationship between the number of lizard species and the mean annual temperature).

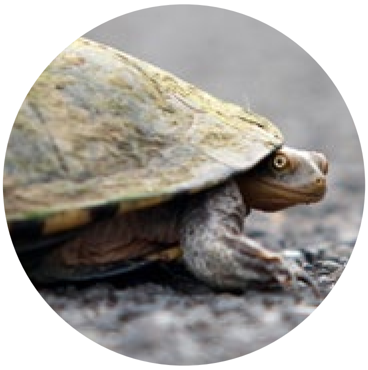
Status: the current situation or 'health' of a species, population, community, habitat, ecosystem or all of biodiversity.

Taxon (plural taxa): any taxonomic category, as species, genus, etc.

Taxonomy: the science of classification.

Trends: directions of change in the environment, as shown by the changing values of measures (like essential variables, indicators or indices).

View towards the Warrumbungles from Doug Sky Lookout, Mount Kaputar National Park. Photo: S Cottrell/DPIE



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