Indicator 1.1d: Fragmentation of forest cover (2025)

This indicator describes the loss of forest cover and the spatial configuration of that loss. Fragmentation can impact on forest-dwelling species and gene pools through changes in the connectivity of populations and the loss of species genetic variability.

Context and definitions

Forest fragmentation describes natural and human-induced breaks in forest cover such that large, continuous forest patches are separated into smaller, sometimes isolated, patches. Fragmentation creates breaks in ecological connectivity, increases edge effects, and can compromise biodiversity and ecosystem resilience. The fragmentation analysis conducted for this indicator was performed at a broad national scale.

Fragmentation:
1. The degree to which forest exists in separate areas that are not spatially connected.
2. The process of loss of spatial connectivity between forest areas.

Connectivity: The degree of vegetation structural links between forest patches in a landscape. Connectivity facilitates species movement across a continuous forested landscape, and is the converse of fragmentation.

Forest-interior: One-hectare spatial units (square pixels) of native forest with all four edge-neighbouring units of native forest.

Forest-exterior: One-hectare spatial units (square pixels) of native forest that have one or more edge-neighbouring units of non-native forest or non-forest.

See Australia's forests and forestry glossary for full definitions and definitions of other terms.

Key points

- Most of Australia's native forest cover is continuous, not fragmented
  - 73% of Australia's native forest is comprised of one-hectare forest units that are completely bounded by native forest
  - Native forest that is not fragmented is found in areas of higher rainfall, and regions that have experienced the least clearing for agricultural land use and infrastructure.
- 53% of Australia's native forest is in patch sizes of over 1 million hectares.
- The largest areas of continuous forest occur in Queensland and the Northern Territory.
- Woodland forest cover is the main component of fragmented forest, likely from the natural interspersion of woodland forest with areas of non-forest vegetation, as occurs in drier ecoregions of Australia, and historic clearing for agriculture
  - 31% of Woodland forest class are forest-exterior units (forest edge), compared to 16% of Open forest and 14% of Closed forest.

National forest fragmentation statistics

A total of 73% of Australia's native forest area (95.6 million hectares) is continuous, indicating low fragmentation. The remaining 27% of native forest (35.9 million hectares) is fragmented.

Nationally, native forest with the lowest fragmentation occurs in regions of higher rainfall and in regions that have experienced lower rates of land clearing. The states and territories with the highest proportion of continuous

native forest (forest-interior) are the Australian Capital Territory (88% of native forest) and Victoria (87%), whereas the lowest proportion of continuous forest (forest-interior) are in South Australia (64%), Northern Territory (65%) and Western Australia (68%). The distribution of native forest by fragmentation class (forest-interior and forest-exterior) across Australia is shown in Figure 1.1d-1.

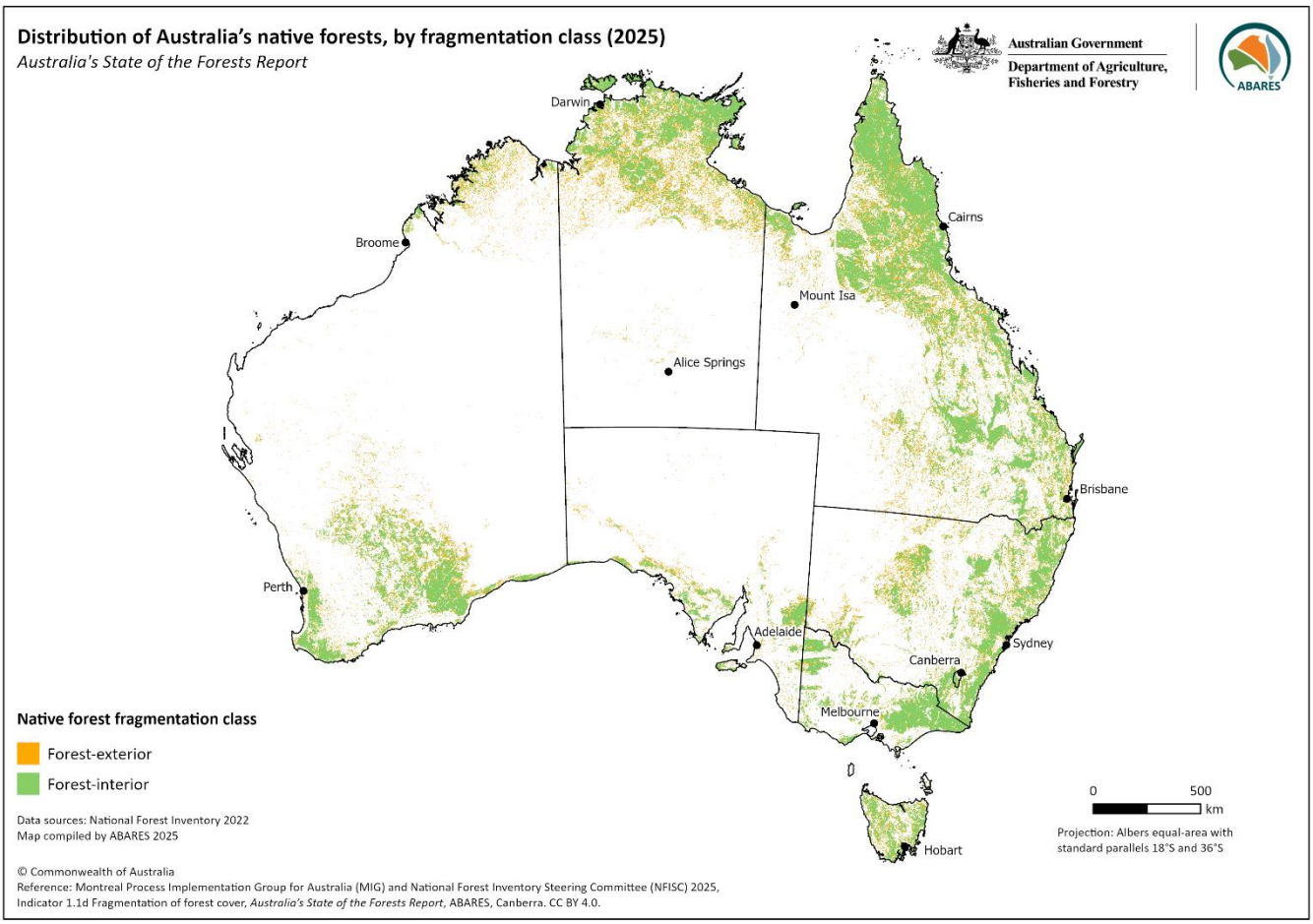
The continuous cover or 'forest-interior' areas are comprised of one-hectare native forest units bounded by other native forest units. Fragmented forest areas have native forest units with at least one edge having an adjoining unit that is not native forest. These native forest units are known as 'forest-exterior' and are an indicator of fragmentation. See Supporting information for Indicator 1.1d for the full method and data sources used for calculating national forest fragmentation statistics.

Table 1.1d-1: Native forest fragmentation, by jurisdiction

Forest coverage as at 2021	ACT	NSW	NT	Qld	SA	Tas.	Vic.	WA	Australia
Native forest area ('000 ha)	130	19,882	23,280	51,750	4,866	3,393	7,790	20,409	131,501
Fragmentation class									
Proportion forest-interior [a]	88%	73%	65%	77%	64%	76%	87%	68%	73%
Proportion forest-exterior [b]	12%	27%	35%	23%	36%	24%	13%	32%	27%

[a] 'Proportion forest-interior' is the proportion of one-hectare forest units that are 'forest-interior'. A forest-interior unit is a native forest unit that has all four neighbouring (edge-adjacent) units with native forest. Only native forest was considered in this analysis.
[b] 'Proportion forest-exterior' is the proportion of one-hectare forest units that are 'forest-exterior'. A forest-exterior unit is a native forest unit that has between 0 and 3 neighbouring (edge-adjacent) units with native forest. Only native forest was considered in this analysis.
The one-hectare units used for this analysis are the 100 metre x 100 metre grid units used by the National Forest Inventory.
Source: ABARES, *Forests of Australia (2023)*.
Click here for a Microsoft Excel workbook of the data for Table 1.1d-1.

Figure 1.1d-1: Distribution of Australia's native forests, by fragmentation class



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Drivers of forest fragmentation include natural processes and landscape features, and human influences. These factors are not separated in the reporting for this indicator.

Natural drivers of forest fragmentation include geology and soil variability, topography, and rainfall gradients, all of which influence the distribution of vegetation communities and vegetation structure, and result in a natural mosaic of habitats and related species.

Human-induced drivers of forest fragmentation arise from land use change where forest has been cleared for agriculture, urban development, and infrastructure such as roads and high voltage power transmission lines. This typically results in a distinct boundary between forest and non-forest, and creates edge effects in forests that otherwise would be areas of continuous (interior) forest. Edge effects can include a change in the composition of forest fauna and flora species (for example, species that occupy forest-edge habitats) or reducing the ecosystem function of forest and habitat values (for example, through the invasion of weeds and an increased exposure to wind). Impacts from forest fragmentation can lead to reduced habitat quality and quantity for forest-dwelling species that rely on continuous areas of forest.

The main cause of increasing forest fragmentation over the past 200 years has been forest clearing associated with land use change, mainly for agriculture, mining and urban development, but also for infrastructure such as roads, railways, pipelines and power lines. As much as one-third of Australia's native woody vegetation in

intensively used areas (mainly the agricultural and urban zones) has been cleared or substantially modified over that time[1].

Forest fragmentation by crown cover

Australia's forests are classified into three structural classes: woodland forest (crown cover of 20–50%), open forest (crown cover of >50–80%) and closed forest (crown cover of >80%). Woodland forest is more fragmented (31% of total woodland forest area) compared to open forest (16%) and closed forest (14%). (Table 1.1d-2).

Woodland forest is naturally more fragmented than open and closed forests as it often transitions into sparse woodland and other non-forest vegetation, usually reflecting changes in rainfall and soil types. Fragmentation in woodland forest also reflects historic land management practices across southern Australia when it was extensively cleared, mainly for agricultural land uses (see Bradshaw 2012). Woodland forest in drier areas of Australia and northern Australia has not been as extensively cleared, contributing to the 69% of woodland forest class that is classified as continuous (forest-interior).

Woodland forest also accounts for the largest area of forest by cover type (71% of Australia's total forest area, see Indicator 1.1a.i), and is widespread across Australia. See Supporting information for Indicator 1.1a-i for an explanation of forest cover types.

Table 1.1d-2: Native forest fragmentation class by crown cover class

Fragmentation class Crown cover class	**Native forest area** ('000 hectares)	**Proportion of total native forest area** (%)	**Proportion of total crown cover type** (%)
Forest-exterior	**35,894**	**27**	
Woodland forest	28,599	22	31
Open forest	5,303	4	16
Closed forest	350	0.3	14
Forest of unknown crown cover	1,641	1	76
Forest-interior	**95,608**	**73**	
Woodland forest	64,356	49	69
Open forest	28,545	22	84
Closed forest	2,201	2	86
Forest of unknown crown cover	506	0.4	24
Total	**131,501**	**100**	

Woodland forest crown cover of 20–50%; Open forest crown cover of >50–80%; Closed forest crown cover of >80%.
Source: ABARES, *Forests of Australia (2023)*.
Click here for a Microsoft Excel workbook of the data for Table 1.1d-2.

Forest patch size

Just over half (53%) of Australia's native forest is in patch sizes of over 1 million hectares, while 10% occurs in patch sizes of 100 hectares or smaller (Table 1.1d-3). The distribution of native forest by patch size across Australia is shown in Figure 1.1d-2.

Patch size reflects the extent to which forest is fragmented: large patches are considered unfragmented, whereas smaller patches are considered more fragmented. Patches sizes are calculated from the number of edge-adjoining one-hectare units, as explained in Supporting information for Indicator 1.1d. At the scale of the forest mapping

[1] Derived from information published in *2021 Australia State of the Environment report* Land chapter.

undertaken for the National Forest Inventory, narrow breaks in forest cover (for example, a minor road), may not sufficiently interrupt the derived forest cover to influence fragmentation analysis. Forest fragmentation is also relative to the species or process, and can occur at multiple scales.

At the national scale there are 11 patches greater than 1 million hectares (Table 1.1d-4). The largest patches of continuous forest are in Queensland (28.2 million hectares) and in the Northern Territory (12.8 million hectares). Elsewhere, large patches occur in Western Australia (6.4 million hectares), Victoria (4.0 million hectares), New South Wales (4.0 million hectares) and Tasmania (1.8 million hectares). These patches are generally found in sparsely populated regions where extensive areas are managed for protection and/or have been subject to relatively low rates of historical land clearing.

South Australia has the highest proportion of native forest in small patch sizes, with 29% of native forest in patches of 1,000 hectares or less (Table 1.1d-3). The average patch size of these patches is 4.6 hectares. This is in part because forest in South Australia is predominantly woodland forest, which is naturally more fragmented, especially as mean annual rainfall decreases.

Table 1.1d-3: Proportion of native forest, by patch size and state and territory

	Proportion of native forest by patch size in hectares						
Jurisdiction	**1–10**	**>10–100**	**>100–1000**	**>1000–10,000**	**>10,000–100,000**	**>100,000–1,000,000**	**>1,000,000**
ACT	1%	2%	2%	5%	0%	90%	0%
NSW	6%	5%	6%	8%	10%	19%	45%
NT	7%	6%	6%	6%	5%	15%	55%
Qld	4%	4%	5%	6%	7%	11%	64%
SA	11%	8%	10%	9%	18%	44%	0%
Tas.	3%	4%	4%	7%	6%	23%	54%
Vic.	3%	2%	3%	6%	10%	24%	52%
WA	8%	7%	8%	8%	12%	15%	42%
Australia	**6%**	**5%**	**6%**	**7%**	**9%**	**16%**	**53%**

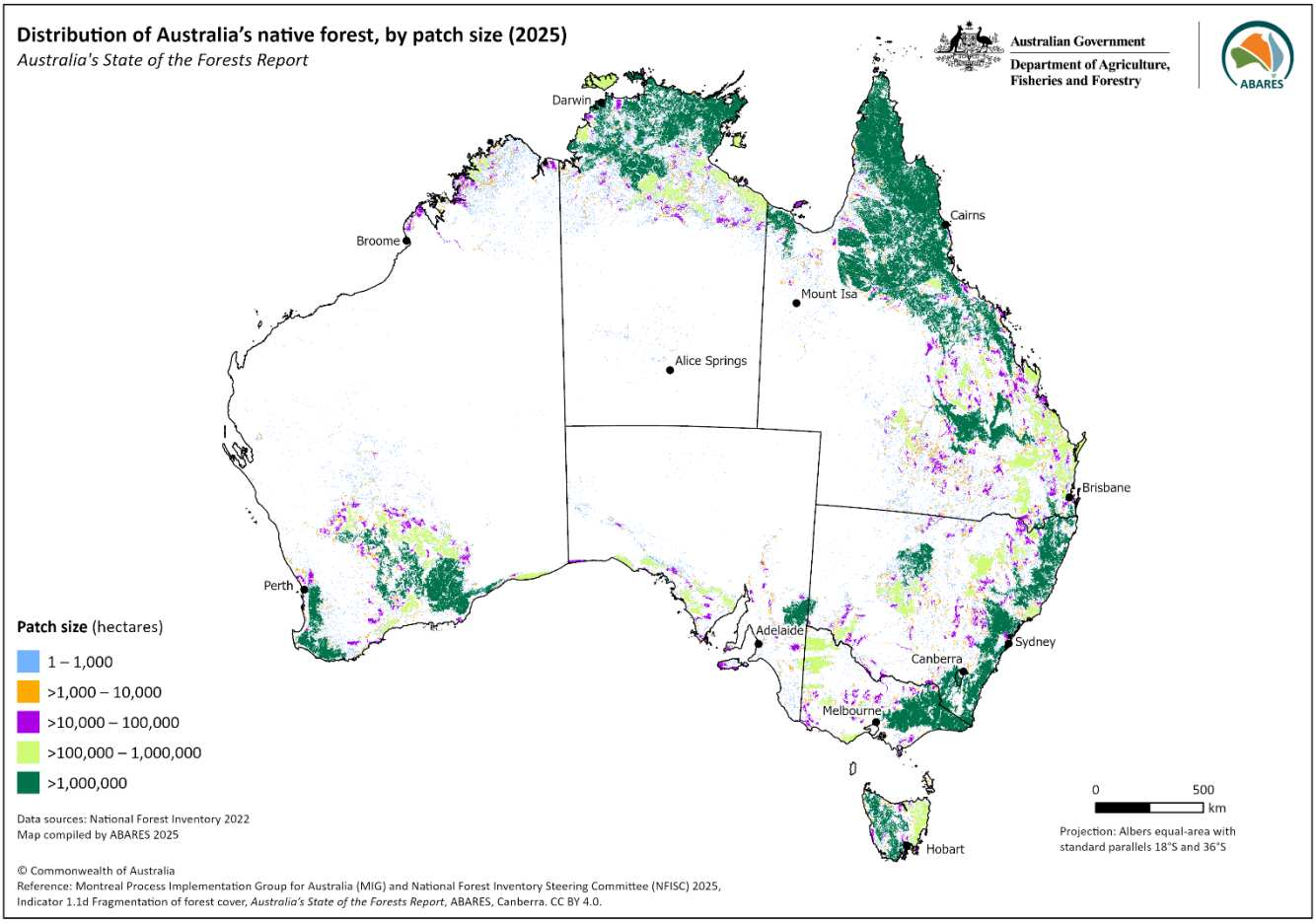
Totals may not tally due to rounding.
Analysis was performed at state and territory level, meaning patches of native forest extending across borders were truncated.
Source: ABARES, *Forests of Australia (2023)*.
Click here for a Microsoft Excel workbook of the data for Table 1.1d-3.

Table 1.1d-4: Count of patches by patch size, by state and territory

	Count of patches by patch size in hectares						
Jurisdiction	**1–10**	**>10–100**	**>100–1000**	**>1000–10,000**	**>10,000–100,000**	**>100,000–1,000,000**	**>1,000,000**
ACT	910	93	7	4	0	1	0
NSW	620,343	37,935	4,514	611	74	12	3
NT	923,096	49,957	5,122	495	51	11	1
Qld	895,306	71,454	10,157	1,179	143	18	3
SA	293,477	15,615	1,783	171	25	7	0
Tas.	39,838	4,220	582	84	10	1	1
Vic.	109,533	7,022	965	165	36	6	1
WA	854,786	52,536	6,278	658	81	11	2
Australia	**3,737,289**	**238,832**	**29,408**	**3,367**	**420**	**67**	**11**

Analysis was performed at state and territory level, meaning patches of native forest extending across borders were truncated.
Source: ABARES, *Forests of Australia (2023)*.
Click here for a Microsoft Excel workbook of the data for Table 1.1d-4.

Figure 1.1d-2: Distribution of Australia's native forest, by patch size



Click here for high-definition copy of Figure 1.1d-2.

Forest fragmentation impacts to threatened species and ecological communities

Forest fragmentation is widely recognised as a threat for forest-dwelling species in Australia (see Bradshaw 2012), as it can reduce the habitat available for fauna and flora species requiring large areas of continuous forest.

However, fragmentation can also have indirect effects on forests, making it complex to quantify. With increasing fragmentation of forest, the amount of forest-exterior increases, exposing more forest to influences from the non-forest landscape. For example, this edge-effect can increase the impact of wind and incursion of weeds and introduced animals into forest-interior areas, which can lead to a reduction of forest condition and increase pressures on native fauna and flora species. The impact of fragmentation generally increases when forests are divided into smaller patches.

No simple fragmentation metric can be used as a surrogate for habitat quality for forest-dwelling species, as species respond to more complex habitat features and landscape patterns (Lindenmayer et al. 2003). Thus, it is not possible to use the analysis undertaken for this indicator to assess the impact of fragmentation on threatened forest-dwelling species.

Data on threatened forest-dwelling species and threatened forest ecological communities, and threats to them, are explored in Indicator 1.2b.

Supporting information for Indicator 1.1d: Fragmentation of forest cover

Method for national forest fragmentation statistics

This indicator reports a simple set of spatial variables that can form the basis of tracking forest fragmentation nationally and regionally over time. Analysis of fragmentation involves measuring one or more of several parameters derived from spatial analysis of the configuration of forest cover (Tickle et al. 1998; Lindenmayer et al. 1999). Fragmentation parameters can include the relative amounts of edge (forest-exterior) and interior forest, and the size and shape of forest patches.

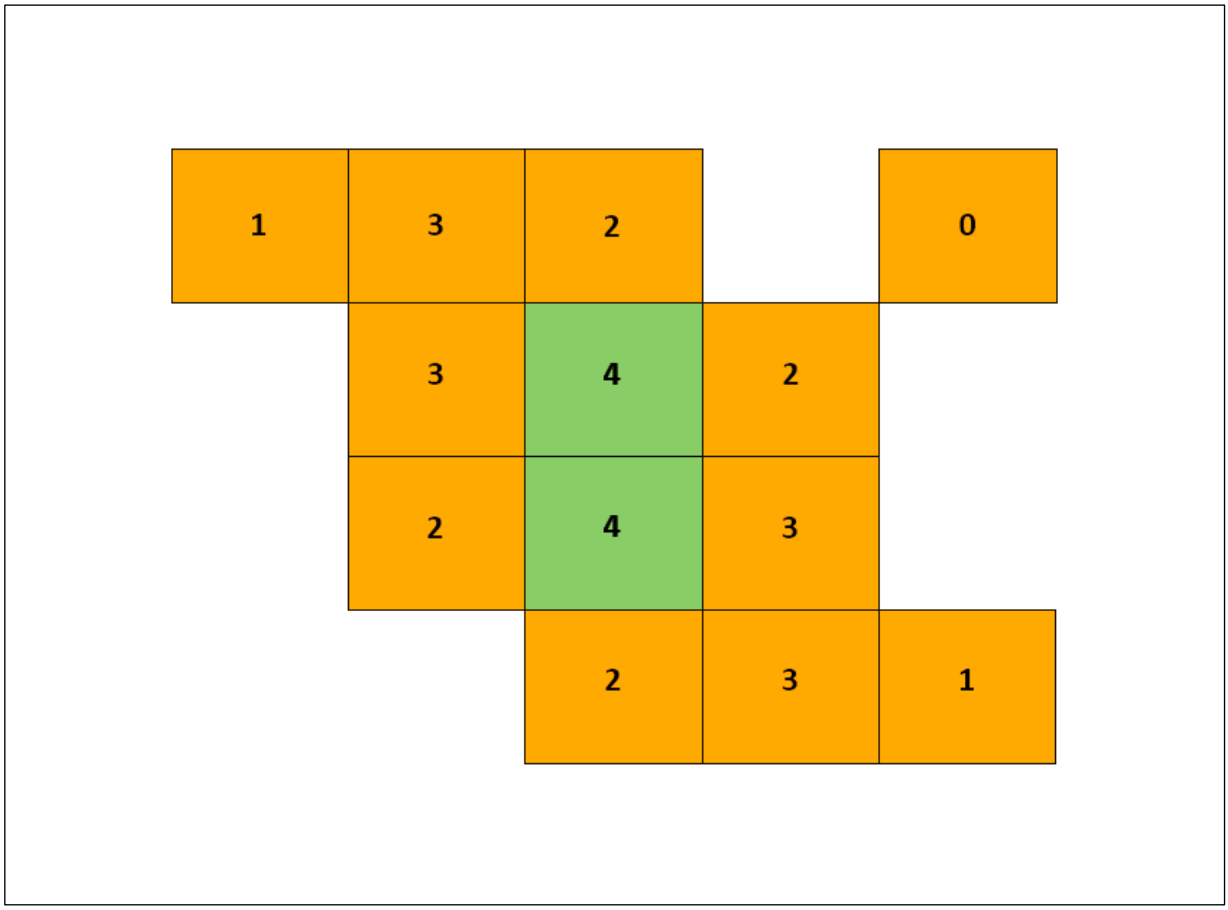
Australia's forests are mapped at a one-hectare scale in the National Forest Inventory (See About Australia's State of the Forests Report for the definitions of forest used in Australia), with each one-hectare unit or 'pixel' across Australia being scored as Native forest, Commercial plantation, Other forest or non-forest (Indicator 1.1a-i). This dataset is suitable for analysis of forest fragmentation at the national scale with limitations. For example, at the scale of the forest mapping undertaken for the National Forest Inventory, narrow breaks in forest cover (for example, a minor road), may not sufficiently interrupt the forest cover when converted to a 100-metre unit to influence fragmentation analysis; fragmentation metrics may also not capture forest that is subject to disturbance but continues to meet the definition of forest.

Two sets of metrics were calculated using only the native forest component of the National Forest Inventory forest dataset (ABARES 2023), fragmentation classes (forest-interior and forest-exterior) derived from the number of forest units that each native forest unit has as (edge-to-edge) neighbours, and patch size which is derived from the size of patches of native forest in which every unit is a neighbour (edge-to-edge) to another native forest unit.

The fragmentation class metric distinguishes two classes (Figure 1.1d-3):

- 'Forest-interior' units are native forest spatial units (square pixels) that have all their four neighbouring (edge-adjacent) units as native forest. A higher proportion of forest-interior units implies a forest that is relatively unfragmented, and not affected by any nearby non-forest and non-native forest area.
- 'Forest-exterior' units are native forest spatial units (square pixels) that have one or more non-forest or non-native forest neighbouring units, and are therefore at a boundary between forest and non-forest or non-native forest. They could also be named 'forest-edge' units. A higher proportion of forest-exterior units and a lower proportion of forest-interior units implies a forest area that is relatively more fragmented.

Figure 1.1d-3: Schematic diagram illustrating fragmentation metrics



Diagrammatic representation of a small area of forest. White, non-forest; orange, forest-exterior units; green, forest-interior units. The figures in each forest unit are the number of neighbouring (edge) units that are forested. Each unit is one hectare (100 metres x 100 metres).

The area represented in Figure 1.1d-3 comprises two patches of forest. The top-right unit is a patch containing one hectare of forest, not being edge-connected to any other forest unit, while the remaining forest units are all edge-connected and make up a 12-hectare patch of forest.

The 13 units in this area of forest comprise 11 forest-exterior units (coloured orange) and 2 forest-interior units (coloured green and containing the number '4'): the latter are the units that have all four of their neighbouring (edge) units as forest. In this area of forest, the proportion of forest-interior units is 2 of 13 units = 15%.

The non-forest adjacent to forest-exterior units may be land cleared for agricultural land use, urban development or infrastructure, with potential to affect the forest ecosystem; may be commercial plantation or other forest; may be woody non-forest vegetation such as sparse woodland with under 20% crown cover, and representing a natural vegetation transition with a lesser impact on the native forest area; or may be other non-forest vegetation.

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More information

Learn more about the Criterion 1 of Australia's State of the Forests Report.

Web agriculture.gov.au/abares/forestsaustralia/sofr/

Download a Microsoft Excel workbook of the data presented in Indicator 1.1d.

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Acknowledgement of Country

We acknowledge the Traditional Custodians of Australia and their continuing connection to land and sea, waters, environment and community. We pay our respects to the Traditional Custodians of the lands we live and work on, their culture, and their Elders past and present.

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