



## DRAFT Conservation Advice for the Ben Halls Gap Sphagnum Moss Cool Temperate Rainforest

*This draft document is being released for consultation on the description, listing eligibility and conservation actions of the ecological community.*

The purpose of this consultation document is to elicit additional information to better understand the definition and status of the ecological community and help inform conservation actions. The draft assessment below should therefore be considered **tentative** at this stage, as it may change as a result of responses to this consultation process.

This document combines the conservation advice and listing assessment for the threatened ecological community. It provides a foundation for conservation action and further planning.



Ben Halls Gap Sphagnum Moss Cool Temperate Rainforest © Doug Beckers

The TEC occurs within country (the traditional lands) of the Gomeroi peoples. We acknowledge their culture and continuing link to the ecological community and the country it inhabits.

### Proposed Conservation Status

The Ben Halls Gap Sphagnum Moss Cool Temperate Rainforest is proposed to be listed in the Endangered or Critically Endangered category of the threatened ecological communities list under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth)(EPBC Act).

# DRAFT Conservation Advice for the Ben Halls Gap Sphagnum Moss Cool Temperate Rainforest

## About this document

This document describes the ecological community and where it can be found (section 1.2); outlines information to assist in identifying the ecological community and important occurrences of it (section 2); and describes its cultural significance (section 3).

In line with the requirements of section 266B of the EPBC Act, it sets out the grounds on which the ecological community is eligible to be listed as threatened (section 6); outlines the main factors that cause it to be eligible for listing (section 4); and provides information about what could appropriately be done to stop its decline and/or support its recovery (section 5).

## CONTENTS

1	Ecological community name and description .....	3
1.1	Name .....	3
1.2	Description of the ecological community and the area it inhabits .....	3
2	Identifying areas of the ecological community .....	7
2.1	Key diagnostic characteristics .....	7
2.2	Additional information to assist in identifying the ecological community .....	8
2.3	Condition classes and thresholds .....	11
2.4	Habitat critical to the survival of the ecological community .....	12
2.5	Areas of high value - surrounding environment and landscape context .....	13
3	Cultural and community significance .....	14
4	Threats .....	15
4.1	Threat table .....	15
5	Conservation of the ecological community .....	18
5.1	Primary conservation objective .....	18
5.2	Existing protection and management plans .....	18
5.3	Principles and standards for conservation .....	18
5.4	Priority conservation and research actions .....	19
6	Listing assessment .....	29
6.1	Reason for assessment .....	29
6.2	Eligibility for listing .....	29
	References .....	34

# 1 Ecological community name and description

## 1.1 Name

Ben Halls Gap Sphagnum Moss Cool Temperate Rainforest (hereafter referred to as 'Ben Halls Gap Rainforest' or 'the ecological community').

The ecological community was listed as an endangered Ecological Community in NSW in 1998 under the name 'Ben Halls Gap National Park Sphagnum Moss Cool Temperate Rainforest' (NSW Scientific Committee 1998). In 2016 the status of the protected area changed from National Park to Nature Reserve. This has resulted in the name of the listing being updated to 'Ben Halls Gap Nature Reserve Sphagnum Moss Cool Temperate Rainforest' (NSW Threatened Species Scientific Committee 2019). As the ecological community proposed for national listing may also occur outside the Nature Reserve, the proposed name has been simplified.

### Consultation Questions on the Name

- Do you agree with the proposed name of the ecological community? If not, please propose an alternative and explain your reasoning.

## 1.2 Description of the ecological community and the area it inhabits

The EPBC Act defines an ecological community as an assemblage of native species that inhabits a particular area in nature. This section describes the species assemblage and area in nature that comprises the Ben Halls Gap Rainforest.

The ecological community described in this conservation advice is the assemblage of plants, animals and other organisms associated with a type of cool temperate rainforest with a low dense canopy, usually associated with sheltered permanent creek lines, occurring in the southern part of the New England Tablelands. It is characterised by (contains or is in close proximity to) areas with a ground layer of the sphagnum moss *Sphagnum cristatum*, where conditions are suitable for development of a shallow but distinctive peat layer.

Cool temperate rainforest vegetation types containing *Sphagnum* species represent communities which were likely to have been more widely distributed on the escarpment of northeastern New South Wales, but are now considered to be rare (NSW Scientific Committee 1998), particularly due to modern-day decline of Sphagnum moss linked to timber harvesting and the introduction of domestic livestock. The ecological community also occupies a westerly location which is biogeographically unusual as this may represent a remnant of a habitat previously more extensive during wetter (geological) periods (NSW Scientific Committee 1998).

This section describes the range of intact states of the ecological community. More information to assist in identifying patches of the ecological community is provided in [section 2](#). Because of past loss or degradation, not all current patches of the ecological community are in a completely intact state. [Section 2.3](#) provides information to identify which patches retain sufficient conservation values to be considered a matter of national environmental significance.

### 1.2.1 Location and physical environment

The currently known area remaining of the ecological community is comprised of patches within Ben Halls Gap Nature Reserve and the adjacent Ben Halls Gap State Forest. These patches occur

on a small plateau on the Great Dividing Range where the Mount Royal Range meets the Liverpool Range (NPWS 2002).

Areas of the ecological community are currently known to occur in or near Ben Halls Gap Nature Reserve and State Forest, which occurs across the boundary of the New England Tablelands (NET03 Walcha Plateau subregion) and NSW North Coast (NNC14 Tomalla subregion) IBRA bioregions (Interim Biogeographic Regionalisation for Australia v. 7, DoE 2012) and across the boundary of the Tamworth Regional and Upper Hunter Local Government Areas. It is typically associated with sheltered permanent creek lines. Other areas of rainforest within these bioregion subregions could be part of this ecological community if they match the description.

The ecological community is known to occur within an altitudinal range of approximately 1250-1500 m above sea level. Areas of potential habitat of the ecological community occur between approximately 1200-1600 m above sea level. The climate is cool and seasonally wet, with frequent dense fog and occasional snow (NPWS 2002). The soils are predominantly derived from Liverpool Range basalt (based on PCT 3051 (DPIE 2021)).

The plateau forms the headwaters of several rivers including the Barnard and the Hunter, which are two of the major rivers in the region. Ben Halls, Brayshaws and Stockyard Creeks flow east into the Barnard River while Pages Creek flows south into Hunter River. The Peel River rises on the western side of the plateau and flows into the Namoi River. The plateau is gently undulating but falls steeply into deep valleys cut by Brayshaws Creek, Ben Halls Creek and Pages Creek. The basalt resulted from the eruption of a number of shield volcanos between Coolah and Barrington Tops, 41 to 50 million years ago. A small outcrop of shale occurs near the Pages River. Deep montane humus soils have developed on the plateau. Small bogs are present where springs emerge on basalt benches on the mid-slopes. On lower and steeper slopes, the soils are shallower. There is little erosion because of the undisturbed dense ground cover and the nature of the soils which are soft and easily rutted or eroded by vehicle use, particularly in the winter months when the ground is frequently wet (NPWS 2002).

#### Consultation Questions on the location and physical environment

- How could the description of the location and physical environment be improved? Please provide supporting evidence.

#### 1.2.2 Relevant biology and ecology

##### 1.2.2.1 VEGETATION STRUCTURE

The ecological community at maturity is multi-layered, with or without a tall eucalypt canopy. The low dense rainforest midstorey canopy is approximately four metres tall and comprises variable species across the extent of the community. An understorey of shrubs, ferns and graminoids is also variable, often with extensive leaf litter. Where conditions are suitable for the formation of a shallow peat layer (mean peat depth ranges from 5 – 43 cm), *Sphagnum cristatum* is distinctive in the ground layer, forming large hummocks with a median size of 34.5 cm (Whinam & Chilcott 2002). The dense midstorey canopy plays a key role in shading and creating the micro-climate for the *Sphagnum* components that usually occur along rocky creeklines.

The community is quite distinct from other cool temperate rainforest remnants found at Barrington Tops and on the escarpment of the northeastern tablelands, as indicated by the common occurrence of distinctive *Sphagnum* moss hummocks, the presence of an undescribed species of *Callistemon*, a new species of orchid (*Corybas longitubus*), and the absence



of *Nothofagus moorei* (Antarctic beech). The ecological community is also near the known northern limit of the *Atherosperma moschatum* (black sassafras) (NSW Scientific Committee 1998).

#### Consultation Questions on the vegetation structure

- How could the description of the vegetation structure be improved?

#### 1.2.2.2 FIRE ECOLOGY

Cool temperate rainforests rarely burn due to their moist microclimates, which render fuels in a state unable to support fire spread except in extended and severe droughts, or during extended heatwaves over a shorter timeframe. Fires, even those with low flame heights, cause prolonged structural and functional transformation through top-kill of the thin-barked rainforest trees and through combustion or scorch death of Sphagnum hummocks. These changes may render the post-fire community unsuitable habitat for a range of rainforest-dependent flora and fauna for a prolonged period, with very long post-fire recovery times likely in these alpine environments.

#### Consultation Questions on the fire ecology

- Can this summary of the fire ecology for the ecological community be refined?

#### Consultation Questions on the functionally important species

- All species in the ecological community play a role, but are there other functionally important species that play a major role in sustaining the ecological community that should be described? If so, please provide key references and other supporting evidence regarding their role in the ecological community.

#### 1.2.3 Flora

The following are the most characteristic species of the ecological community.

##### 1.2.3.1 CANOPY AND MIDSTOREY SPECIES

Where present, in association with the species below, emergent eucalypts and other canopy species include *Eucalyptus dalrympleana* subsp. *dalrympleana* (mountain gum), *E. laevopinea* (silver top stringybark), *E. nobilis* (ribbon gum), *E. obliqua* (messmate), *E. pauciflora* (snow gum), *E. stellulata* (black sallee), *E. viminalis* (ribbon gum or manna gum) and *Acacia melanoxylon* (blackwood).

Common midstorey (or subcanopy) species include a combination of rainforest (mesophyllous) and sclerophyllous trees and tall shrubs such as *Atherosperma moschatum* (black sassafras), *Banksia integrifolia* subsp. *monticola*, *Callistemon* sp. nov., *Elaeocarpus holopetalus* (black olive berry), *Leptospermum polygalifolium* subsp. *montanum* (common teatree) and *Quintinia sieberi* (rough possumwood) (NSW Scientific Committee 1998; NSW DPIE 2021). Tall ferns including *Dicksonia antarctica* (soft tree-fern) and *Todea barbara* (king fern) may also be part of the midstorey, or the understorey if not at full potential growth height.

##### 1.2.3.2 UNDERSTOREY AND GROUND LAYER SPECIES

Understorey species include *Blechnum nudum*, *Bursaria spinosa* and *Deyeuxia gunniana*.

Ground layer species include *Corybas longitubus*, *Juncus alexandri*, *J. laeviusculus*, *Microsorium pustulatum* subsp. *pustulatum* (syn. *Microsorium diversifolium*; kangaroo fern). The ground layer

can be dominated by large hummocks of *Sphagnum cristatum* (Sphagnum moss), where conditions are suitable.

#### 1.2.4 Fauna

Ben Halls Gap Nature Reserve, where most of the ecological community occurs, has been shown to support a wide variety of birds, mammals, frogs and invertebrates (NSW Scientific Committee 1998).

##### 1.2.4.1 MAMMALS

Ben Halls Gap Nature Reserve supports a diversity of native mammal species, particularly arboreal mammals and these are likely all be found in the ecological community and may require tree hollows. Arboreal mammals include *Trichosurus vulpecula* (common brushtail possum), *Petauroides volans* (greater glider), *Acrobates pygmaeus* (feathertail glider) and nine species of bat including *Tadarida australis* (white-striped mastiff bat) and *Falsistrellus tasmaniensis* (eastern false pipistrelle) which is listed Vulnerable under the NSW *Biodiversity Conservation Act 2016* (NPWS 2002). Relatively common ground dwelling species include *Wallabia bicolor* (swamp wallaby), *Macropus rufogriseus* (red-necked wallaby), *Vombatus ursinus* (common wombat), *Tachyglossus aculeatus* (short-beaked echidna), *Isodon macrourus* (northern brown bandicoot), *Sminthopsis murina* (common dunnart), *Antechinus stuartii* (brown antechinus) and *Rattus fuscipes* (bush rat) (NPWS 2002).

##### 1.2.4.2 BIRDS

Eighty-seven native bird species have been recorded in Ben Halls Gap Nature Reserve. Sixteen of these are tree-hollow dwelling species and a number are largely dependent upon rainforest or tall open forest. Four of the bird species recorded; *Cacatua galerita* (sulphur-crested cockatoo), *Calyptorhynchus funereus* (yellow-tailed black cockatoo), *Ninox novaeseelandiae* (southern boobook owl) and the state-threatened (NSW) *Ninox strenua* (powerful owl) require large hollows in old trees for nesting. Such hollows may take up to 200 years to develop (Wormington & Lamb 1999). Other notable birds recorded include *Pachycephala olivacea* (olive whistler), *Falco peregrinus* (peregrine falcon), *Cinclosoma punctatum* (spotted quail-thrush), *Sericornis citreogularis* (yellow throated scrubwren) and *Climacteris erythrops* (red-browed tree-creeper). More common species include the *Acanthiza nana* (yellow thornbill), *Anthochaera carunculata* (red wattlebird), *Lalage tricolor* (white-winged triller), *Petroica phoenicea* (flame robin), *Scythrops novaehollandiae* (channel-billed cuckoo), *Halcyon sancta* (sacred kingfisher), *Coracina tenuirostris* (cicadabird), *Melithreptus brevirostris* (brown-headed honeyeater) and *Ailuroedus melanotis* (green catbird) (NPWS 2002).

##### 1.2.4.3 REPTILES AND AMPHIBIANS

Information about reptiles and amphibians in Ben Halls Gap Nature Reserve is limited. *Litoria booralongensis* and *L. daviesae* are examples of species closely tied to the hydrological conditions of the ecological community. The following species have been recorded, Frogs: *Litoria booralongensis*, *L. daviesae*, *L. verreauxii* (Verreaux's tree frog), *Pseudophryne* sp. (a toadlet) and *Ranidella signifera* (common eastern froglet); Reptiles: *Egernia whitii* (White's skink), *Eulamprus tympanum* (a water skink), *Lampropholis caligula* (montane sunskink), *Lampropholis mustelina* (weasel skink), *Notechis scutatus* (tiger snake), *Pseudechis porphyriacus* (red-bellied black snake), *Pseudemoia entrecasteauxii* (southern grass skink) and *Saiphos equalis* (a burrowing skink).

#### 1.2.4.4 INVERTEBRATES

An invertebrate survey of Ben Halls Gap Nature Reserve (Gunning 1995) found it to be very rich in insect species, with a particularly high diversity of butterflies, moths, beetles, bugs and wasps and of soil and ground dwelling insects associated with the large amount of organic matter on the forest floor. Two rare species were identified, *Eutanyderus* sp. (an alpine fly) and *Oxeixenica kershawii* (Kershaw's brown butterfly), both of which are significant new distribution records as outliers from their main distribution further south. *Acripeza reticulata* (mountain katydid) was also found in the park. This is an alpine species and its finding in Ben Halls Gap is a significant range extension (NPWS 2002).

#### Consultation Questions on the species assemblage

- Please point out any characteristic species or important interactions between species that we have missed in the description for this ecological community (and references/where to find source data); plus any species we included but shouldn't have (explain why).

## 2 Identifying areas of the ecological community

Section 1.2 describes this ecological community and the area it inhabits. This section provides additional information to assist with the identification of the ecological community and important occurrences of it.

The Ben Halls Gap Sphagnum Moss Cool Temperate Rainforest intergrades with other vegetation types and ecological communities (see section 2.2.6). Key diagnostic characteristics are used to identify an area of native vegetation as being the Ben Halls Gap Sphagnum Moss Cool Temperate Rainforest, and define the features that distinguish it from other communities, noting that additional information to assist with identification is provided in the other sections of this document, particularly the description (section 1.2).

### 2.1 Key diagnostic characteristics

The key diagnostic characteristics are designed to allow identification of the ecological community irrespective of the season.

Areas of vegetation that do not meet the key diagnostics are not the nationally listed ecological community.

The ecological community is defined as patches of native vegetation meeting the description in section 1.2 that meet the following key diagnostic characteristics:

- Overall, the ecological community is characterised by a combination of cool temperate non-sclerophyll tree and shrub species (see below), with *Sphagnum cristatum* in the ground layer across some parts of the patch.
- It typically appears as a forest with a low dense canopy or midstorey dominated by rainforest species and ferns around four-metres-tall, and an understorey of shrubs, smaller ferns and mostly graminoids in the ground layer. Where conditions are suitable for the formation of a shallow peat layer, *Sphagnum cristatum* is distinctive in the ground layer (particularly along rocky creeklines).

- Characteristic species in the canopy and midstorey include *Atherosperma moschatum* (black sassafras), *Banksia integrifolia* subsp. *monticola*, *Callistemon* sp. nov., *Elaeocarpus holopetalus* (black olive berry), *Leptospermum polygalifolium* subsp. *montanum* (common teatree) and *Quintinia sieberi* (rough possumwood) (NSW Scientific Committee 1998; NSW DPIE 2021). Tall ferns include *Dicksonia antarctica* (soft tree-fern) and *Todea barbara* (king fern). Unlike most other cool temperate rainforests in the region, *Nothofagus moorei* (Antarctic beech) is absent from this community.
- Other canopy trees may or may not be present in association with the above species, including *Eucalyptus dalrympleana* subsp. *dalrympleana* (mountain gum), *E. laevopinea* (silver top stringybark), *E. nobilis* (ribbon gum), *E. obliqua* (messmate), *E. pauciflora* (snow Gum), *E. stellulata* (black sallee), *E. viminalis* (ribbon gum) and *Acacia melanoxylon* (blackwood).
- Understorey species include *Blechnum nudum*, *Bursaria spinosa* and *Deyeuxia gunniana*.
- Ground layer species include *Corybas longitubus*, *Juncus alexandri*, *J. laeviusculus*, *Microsorium pustulatum* subsp. *pustulatum* (syn. *Microsorium diversifolium*; king fern) and can be dominated by large hummocks of *Sphagnum cristatum* (sphagnum moss) over a peat layer, where conditions are suitable.
- Areas of the ecological community are currently known to occur in or near Ben Halls Gap Nature Reserve and State Forest, which occurs across the boundary of the New England Tablelands (NET03 Walcha Plateau subregion) and NSW North Coast (NNC14 Tomalla subregion) IBRA bioregions (Interim Biogeographic Regionalisation for Australia v. 7, DoE 2012). It is typically associated with sheltered permanent creek lines. Other areas of rainforest within these bioregion subregions could be part of this ecological community if they match the description.
- Areas of potential habitat of the ecological community occur between approximately 1200-1600 m above sea level.

#### Consultation Questions on the key diagnostic characteristics

- Could the key diagnostics be improved?
- Which characteristic species should we add or remove from each vegetation layer, and why?
- Is there a minimum percentage of crown cover expected for this ecological community if the canopy is relatively undisturbed? (if we included one we would note that it can have less crown cover for some time after a fire or other major disturbance)
- Are there any faunal elements that could be used in the diagnostic characteristics?

## 2.2 Additional information to assist in identifying the ecological community

The following information should also be taken into consideration when applying the key diagnostic characteristics to assess if a site may include the ecological community.



### 2.2.1 Identifying a patch

A patch is a discrete and mostly continuous area of the ecological community, as defined by the key diagnostics, but can include small-scale variations, gaps and disturbances within this area. The smallest patch size that can be identified is 0.1 ha, as the key diagnostics cannot reliably be identified for smaller areas than this. Where a larger area has been mapped or classified as a different vegetation type, localised areas of the ecological community greater than 0.1 ha may be present within this larger area.

### 2.2.2 Breaks in a patch

In defining a patch of the ecological community allowances are made for “breaks” up to 30 metres between areas that meet the key diagnostics. Such breaks may be the result of tracks, paths, roads, gaps made by exposed areas of soil, leaf litter or cryptogams, and areas of localised variation in vegetation that do not meet the key diagnostics. For example, a single patch could include two areas of the ecological community that meet the key diagnostics, but which are separated by a track or road. Such breaks do not significantly alter the overall functionality of the ecological community and form a part of the patch. Gaps made by exposed areas of soil or leaf litter, and areas of localised variation in vegetation should be included in the calculation of the size of the patch and be taken into account when determining the overall condition of the patch. Tracks, paths, roads or other man-made surfaces should be excluded from the calculation of patch size and condition.

Where there is a break in the ecological community of 30 metres or more (e.g. due to permanent artificial structures, wide roads or other barriers, water bodies or other types of vegetation) then the gap indicates that separate patches are present.

### 2.2.3 Variation within a patch

Patches of the ecological community may contain areas that vary in structural or biological characteristics. For example, one part of the midstorey of a patch may consist of mostly rainforest species, whereas another part of the midstorey in the same patch may be dominated by tree-ferns; or one part of a patch may have been more recently burnt and therefore at a different stage of regeneration. Additionally, *Sphagnum cristatum* should occur in the ground layer across some parts of the patch but not the entire patch. Variation in vegetation across a patch should not be considered to be evidence of multiple patches, so long as it meets the key diagnostics.

### 2.2.4 Revegetation and regrowth

Revegetated or otherwise restored sites or areas of regrowth are not excluded from the listed ecological community so long as the patch meets the key diagnostic characteristics.

Where ecological restoration is planned, the aim should be for recovery of as many key biodiversity an ecosystem attributes as practical for a particular site, so that the ecological community is on a trajectory to recovery and is self-sustaining. This should be based on identifying appropriate reference site(s) for the ecological community following the *National Standards for the Practice of Ecological Restoration in Australia* (Standards Reference Group SERA 2021) (also see [Section 5.4.2](#)).

### 2.2.5 Survey requirements

Patches of the ecological community can vary markedly in their shape, size, condition and features. Thorough and representative on-ground surveys are essential to accurately assess the extent and condition of a patch. The Australian Soil and Land Survey Field Handbook (National Committee on Soil and Terrain 2009), and New South Wales BioNet Vegetation Classification User Manual (NSW Office of Environment and Heritage 2018) may provide guidance.

The size, number and spatial distribution of plots or transects must be adequate to represent variation across the patch. Sampling should address likely variation in species composition and significant variation in the vegetation (including areas of different condition), landscape qualities and management history (where known) across the patch.

Recording the search effort (identifying the number of person hours spent per plot/transect and across the entire patch; along with the surveyor's level of expertise and limitations at the time of survey) is useful for future reference.

Whilst identifying the ecological community and its condition is possible at most times of the year, consideration must be given to the role that season, rainfall and disturbance history may play in an assessment. For example, after a fire one or more vegetation layers, or groups of species, may not be evident for a time. Timing of surveys should allow for a reasonable interval after a disturbance (natural or human-induced) to allow for regeneration of species to become evident, and be timed to enable diagnostic species to be identified. At a minimum, it is important to note climate conditions and what kind of disturbance may have happened within a patch, and when that disturbance occurred.

### 2.2.6 Mapping and vegetation classifications

There are a number of mapping and vegetation classification schemes in New South Wales. The primary scheme used by the NSW Government at this time is the Plant Community Type (PCT) system. Although no current classification system directly maps areas of this ecological community according to the key diagnostics, the ecological community is within the broader NSW Plant Community Type (PCT) 3051, Mount Royal Range Cool Temperate Rainforest (DPIE 2021).

Table 1 outlines how the ecological community can be distinguished from a number of similar vegetation types.

**Table 1: Key features distinguishing TEC from other vegetation types**

Code / Number	Name	Key distinguishing features
PCT 3051	Mount Royal Range Cool Temperate Rainforest	<ul style="list-style-type: none"><li>The ecological community is within unit PCT 3051 but is quite distinct from other cool temperate rainforest remnants (that also may be within PCT 3051) found at Barrington Tops and on the northern tablelands, as indicated by the presence of an undescribed species of <i>Callistemon</i>, a new taxon of orchid (<i>Corybas</i> sp.), the absence of <i>Nothofagus moorei</i> (Antarctic Beech) and the common occurrence of distinctive Sphagnum moss hummocks. The ecological community is also near the known northern limit of the <i>Atherosperma moschatum</i> (Black Sassafras) (NSW Scientific Committee 1998).</li></ul>

Source: NSW Scientific Committee (1998); DPIE (2021).

### 2.2.7 Other relevant listed ecological communities

The ecological community includes the endangered ecological community 'Ben Halls Gap Nature Reserve Sphagnum Moss Cool Temperate Rainforest' that is listed under the *NSW Biodiversity Conservation Act 2016*. At the time of writing the NSW-listed ecological community is restricted to occurrences within Ben Halls Gap Nature Reserve (NSW Scientific Committee 1998; NSW Threatened Species Scientific Committee 2019).

There is also another nationally-listed threatened rainforest that occurs nearby, but within a lower altitude range:

- Lowland rainforest of subtropical Australia (critically endangered) – also listed in NSW as the Lowland Rainforest on Floodplain in the NSW North Coast bioregion (NSW TSSC 2019).

#### Consultation Questions on the identification information

- How could we improve on the information to assist with identifying the ecological community?

## 2.3 Condition classes and thresholds

In order to be protected as a matter of national environmental significance through the referral, assessment, approval and compliance provisions of national environment law (the EPBC Act) areas for the ecological community must meet the description ([section 1](#)) and key diagnostic characteristics ([section 2.1](#)).

No minimum condition threshold is prescribed for this ecological community. The ecological community has a very restricted extent, most within conservation tenure where the natural vegetation remains largely unmodified by modern developments or agriculture. Fire, extreme storm events and feral animals are currently the key long term habitat modifiers in this landscape.

A high-quality *condition class* is specified to guide management and restoration decisions for existing high-quality patches or to increase the quality of relatively degraded patches. Key to the ecological community's development is the presence of a closed canopy to maintain conditions suitable for understorey rainforest species, and in some areas, a ground layer of *Sphagnum cristatum*. Maintenance of suitable hydrological conditions is also important.

#### High-quality condition class:

- Canopy and/or midstorey cover of at least 70% projective foliage cover<sup>1</sup> of native species; AND

---

<sup>1</sup> On average, across the patch. Canopy cover may be measured, for example, along a 50 m transect.

- A diversity of midstorey, understorey and ground layer plant species<sup>2</sup>, with at least 10 'rainforest species\*'; AND
- Where applicable to some areas of a patch, a ground layer of *Sphagnum cristatum* is present, sometimes forming hummocks with a median size of 34.5cm.

When assessing condition of a patch of the ecological community it is important to also consider *Additional information to assist in identifying the ecological community*, including patch definition information ([section 2.2](#)).

#### Consultation Questions on the condition classes and thresholds

- How can we improve on the proposed condition information?
- \*Which species are most relevant for contributing to the 'rainforest species' threshold?
- We would greatly appreciate your input on the proposed specific thresholds for each category, including whether or not we should have minimum thresholds for this EC?

## 2.4 Habitat critical to the survival of the ecological community

The habitat requirements for an ecological community include areas with the necessary physical, geological and climatic conditions, as well as the necessary biological conditions which may be provided by other species in the assemblage. Consequently, habitat includes the plants that provide the vegetation structure and resources for fauna, such as food, nesting sites (e.g. tree hollows) and shelter.

The habitat or areas most critical to the survival of the ecological community includes all patches that meet the Key diagnostic characteristics ([section 2.1](#)) for the ecological community plus a buffer zone (particularly where the buffer includes native vegetation) (see [5.4.1.3 Apply buffer zones](#)). It also includes areas within the local catchments that influence patches of the ecological community, given that hydrological conditions (e.g. water availability and quality) are important requirements for development of the ecological community, particularly the peat layer with *Sphagnum cristatum*. The peat layer of this ecological community is shallow (compared to most other peatlands in Australia) so is susceptible to stochastic disturbance events.

No Critical Habitat as defined under section 207A of the EPBC Act has been identified or included in the Register of Critical Habitat at this time.

#### Consultation Questions on the habitat critical to the survival

- How can this section be improved?
- Can you provide any information on particular locations or habitat that would be *critical* to the survival of this ecological community?
- Does the ecological community occur within any areas of Commonwealth Land? If so, which of those areas should be considered for the Critical Habitat Register under section 207A of the EPBC Act upon listing this ecological community?

---

<sup>2</sup> Within a 20 x 20 m quadrat, with representative plots sampled across the patch.

## 2.5 Areas of high value - surrounding environment and landscape context

Patches of the ecological community do not occur in isolation. The surrounding vegetation and other landscape considerations will also influence how important a patch is to the ecological community as a whole. Patches that are larger and less disturbed are likely to provide greater biodiversity value. Patches that are spatially linked, whether ecologically through dispersal or gene flow, for instance, or by proximity, are particularly important as wildlife habitat and to the viability of those patches of the ecological community into the future. However, this still does not necessarily consider the full landscape context. For natural resource management activities or actions that may have 'significant impacts' and require approval under the EPBC Act, it is important to consider the whole environment surrounding patches of the ecological community.

The ecological community often occurs in association with other native vegetation types. Patches of the ecological community that remain connected with other native vegetation have a better chance of future survival and restoration success, because connected patches are buffered from disturbance by the surrounding native vegetation.

The following indicators of high-value should be considered when assessing the impacts of proposed actions under the EPBC Act, or when determining priorities for protection, recovery, management and funding.

- Patches that meet, or are closest to the high-quality condition class for this ecological community. These may be based on on-site observations or known past management history.
- Patches with or in close proximity to an intact ground layer of *Sphagnum cristatum*.
- Patches with a larger area to boundary ratio – such patches are more resilient to edge effect disturbances such as weed invasion and human impacts.
- Patches within or near to a larger native vegetation remnant and that contribute to a mosaic of vegetation types present at a site. Areas of mosaic native vegetation provide a wider range of habitats that benefit flora and fauna diversity. Other patches are important as linkages among remnants, acting as 'stepping stones' of native remnants in the landscape. Connectivity includes actual or potential connectivity to restoration works (e.g. native plantings).
- Patches that occur in areas where the ecological community has been most heavily cleared and degraded, or that are at the natural edge of its range, particularly where there is genetic distinction, or absence of some threats. These may include unique variants of the ecological community, e.g. with a unique flora and/or fauna composition, or a patch that contains flora or fauna that have largely declined across the broader ecological community or region.
- Patches that show evidence of recruitment of key native plant species or the presence of a range of age cohorts (including through successful assisted regeneration or management of sites).
- Patches with good faunal habitat as indicated by diversity of landscape, diversity of plant species and vegetation structure, diversity of age class, presence of movement corridors, mature trees (particularly those with hollows), logs, watercourses, etc.



- Patches containing nationally or state-listed threatened species.
- Patches with high species richness, as shown by the variety of native understorey plant species, or high number of native fauna species (vertebrates and/or invertebrates).
- Patches with relatively low levels of weeds and feral animals or areas where these can be managed efficiently.

#### Consultation Questions on the areas of high value

- How can this section be improved? Can you provide any additional information on qualities that would denote areas of particularly high conservation value?

### 3 Cultural and community significance

The TEC occurs within country (the traditional lands) of the Gomeroi people. We acknowledge their culture and continuing link to the ecological community and the country it inhabits.

The significance of the ecological community, particular species, spiritual and other cultural values are diverse and varied for the Indigenous Australians that live in the vicinity and care for Country. This section describes some examples of this significance but is not intended to be comprehensive or applicable to, or speak for, all Indigenous people. Such knowledge may be only held by Indigenous groups and individuals who are the custodians of this knowledge.

A wide variety of plant and animal resources from within the ecological community are traditionally used for food, medicine and materials.

NPWS (2002) describes that the area of the Nature Reserve was located in the lands of the Gumaroi Aboriginal people. It is now in the area of the Nungaroo Local Aboriginal Land Council but Aboriginal people living in other land council areas may have an interest in the management of the park and the ecological community. Traditional knowledge held by Indigenous people today indicates that the Nature Reserve was significant (Tommy Taylor, pers. comm., cited in NPWS 2002). There is known to have been movement from the Nowendoc area into the Hunter Valley and it is probable that Ben Halls Gap was used as a travel route as it is a relatively low point in the ranges and permanent water is available. No Aboriginal sites have been located at this time in the Nature Reserve but sufficient surveys have not been undertaken. A scarred tree and open campsite have been recorded along Ben Halls Creek immediately east of the Nature Reserve. Aboriginal sites known to occur in surrounding areas include campsites, axe-grinding grooves and a carved tree.

#### Consultation Questions on the cultural and community significance

- We would very much like to provide more details in this section, and would be very open to your suggestions of contacts/resources that we could connect with/use to increase our knowledge and add value to this section.
- We would like to ensure that we cover all Indigenous peoples that are associated with the ecological community, so please indicate any additional groups that should be acknowledged.

For Traditional Custodians only:

- Do you have any information you are willing to share about the cultural significance of the ecological community, forests in the area generally or the Country that supports the ecological community?
- Do you know any people or organisations we could contact in the region who may have information they are willing to share?
- Do you know of any books, reports, articles or online resources about the Gumaroi People's relationships with the forest or the landscape you think would be sources of appropriate information?

## 4 Threats

Ben Halls Gap Sphagnum Moss Cool Temperate Rainforest has been primarily impacted by fire and drought, weed invasion and disturbance by humans and non-native animals.

### 4.1 Threat table

Table 2 outlines the key threats facing the ecological community. The key threats faced by the ecological community are described to help explain why this ecological community merits listing as threatened and supports the assessment against the criteria at [section 6](#). Although presented as a list, in reality these threats often interact, rather than act independently.

**Table 2: Summary of threats facing the ecological community**

Threat	Threat Status*	Threat Impacts and Evidence Base
Inappropriate fire regimes (including fires which cause decline in biota)	<i>Timing:</i> ongoing <i>Severity:</i> extreme <i>Scope:</i> whole	<ul style="list-style-type: none"> <li>• The ecological community is highly vulnerable to the impacts of inappropriate fire regimes including fire frequency, intensity, seasonality, and scale (NSW Scientific Committee 1998; NSW DPIE 2021). The cool temperate rainforest microclimate is particularly susceptible to disturbance from an increased fire frequency. Increased sedimentation from fire events may affect the organic content of the site and inhibit re-establishment of sphagnum moss (Whinam &amp; Chilcott 2002).</li> <li>• Approximately 50 % of the ecological community was burnt in December 2019 – January 2020 with the remainder of the extent likely to have been affected (e.g., through increased sedimentation and solar radiation) by burning of adjacent and nearby vegetation communities (based on expert input and analysis of DAWE (2020) and PCT 3051 (DPIE 2021) in the Ben Halls Gap area). Canopy cover was affected substantially so the ability of all components of the ecological community to recover is uncertain given increased exposure to light and solar radiation (e.g., moist rainforest components of the midstorey, understorey and ground layer).</li> <li>• Damage from fire also leaves the ecological community more susceptible to impacts from other threats such as invasion and rapid spread of weeds and pest animals, disease, and drought / a drying climate</li> </ul>
Disturbance to water quality and quantity	<i>Timing:</i> ongoing <i>Severity:</i> extreme <i>Scope:</i> whole	<ul style="list-style-type: none"> <li>• The ecological community is vulnerable to sediment entering the streams due to soil disturbance, for example during track and road construction or grazing in the water catchment.</li> <li>• Increased human visitation or pest species may impact on water quality in the area (NSW DPIE 2021).</li> <li>• Characteristic rainforest species, large ferns and sphagnum moss are very susceptible to changes in water availability.</li> <li>• Groundwater drawdown due to domestic, commercial, and mining activity is a potential threat.</li> </ul>

Threat	Threat Status*	Threat Impacts and Evidence Base
Climate change	<p><i>Timing:</i> ongoing</p> <p><i>Severity:</i> extreme</p> <p><i>Scope:</i> whole</p>	<ul style="list-style-type: none"> <li>Projections of future changes in climate for northern NSW include higher average temperatures, more intense but likely reduced annual average rainfall, increased temperature extremes and higher evaporative demand (Hennessy 2011). Increasing temperatures and less rainfall events will decrease water availability resulting in degradation and contraction of the community.</li> <li>Characteristic rainforest species, large ferns and sphagnum moss are very susceptible to drier, hotter weather, particularly when fires also damage the midstorey and canopy and exacerbate the impacts of solar radiation on higher evaporation rates.</li> <li>Severe drought conditions over the past decade have resulted in a decrease in the range of the ecological community due to its reliance on water. Research is currently being conducted into how much of the ecological community has been lost because of drought.</li> </ul>
Disturbance due to heavy snowfall and storm events	<p><i>Timing:</i> ongoing</p> <p><i>Severity:</i> major</p> <p><i>Scope:</i> whole (TBC)</p>	<ul style="list-style-type: none"> <li>Damage from heavy snowfalls, rain and high winds in 2021 has resulted in severe canopy damage to areas of the ecological community. The extent and severity of the damage is being evaluated.</li> </ul>
Invasive species - Plants	<p><i>Timing:</i> ongoing</p> <p><i>Severity:</i> major</p> <p><i>Scope:</i> whole</p>	<ul style="list-style-type: none"> <li>Introduced plants such as Blackberry are present in the Nature Reserve and may outcompete native flora. The presence of these introduced plants may also provide habitat for introduced pest animals (NSW DPIE 2021).</li> <li>Sphagnum moss is very susceptible to competition from weeds, particularly following disturbance such as fire and damage by pest animals (Whinam &amp; Chilcott 2002).</li> </ul>
Invasive species - Pathogens	<p><i>Timing:</i> ongoing</p> <p><i>Severity:</i> minor</p> <p><i>Scope:</i> majority</p>	<ul style="list-style-type: none"> <li>Plant pathogens such as Phytophthora and myrtle rust (<i>Austropuccinia psidii</i>) (NSW DPIE 2021) may cause disease in the ecological community</li> <li>Infection by myrtle rust is potentially a threat to various trees and shrubs in the Myrtaceae family in the ecological community (Makinson 2018), particularly <i>Callistemon</i> sp. and <i>Leptospermum polygalifolium</i> subsp. <i>montanum</i>.</li> <li>Chytrid fungus is a threat to the various frogs of the ecological community.</li> </ul>
Invasive species - Animals	<p><i>Timing:</i> ongoing</p> <p><i>Severity:</i> major</p> <p><i>Scope:</i> whole</p>	<ul style="list-style-type: none"> <li>Impacts from feral animals occur through substrate disturbance, herbivory, and predation.</li> <li>Feral herbivores like goats, deer and cattle are known to selectively graze along permanent water sources in the area, damaging plants, particularly sphagnum moss (NPWS 2002).</li> <li>Pest animals that dig and wallow in watercourses and peat/sphagnum moss, such as pigs and deer, also cause habitat destruction through trampling, soil disturbance, eroding banks of watercourses and polluting the water, as well as promoting weed invasion and disease transmission.</li> <li>Feral horses do not currently occur in the area, but may invade from regional populations in the future, and would be an extreme additional threat to the sphagnum moss and riparian plants.</li> <li>Pigs, foxes, cats and wild dogs prey on native fauna species in the ecological community within the Nature Reserve.</li> </ul>
Disturbance by humans	<p><i>Timing:</i> ongoing</p> <p><i>Severity:</i> minor</p> <p><i>Scope:</i> minority</p>	<ul style="list-style-type: none"> <li>The sphagnum moss-rainforest elements are vulnerable to visitor pressure which may disturb the community and destroy the sphagnum moss through trampling (NSW Scientific Committee 1998).</li> <li>Illegal removal of sphagnum moss for commercial and domestic purposes is a significant risk for the ecological community (NSW Scientific Committee 1998).</li> <li>Visitation may also result in further weed invasion and the spread of plant pathogens (NSW Scientific Committee 1998).</li> </ul>

Threat	Threat Status*	Threat Impacts and Evidence Base
<p><b>*Timing</b> – the threat occurs in the <b>past</b> (and unlikely to return), is <b>ongoing</b> (present/continuing), is likely to occur/return in the <b>future</b>, or timing is <b>unknown</b></p> <p><b>Severity</b> – the threat causes or has the potential to cause impacts that are <b>extreme</b> (leading to loss or transformation of affected patches/occurrences), <b>major</b> (leading to degradation of affected patches/occurrences), <b>minor</b> (impacting some components of affected patches/occurrences), <b>negligible</b> or <b>unknown</b></p> <p><b>Scope</b> – the threat is affecting the <b>whole</b> (&gt;90%), a <b>majority</b> (&gt;50%), a <b>minority</b> (&lt;50%), a <b>negligible</b> amount, or <b>unknown</b> amount of the ecological community</p>		

#### 4.1.1 Key threatening processes

The EPBC Act provides for the identification and listing of key threatening processes. A process is defined as a key threatening process if it threatens or may threaten the survival, abundance or evolutionary development of a native species or ecological community.

The following are EPBC-listed key threatening processes, current at the date of writing, that may be relevant to the ecological community or specific plants and animals that comprise it:

- Competition and land degradation by unmanaged goats
- Dieback caused by the root-rot fungus (*Phytophthora cinnamomi*)
- Infection of amphibians with chytrid fungus resulting in chytridiomycosis
- Land clearance
- Loss of climatic habitat caused by anthropogenic emissions of greenhouse gases
- Novel biota and their impact on biodiversity
- Predation, Habitat Degradation, Competition and Disease Transmission by Feral Pigs
- Predation by European red fox
- Predation by feral cats.

Any approved threat abatement plans or advice associated with these items provides information to help landowners manage these threats and reduce their impacts to biodiversity. These can be found at <http://www.environment.gov.au/cgi-bin/sprat/public/publicgetkeythreats.pl>.

#### Consultation Questions on the threats

- How can the Threats analysis be improved?
- In particular, what threat and threat impacts are missing?
- Are any of the listed threats more, or less, severe or of different timing or scope than currently proposed for this ecological community?
- Please provide additional example of threat impacts, references and other evidence.

## 5 Conservation of the ecological community

### 5.1 Primary conservation objective

To mitigate the risk of extinction of the Ben Halls Gap Sphagnum Moss Cool Temperate Rainforest, and help recover its biodiversity and function through protecting it from significant impacts as a Matter of National Environmental Significance under national environmental law, and by guiding implementation of management and recovery, consistent with the recommended priority conservation and research actions set out in this advice.

### 5.2 Existing protection and management plans

#### 5.2.1 Existing protections

Almost all of the known extent is within Ben Halls Gap Nature Reserve. The largely equivalent 'Ben Halls Gap Nature Reserve Sphagnum Moss Cool Temperate Rainforest' is listed as endangered under the NSW *Biodiversity Conservation Act* (2016).

#### 5.2.2 Existing management plans

- Department of Agriculture, Water and the Environment [DAWE] (2020) *Bushfire impacts and threatened ecological communities*. Commonwealth Department of Agriculture, Water and the Environment, Canberra.  
Available at: <https://www.awe.gov.au/sites/default/files/env/pages/cae21f42-9328-45ee-b558-a79628aaf68f/files/tecs-data-release-factsheet.pdf>
- NPWS (2002) Ben Halls Gap National Park Plan of Management. NSW National Parks and Wildlife Service. Available on the internet at:  
<https://www.environment.nsw.gov.au/-/media/OEH/Corporate-Site/Documents/Parks-reserves-and-protected-areas/Parks-plans-of-management/ben-halls-gap-national-park-plan-of-management-020091.pdf>
- Makinson (2018) Myrtle Rust in Australia – a draft Action Plan. Plant Biosecurity Cooperative Research Centre. [www.anpc.asn.au/myrtle-rust/](http://www.anpc.asn.au/myrtle-rust/)

Consultation Questions on existing protections and management plans

- Which other management plans are worth including?

### 5.3 Principles and standards for conservation

To undertake priority actions to meet the conservation objective, the overarching principle is that it is preferable to maintain existing areas of the ecological community that are relatively intact and of high quality. There are good, practical reasons to do so. It is typically more cost-effective to retain an intact remnant than to allow degradation and then attempt to restore it or another area. The more disturbed and modified a patch of the ecological community, the greater the recovery effort that is required. Also, intact remnants are likely to retain a fuller suite of native plant and animal species, and ecological functions. Certain species may not be easy to recover in practice, if lost from a site.



This principle is highlighted in the *National Standards for the Practice of Ecological Restoration in Australia* (Standards Reference Group SERA, 2021):

***“Ecological restoration is not a substitute for sustainably managing and protecting ecosystems in the first instance.***

*The promise of restoration cannot be invoked as a justification for destroying or damaging existing ecosystems because functional natural ecosystems are not transportable or easily rebuilt once damaged and the success of ecological restoration cannot be assured. Many projects that aspire to restoration fall short of reinstating reference ecosystem attributes for a range of reasons including scale and degree of damage and technical, ecological and resource limitations.”*

*Standards Reference Group SERA (2021) – Appendix 2.*

The principle discourages ‘offsets’ where intact remnants are removed with an undertaking to set aside and/or restore other, lesser quality, sites. The destruction of intact sites represents a net loss of the functional ecological community because there is no guarantee all the species and ecological functions of the intact site can be replicated elsewhere.

Where restoration is to be undertaken, it should be planned and implemented with reference to the *National Standards for the Practice of Ecological Restoration in Australia*. These Standards guide how ecological restoration actions should be undertaken and are available online from the Standards Reference Group SERA (2021). They outline the principles that convey the main ecological, biological, technical, social and ethical underpinnings of ecological restoration practice.

## **5.4 Priority conservation and research actions**

Priority actions are recommended for the abatement of threats and supporting recovery of the ecological community. They are designed to provide guidance for:

- planning, management and restoration of the ecological community by State agencies, landholders, Traditional custodians, NRM and community groups and other land managers;
- conditions of approval for relevant controlled actions under national environment law (the EPBC Act); and
- prioritising activities in applications for Australian Government funding programs.

Detailed advice on actions may be available in specific plans, such as management plans for weeds, fire or certain parks or regions. The most relevant at the time this conservation advice was developed are listed in [section 5.2.1.2](#).

This conservation advice identifies priority conservation actions under the following key approaches:

- PROTECT the ecological community to prevent further losses;
- RESTORE the ecological community by active abatement of threats, appropriate management, restoration and other conservation initiatives;

- COMMUNICATE, ENGAGE WITH AND SUPPORT people to increase understanding of the value and function of the ecological community and encourage their efforts in its protection and recovery; and
- RESEARCH AND MONITORING to improve our understanding of the ecological community and the best methods to aid its management and recovery.

These approaches overlap in practice; and form part of an iterative approach to management that includes research, planning, management, monitoring and review.

The actions below do not necessarily encompass all actions in detail that may benefit the ecological community. They highlight general but key actions required to at least maintain survival of the ecological community at the time of preparing this Conservation Advice.

#### 5.4.1 *PROTECT the ecological community*

This key approach includes priorities intended to protect the ecological community by preventing further losses of occurrences.

- The ecological community should be properly taken into account during the early stages of zoning and development planning decisions, including strategic planning documents at state, regional and local levels.
- Liaise with local councils and state authorities to ensure that cumulative impacts on the ecological community are reduced as part of broader strategic planning (including fire management).
- Undertake activities to mitigate future climate change and therefore reduce the impacts of climate stress on this ecological community.

##### 5.4.1.1 *CONSERVE REMAINING PATCHES*

There should be no further clearance and damage to this ecological community because of its very restricted geographic distribution.

- Protect and conserve remaining areas of the ecological community, particularly areas that are habitat critical to survival.
- Given that this ecological community is very restricted in spatial extent, this means avoiding any further losses to any patches of the ecological community that meet the minimum condition thresholds.
- Retain other native vegetation near patches of the ecological community, and consider inclusion in the conservation estate, as it is important for connectivity, diversity of habitat and act as buffer zones between the ecological community and threats. This includes investigating formal conservation arrangements, joint management agreements with Traditional custodians, and co-management agreements and covenants to protect nearby native vegetation on private land.
- Where regeneration is occurring, provide measures that will support the regeneration to maturity (e.g. provide fencing and avoid further fires to minimise damage risk).

- Protect mature and over-mature trees and stags, particularly with hollows. Large and old trees typically have numerous hollows or fissures that provide shelter and support a diversity of animals.

#### 5.4.1.2 *MANAGE ACTIONS TO MINIMISE IMPACTS*

When considering potential negative impacts on the ecological community from development or other actions in or nearby the ecological community, avoidance is the appropriate approach. The highest priority is to prevent direct disturbance of areas of the ecological community, but it is also important to avoid off-site impacts such as changes to hydrology or other ecological processes and damage to landscape function, particularly by preventing loss of nearby native vegetation and avoiding impacts in the catchment that may impact the ecological community. Where possible, facilitate the recovery of areas that are within the former range of the ecological community and retain suitable conditions for recovery such as appropriate soils and microclimate.

Land use and management in the vicinity of this ecological community should:

- Minimise the risk of indirect impacts to the ecological community from actions outside but near to patches of the ecological community. For example, prevent sediment entering the streams due to soil disturbance, for activities such as track and road construction in the water catchment.
- Avoid activities that are inconsistent with the fire regime considered appropriate for the ecological community (i.e. fire avoidance) using the best information available. Ensure that fire management activities (including creation of any new fire access tracks and asset protection zones) do not have detrimental impacts on the integrity of the ecological community. Avoid development that will limit future ecological management of fire.
- As this ecological community is highly restricted in extent, it is not appropriate to propose offsets for actions that may cause damage.

#### 5.4.1.3 *APPLY BUFFER ZONES*

- Protect and apply appropriate buffers, particularly of other native vegetation, around patches of the ecological community to minimise off-site impacts. A buffer zone is a contiguous area adjacent to a patch that is important for protecting the integrity of the ecological community. As the risk of indirect damage to an ecological community is usually greater where actions occur close to a patch, the purpose of the buffer zone is to minimise this risk by guiding land managers to be aware that the ecological community is nearby and take extra care. For instance, the buffer zone will help protect the root zone of edge trees and other components of the ecological community from spray drift (fertiliser, pesticide or herbicide sprayed in adjacent land), weed invasion, polluted water runoff and other damage. The best buffer zones are typically comprised of other native vegetation. Fire breaks and other built asset protection zones do not typically provide a suitable buffer and should be additional to a vegetated buffer.
- The recommended minimum buffer zone is 50 m from the outer edge of the patch as this distance accounts for likely influences upon the root zone. A larger buffer zone should be applied, where practical, to protect patches that are of very high conservation value or depending on the threat. Judgement should be exercised to determine an appropriate buffer distance, depending on circumstances and how a patch may be detrimentally impacted.

*5.4.1.4 PREVENT THE INTRODUCTION AND SPREAD OF EXOTIC SPECIES*

- Support strong border biosecurity and avoid importing or accidentally introducing invasive species and pathogens that may have a serious adverse impact on this ecological community.
- Prevent planting of known or potentially invasive species in gardens, developments and landscaping near the ecological community.
- Prevent dumping of garden waste into bushland, especially in or near patches of the ecological community.
- Avoid the sale and planting of known invasive species in areas where the ecological community occurs. Review the planting schedule for new developments and landscaping to ensure that potential weeds or other inappropriate plants (e.g. native plants likely to contaminate the local gene pool) are not included.
- Control runoff during nearby construction activities to prevent movement of weeds and pathogens into the ecological community.
- When conducting activities in or around the ecological community, practice good biosecurity hygiene to avoid spreading weeds or pathogens (see DoE, 2015).
- Minimise unnecessary soil disturbance that may facilitate weed establishment.
- If new invasive species incursions do occur, detect and control them early, as small infestations are more likely to be eradicated.
- Limit or prevent access of grazing animals to patches of the ecological community (e.g. construct fences) where practicable. Provide advice and support to landholders to assist with this.
- Limit or prevent access of vehicles to patches of the ecological community.
- Prevent further incursions of feral animals into the ecological community.

*5.4.2 RESTORE and MANAGE the ecological community*

This key approach includes priorities to restore and maintain the remaining occurrences of the ecological community by active abatement of threats, appropriate management, restoration and other conservation initiatives.

- Implement management actions that mitigate against trampling, further weed encroachment, fire, drainage and sedimentation impacts.
- Liaise with landholders in surrounding areas and undertake and promote programs that ameliorate threats such as invasive plants and animals and disturbance from livestock.
- Identify and prioritise other specific threats and undertake appropriate on-ground site management strategies where required.

#### 5.4.2.1 *MANAGE WEEDS, PESTS AND DISEASES*

Implement effective integrated control and management techniques for weeds, pests and diseases affecting the ecological community and manage sites to prevent the introduction of new, or further spread of, invasive species.

- Identify potential new weed incursions early and manage for local eradication, where possible.
- Prioritise weeds and patches for which management is most urgent.
- Plan and budget for both initial weed management and for follow up treatment for as long as this is needed.
- Target control of key weeds that threaten the ecological community using appropriate methods that avoid impacts to non-target species.
- Encourage appropriate use of local native plant species in developments in the region through local government and industry initiatives and best practice strategies.
- Ensure chemicals, or other mechanisms used to manage weeds, do not have significant adverse, off-target impacts on the ecological community or adjacent native vegetation or waterbodies.
- Implement controls to prevent or reduce infection by fungal pathogens, especially myrtle rust (*Austropuccinia psidii*).
- Control introduced pest animals through coordinated landscape-scale control programs, with a particular focus on feral pigs, deer and goats.

#### 5.4.2.2 *MANAGE TRAMPLING, BROWSING AND GRAZING*

- Any livestock grazing which may be occurring in the ecological community should cease and fencing may be required for exclusion of stock.
- Low level grazing, firewood cutting and other uses which may be acceptable in dry forests are not appropriate to maintain the integrity of this ecological community.

#### 5.4.2.3 *MANAGE INAPPROPRIATE BEHAVIOURS*

- Avoid disturbance from visitors to sites containing the ecological community. Stay on established walking tracks when visiting national parks and nature reserves.
- Avoid/prohibit and monitor wood collection, such as for firewood or fencing, that leads to the loss and damage of trees, stags, logs or disturbs the natural litter layer.
- Avoid/prohibit and monitor destructive activities such as off-road trail bike or four-wheel-driving.
- Avoid/prohibit and monitor rubbish dumping.
- Avoid/prohibit and monitor wildflower, invertebrate and other fauna collection.
- Leave Sphagnum Moss in its natural setting and obtain garden moss only from commercially authorised suppliers (or use an alternative).



#### 5.4.2.4 *MANAGE APPROPRIATE FIRE REGIMES*

Generally, fire should be excluded from the ecological community and nearby areas (NPWS 2002). Areas of this ecological community were recently affected by the fire occurring from December 2019 to January 2020. The following actions were identified for related ecological communities affected by the 2019-20 bushfires (Keith et al. 2020). For example, to reduce risks from fire-drought interactions and frequent fire, more specific actions may include:

- Avoid implementing fires including hazard reduction burns in all recently burnt habitat (including but not limited to habitat burnt in 2019/2020).
- Protect unburnt parts of TEC distributions that function as refuges (i.e. avoid burning, clearing or logging in that habitat) in order to avoid putting all the species at risk at once.
- Develop and adapt fire management plans to ensure that any future wildfires that threaten to burn over recovering sites are rapidly extinguished and to avoid or minimise risks from hazard reduction burning in adjacent areas (i.e. by escaping containment lines).
- Monitor recovery of key TEC components to determine the time required to re-establish habitat
- Undertake post-fire on-ground surveys to quantify impacts, management needs and monitor recovery.
- Protect unburnt fire refuges from future fires.
- Protect burnt areas from future fires.
- Install targeted fencing to exclude livestock, feral grazers, or overabundant native herbivores, and manage people and vehicle access to enable recovery.
- Control feral pigs and deer.
- Controlling feral predators post-fire is not typically considered a high priority for this ecological community, but monitor for impacts on fauna after fire and undertake control measures as required.
- Manage structural components of sites and undertake habitat supplementation if required.
- Undertake weed surveys, treatment and removal.
- Undertake planning to accommodate co-dependency of management actions.
- Undertake strategic research to develop or assess management options. This may include investigating specific fire prevention and recovery interventions for this ecological community in future extreme fire conditions, such as installing perimeter watering points and watering key areas (e.g. where sphagnum is present) pre-fire and shading post-fire.

#### 5.4.2.5 *UNDERTAKE RESTORATION*

- Undertake restoration of degraded areas of the ecological community and surrounding native vegetation. Aim to restore patches to high quality, including restoration of patches

that do not currently meet the minimum condition thresholds for protection to a condition that does.

- Restoration to improve the condition of degraded patches should aspire to the 5 Star Standard of the SERA Standards. Land managers should aim for the highest and best recovery of the ecological community to maximise biodiversity and ecological function based on appropriate metrics for each site (see Condition Thresholds in Section 2 and SERA (2021) for guidance on implementing appropriate standards). This is particularly the case for sites that are being restored or reconstructed from highly altered states.
- Work with landholders to restore and reconnect patches of the ecological community and other adjacent or nearby native vegetation (including buffer areas)
- Maintain stags, logs, and mature and old-growth trees with hollows as they provide important habitat for fauna.
- If necessary, supplement, (but do not replace) habitat as part of restoration projects by placing hollow logs, large rocks or other habitat features (such as artificial hollows or various sized nest boxes) in or near to, the ecological community. This may be particularly important after disturbance such as a severe fire event.
- Use local native species in restoration/revegetation projects for the ecological community and restore understorey vegetation to a structure and diversity appropriate to the site.
- In general, use locally collected seeds, where available, to revegetate native plant species. However, choosing sources of seed closer to the margins of their range may increase resilience to climate change. Take into account key plant species' growing seasons to successfully achieve seed set.
- Ensure commitment to follow up after any planting, such as watering, mulching, weeding and use/removal of tree guards.
- Close and rehabilitate unnecessary roads and tracks and otherwise control access to restored patches.
- Implement effective adaptive management regimes using information from available research and management guidelines, for example, see the *National Standards for the Practice of Ecological Restoration in Australia* (Standards Reference Group SERA, 2021), relevant research or advice from local authorities.

#### 5.4.3 COMMUNICATE, engage with and support

This key approach includes priorities to promote the ecological community to build awareness and encourage people and groups to contribute to its recovery. This includes communicating, engaging with and supporting the public and key stakeholders to increase their understanding of the value and function of the ecological community and to encourage and assist their efforts in its protection and recovery. Key groups to communicate with include landholders, land managers, land use planners, researchers, community members and Indigenous communities.

#### 5.4.3.1 *RAISE AWARENESS*

- Communicate with relevant agencies, surrounding landholders/managers, and the public to emphasise the value of the ecological community, the key threats, its significance, and appropriate management. Encourage surrounding landholders to talk with local NRM organisations and other knowledgeable groups.
- Undertake effective community engagement and education to highlight the importance of minimising disturbance (e.g. during recreational activities) and of minimising pollution and littering (e.g. via signage).
- Inform landholders about incentives, such as conservation agreements, stewardship projects, funding and government NRM programs etc. that may apply to help look after native vegetation and waterways in the surrounding catchment.

#### 5.4.3.2 *PROVIDE INFORMATION*

- Develop education programs, information products and signage to help the public recognise the presence and importance of the ecological community, and their responsibilities under state and local regulations and national environment law (the EPBC Act).
- Improve understanding of Traditional Ecological Knowledge and, where agreed by the knowledge-holders, identify and support culturally appropriate mechanisms to share and maintain this knowledge to protect and restore the ecological community.
- Install signage to discourage damaging activities such as the removal of dead timber, dumping garden waste and other rubbish, creating informal paths and tracks, and the use of off-road vehicles in patches of the ecological community.
- Promote knowledge about local weeds and what garden plants to avoid planting. Recommend local native species for revegetation and landscaping or safe alternative garden plants.

#### 5.4.3.3 *COORDINATE EFFORTS*

- Liaise with local fire management authorities and agencies and engage their support in preventing fire from the ecological community. Ensure land managers in the catchment are given information about how to manage fire risks to conserve this and other threatened ecological communities and species.
- Develop coordinated incentive projects to encourage conservation and stewardship of the surrounding native vegetation on private land, and link with other programs and activities, especially those managed by regional Natural Resource Management groups.
- Support opportunities for traditional owners/custodians or other members of the Indigenous community to manage the ecological community.
- Promote awareness and protection of the ecological community with relevant agencies and industries. For example with:
  - state and local government planning authorities, to ensure that planning takes the protection of remnants into account; infrastructure or development works involving substrate or vegetation disturbance in the surrounding areas do not adversely impact the ecological community; maintenance activities (e.g. roads

and roadsides) avoid the introduction or spread of weeds; with due regard to principles for long-term conservation;

- land owners and developers, to minimise threats associated with land conversion and development in surrounding areas;
- Natural Resource Management organisations, conservation organisations and groups volunteering time for restoration and ecological management.

#### *5.4.4 RESEARCH and monitoring*

This key approach includes priorities for research into the ecological community, and monitoring, to improve understanding of the ecological community and the best methods to aid its recovery through restoration and protection. Relevant and well-targeted research and other information gathering activities are important in informing the protection and management of the ecological community.

##### *5.4.4.1 SURVEY AND MAPPING*

- Collate existing vegetation mapping information and associated data for this ecological community and identify gaps in knowledge.
- Comprehensively survey and map the extent and condition of the ecological community:
  - support field survey and interpretation of other data such as aerial photographs and satellite images to more accurately document current extent, condition, threats, function, presence and use by regionally significant or threatened species.
  - support and enhance existing programs to model the pre-1750 extent across the entire range of the ecological community to inform restoration;
  - identify the most intact, high conservation value remnants and gain a better understanding of variation across the ecological community;
  - identify and map the fire interval status of the ecological community and surrounding fire-dependent and/or fire sensitive vegetation;
  - collate existing information on populations of fauna characteristic of the ecological community across its range.

##### *5.4.4.2 OPTIONS FOR MANAGEMENT*

- Investigate key ecological interactions, such as the role of fauna in pollination, seed dispersal and nutrient cycling.
- Research into appropriate and integrated methods to manage pests and weeds that affect the ecological community.
- Assess the vulnerability of the ecological community to climate change and investigate ways to improve resilience through other threat abatement and management actions.
- Conduct research leading to the development of effective landscape-scale restoration techniques for the ecological community. Investigate the interaction between disturbance types, such as fire and invasion by weeds and feral animals, to determine how an integrated approach to threat management can be implemented.

#### 5.4.4.3 MONITORING

- It is important that any monitoring is planned before management commences and considers what data are required to address research questions. Monitoring must also be resourced for management activities, especially for those using a novel approach, and applied during and following the management action.
  - Monitor for signs of decline, in terms of known problems e.g. *Phytophthora* dieback, and new incursions, e.g. myrtle rust.
  - Monitor changes in the condition, composition, structure and function of the ecological community, including response to climate change, fire and all types of management actions and use this information to increase understanding of the ecological community and inform recommendations for future management.

#### Consultation Questions on the priority actions

- Is this list of proposed priority actions to conserve this ecological community complete and appropriate?
- The Committee and Department would appreciate any additional information or advice to improve this section, including an indication of what are the highest priorities and why.



## 6 Listing assessment

The Threatened Species Scientific Committee has provided this draft assessment for consultation.

### 6.1 Reason for assessment

This assessment follows prioritisation of a nomination from the Threatened Species Scientific Committee in response to the impacts of the 2019-2020 bushfires.

### 6.2 Eligibility for listing

This assessment uses the criteria set out in the [EPBC Regulations](#) and TSSC [Guidelines for Nominating and Assessing Threatened Ecological Communities](#), as in force at the time of the assessment.

#### Consultation Questions on the draft assessment against listing criteria

- Please provide any additional information that is relevant to any of the listing criteria below.

#### 6.2.1 Criterion 1 – decline in geographic distribution

Insufficient data to determine eligibility under Criterion 1

	Category		
	Critically Endangered	Endangered	Vulnerable
Its decline in geographic distribution is:	very severe	severe	substantial
<i>decline relative to the longer-term/1750 timeframe</i>	≥90%	≥70%	≥50%
<i>decline relative to the past 50 years</i>	≥80%	≥50%	≥30%

Source: TSSC 2017

#### Evidence:

The NSW Scientific Committee (1998) note that the occurrence of sphagnum communities beneath a mix of cool temperate rainforest species represents communities which were formerly widespread on the northern tablelands but are now considered to be rare [due to timber harvesting and the introduction of domestic livestock]. The area surrounding Ben Halls Gap Nature Reserve is steep, partially cleared country used for grazing and some agriculture (NPWS 2002). Ben Halls Gap Nature Reserve was grazed in the past but not logged, however the area currently designated as Ben Halls Gap National Park (to the north of the Nature Reserve) did have some logging and was grazed until recently (2016). However, the pre-1750 extent of the ecological community is unknown. The pre-1750 data for the related Plant Community Type, PCT 3051 (DPIE 2021), is restricted to areas at Ben Halls Gap and Barrington Tops, so does not show any decline of this vegetation unit.

Following assessment of the available data the Committee has determined that there is insufficient information to assess the ecological community under Criterion 1.

## 6.2.2 Criterion 2 – limited geographic distribution coupled with demonstrable threat

Eligible under Criterion 2 for listing as **Endangered** or **Critically Endangered**.

	Category		
	Critically Endangered	Endangered	Vulnerable
Its geographic distribution is:	very restricted	restricted	limited
<i>Extent of Occurrence (EoO)</i>	<100 km <sup>2</sup>	< 1,000 km <sup>2</sup>	< 10,000 km <sup>2</sup>
<i>Area of Occupancy (AoO)</i>	<10 km <sup>2</sup>	< 100 km <sup>2</sup>	< 1,000 km <sup>2</sup>
<i>Average patch size</i>	<0.1 km <sup>2</sup>	< 1 km <sup>2</sup>	
AND the nature of its distribution makes it likely that the action of a threatening process could cause it to be lost in:	the immediate future	the near future	medium term future
<i>timeframe</i>	10 years or 3 generations (up to a maximum of 60 years)	20 years or 5 generations (up to a maximum of 100 years)	50 years or 10 generations (up to a maximum of 100 years)

Source: TSSC 2017

### Evidence:

The ecological community's Extent of Occurrence is approximately 25 km<sup>2</sup>, the Area of Occupancy is approximately 1 km<sup>2</sup> (100 ha). Both of these measures are indicative of a *very restricted* geographic distribution. Patch sizes were not evaluated because the distribution of this community has not been fragmented by clearing, almost all occurrences are within a conservation tenure within a matrix of other forested land. In addition, the resolution of available spatial data may not be suitable for patch size analysis.

### Timeframes and threats.

The ecological community is subject to key threats that impact upon it over a variety of timeframes, as described in *Section 4 Threats* and *Table 4.1*. The ecological community is sensitive to disturbance in the catchment (e.g. changes in hydrology including water availability and quality/sedimentation) and locally (physical disturbance, weeds, feral animals). It is also particularly vulnerable to stochastic events, given its very restricted geographic distribution. This is also particularly relevant to the relatively shallow *Sphagnum* peat layer. Initial estimates are that approximately 50 % of the ecological community was directly burnt in December 2019 – January 2020, with the remainder of the extent likely to have been affected (e.g. increased sedimentation and solar radiation) following burning of adjacent and nearby vegetation communities. Recovery from this event is uncertain, particularly in conjunction with subsequent canopy damage from heavy rain, snow and high wind events. These fire events are likely to become more frequent in the future because the drying climate associated with climate change is likely to increase the duration, frequency and intensity of fires (BOM 2021).

### Summary

This represents a **very restricted** geographic distribution, and the nature of this distribution makes it likely that the action of a threatening process could cause it to be lost in the near future, potentially the immediate future, depending on the frequency of severe fires. Following preliminary assessment, the Committee therefore considers that the ecological community is

likely to meet the relevant elements of Criterion 2 to make it eligible for listing at Endangered or Critically Endangered.

### 6.2.3 Criterion 3 – decline of functionally important species

Insufficient data to determine eligibility under Criterion 3

	Category		
	Critically Endangered	Endangered	Vulnerable
For a population of a native species that is likely to play a major role in the community, there is a:	very severe decline	severe decline	substantial decline
<i>Estimated decline over the last 10 years or three generations, whichever is longer</i>	80%	50%	20%
to the extent that restoration of the community is not likely to be possible in:	the immediate future	the near future	the medium-term future
<i>timeframe</i>	10 years or 3 generations (up to a maximum of 60 years)	20 years or 5 generations (up to a maximum of 100 years)	50 years or 10 generations (up to a maximum of 100 years)

Source: TSSC 2017

#### Evidence:

At this time, the Committee considers that there is insufficient information to determine the eligibility of the ecological community for listing in any category under Criterion 3.

### 6.2.4 Criterion 4 – reduction in community integrity

Insufficient data to determine eligibility under Criterion 4

	Category		
	Critically Endangered	Endangered	Vulnerable
The reduction in its integrity across most of its geographic distribution is:	very severe	severe	substantial
as indicated by degradation of the community or its habitat, or disruption of important community processes, that is:	very severe	severe	substantial
<i>such that restoration is unlikely (even with positive human intervention) within</i>	<i>the immediate future (10 years or 3 generations up to a maximum of 60 years)</i>	<i>the near future (20 years or 5 generations up to a maximum of 100 years)</i>	<i>the medium-term future (50 years or 10 generations up to a maximum of 100 years)</i>

Source: TSSC 2017

#### Evidence:

The ecological community has been subject to a reduction in integrity due to weeds, pests (hard hooved animals) and sediment. The ground layer and peat has also been exposed to solar radiation (heat/light) due to loss of canopy cover in the ecological community and surrounding vegetation (which is considered under Criterion 5). The condition state of the ecological community will be assessed following upcoming monitoring, which is expected to provide further information relevant to assessment against this criterion.

At this time the Committee considers that there is insufficient information to determine the eligibility of the ecological community for listing in any category under Criterion 4.

#### 6.2.5 Criterion 5 – rate of continuing detrimental change

Eligible under Criterion 5 for listing as **Endangered** under Criterion 5

	Category		
	Critically Endangered	Endangered	Vulnerable
Its rate of continuing detrimental change is: as indicated by:	very severe	<b>severe</b>	substantial
(a) rate of continuing decline in its geographic distribution, or a population of a native species that is believed to play a major role in the community, that is: OR	very severe	severe	serious
(b) intensification, across most of its geographic distribution, in degradation, or disruption of important community processes, that is:	very severe	<b>severe</b>	serious
<i>an observed, estimated, inferred or suspected detrimental change over the immediate past, or projected for the immediate future (10 years or 3 generations, up to a maximum of 60 years), of at least:</i>	<b>80%</b>	<b>50%</b>	<b>30%</b>

Source: TSSC 2017

#### Evidence:

It is estimated that approximately half of the ecological community was directly burnt during the 2019-20 fires (based on expert input and analysis of DAWE (2020) and PCT 3051 (DPIE 2021) in the Ben Halls Gap area). The ecological community is particularly susceptible to the effects of fires, including from fires in surrounding vegetation and more broadly in the catchment.

Detrimental impacts include increased solar radiation due to loss of canopy shading effects, reducing conditions suitable for the cool temperate rainforest species and *Sphagnum cristatum*, and an influx of sediment along watercourses. Heavy rain, snow and high wind events in 2021 has also resulted in further canopy damage across most occurrences of the ecological community.

The impacts from the 2019-20 fires, as well as subsequent canopy damage, on the ecological community and surrounding vegetation may represent a **severe** rate of continuing detrimental change as indicated by a **severe** intensification in degradation across most of its geographic distribution that is observed over the immediate past. Following preliminary assessment, the Committee therefore considers that the ecological community may meet the relevant elements of Criterion 5 to make it eligible for listing as **Endangered**.

## 6.2.6 Criterion 6 – quantitative analysis showing probability of extinction

Insufficient data to determine eligibility under Criterion 6.

		Category		
		Critically Endangered	Endangered	Vulnerable
A quantitative analysis shows that its probability of extinction, or extreme degradation over all of its geographic distribution, is:		at least 50% in the immediate future	at least 20% in the near future	at least 10% in the medium-term future
<i>timeframes</i>		10 years or 3 generations (up to a maximum of 60 years)	20 years or 5 generations (up to a maximum of 100 years)	50 years or 10 generations (up to a maximum of 100 years)

Source: TSSC 2017

### Evidence:

Quantitative analysis of the probability of extinction or extreme degradation over all its geographic distribution has not been undertaken. Therefore, there is insufficient information to determine the eligibility of the ecological community for listing in any category under this criterion.

### Consultation Questions on the listing assessment

- Do you agree with the draft conclusions against the listing criteria? If not, why not?
- How could the analysis against each of the criteria be improved?
- Please provide any additional data or evidence to support the assessment against the criteria?

## References

- Benson J & Andrew D (1990) *Vegetation Community Mapping for Ben Halls Gap National Park*. State Government of NSW and Department of Planning, Industry and Environment 2012. Available at: [https://datasets.seed.nsw.gov.au/dataset/ben-halls-gap-national-park-vegetation-1990-vis\\_id-909628c](https://datasets.seed.nsw.gov.au/dataset/ben-halls-gap-national-park-vegetation-1990-vis_id-909628c)
- Bland L, Keith D, Miller R, Murray N and Rodriguez J (eds) (2017) *Guidelines for the application of IUCN Red List of Ecosystem Categories and Criteria, Version 1.1*. IUCN, Switzerland. Available at: <https://www.iucn.org/es/content/guidelines-application-iucn-red-list-ecosystems-categories-and-criteria>
- BOM (2021) State of the Climate. In Australia's Changing Climate.
- DAWE [Department of Agriculture, Water and the Environment] (2020) *National Indicative Aggregated Fire Extent Datasets (NIAFED)*. Australian Government Department of Agriculture, Water and the Environment, Canberra.
- DoE [Department of the Environment] (2012) *Interim Biogeographic Regionalisation for Australia (Subregions - States and Territories) v. 7*.
- DoE [Department of the Environment] (2015) *Arrive Clean, Leave Clean. Guidelines to help prevent the spread of invasive plant diseases and weeds threatening our native plants, animals and ecosystems*. Commonwealth of Australia. Available at <https://www.environment.gov.au/biodiversity/invasive-species/publications/arrive-clean-leave-clean>
- Department of Planning Industry and Environment [DPIE] (2021) NSW State Vegetation Type Map (SVTM). Pre-Release v1.1.0 Eastern NSW Extant Plant Community Type. Full package available at <https://datasets.seed.nsw.gov.au/dataset/nsw-state-vegetation-type-map>
- Ellis R (1985) The relationships among eucalypt forest, grassland and rainforest in a highland area in north-eastern Tasmania. *Austral Ecology*, 10, 297–314. <https://doi.org/10.1111/j.1442-9993.1985.tb00891.x>
- Fensham RJ, Fairfax RJ, Butler DW & Bowman DMJS (2003) Effects of Fire and Drought in a Tropical Eucalypt Savanna Colonized by Rain Forest, *Journal of Biogeography*, 30, 9 pp. 1405–1414.
- Gunning RV (1995) Insect Survey of Ben Halls Gap State Forest. *Proceedings of 26th AGM and Scientific Conference of the Australian Entomological Society, Tamworth NSW*.
- Harvest T, Davidson N & Close D (2008) Is decline in high altitude eucalypt forests related to rainforest understorey development and altered soil bacteria following the long absence of fire? *Austral Ecology*, 33, 880–890. <https://doi.org/10.1111/j.1442-9993.2008.01859.x>
- Hennessy K (2011) Climate change impacts. In Cleugh H, Stafford Smith M, Battaglia M & Graham P (Eds.), *Climate Change: science and solutions for Australia* (pp. 45–57) CSIRO Publishing.

- Keith DA, Auld TD, Barrett S, English V, Gallagher R, Gray R, van Leeuwen S, McIlwee A, Mitchell D, Tozer MG, Williams RJ, Yates CJ, Neldner J, Buchan A, White MD, Rogers D, West A, Seddon J, Simpson CC (in prep) *Terrestrial Ecological Communities in Australia: initial assessment and management after the 2019-20 bushfires*. Report to the Wildlife and Habitat Bushfire Expert Panel and the Australian Department of Agriculture, Water and the Environment. Centre for Ecosystem Science, University of NSW, Sydney. Available at: <https://www.awe.gov.au/sites/default/files/env/pages/cae21f42-9328-45ee-b558-a79628aaf68f/files/tecs-threats-and-actions.pdf>
- National Committee on Soil and Terrain (2009) *The Australian Soil and Land Survey Field Handbook*. CSIRO.
- NPWS (1999) *Vegetation Community Profiles of Ben Halls Gap National Park*. Adapted from Benson J & Andrew D (1990) *The Flora, Fauna and Conservation Significance of Ben Halls Gap State Forest*, Nundle, NSW. NSW NPWS, Hurstville.
- NPWS (2002) *Ben Halls Gap National Park Plan of Management*. NSW National Parks and Wildlife Service. Available on the internet at: <https://www.environment.nsw.gov.au/-/media/OEH/Corporate-Site/Documents/Parks-reserves-and-protected-areas/Parks-plans-of-management/ben-halls-gap-national-park-plan-of-management-020091.pdf>
- NSW DPIE [Department of Planning, Industry and Environment] (2021) *Ben Halls Gap Nature Reserve Sphagnum Moss Cool Temperate Rainforest – profile*. NSW Government. Available at: <https://www.environment.nsw.gov.au/threatenedSpeciesApp/profile.aspx?id=10091>
- NSW Office of Environment and Heritage (2018) *New South Wales BioNet Vegetation Classification User Manual*. State of NSW and Office of Environment and Heritage. Available at: <https://www.environment.nsw.gov.au/-/media/OEH/Corporate-Site/Documents/BioNet/bionet-vegetation-classification-user-manual-180423.pdf>
- NSW Scientific Committee (1998) *Ben Halls Gap National Park Sphagnum Moss Cool Temperate Rainforest Community - endangered ecological community listing*. Final Determination. Available at: <https://www.environment.nsw.gov.au/topics/animals-and-plants/threatened-species/nsw-threatened-species-scientific-committee/determinations/final-determinations/1996-1999/ben-halls-gap-sphagnum-moss-cool-temperate-rainforest-endangered-ecological-community-listing>
- NSW Threatened Species Scientific Committee (2019) *Final Determination (2019-221) under the NSW Biodiversity Conservation Act 2016*. Available at: <https://legislation.nsw.gov.au/view/pdf/asmade/sl-2019-221>
- Standards Reference Group SERA (2021) *National Standards for the Practice of Ecological Restoration in Australia*. Edition 2.2. Society for Ecological Restoration Australasia. Available at: <http://www.seraustralasia.com/pages/standards.html>
- Whinam J & Chilcott N (2002) Floristic description and environmental relationship of Sphagnum communities in NSW and the ACT and their conservation management. *Cunninghamia* 7(3): 463–500.



- Wormington K & Lamb D (1999) Tree hollow development in wet and dry sclerophyll eucalypt forest in south-east Queensland, Australia. *Australian Forestry* 62(4): 336–345.

