Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) (s266B)

Conservation Advice (incorporating listing advice) for Illawarra–Shoalhaven subtropical rainforest of the Sydney Basin Bioregion

1. The Threatened Species Scientific Committee (the Committee) was set up under the EPBC Act to give advice to the Minister for the Environment (the Minister) in relation to the listing and conservation of threatened ecological communities, including under sections 189, 194N and 266B of the EPBC Act.

2. The Committee conducted a listing assessment following the ecological community being placed on the 2017 Finalised Priority Assessment List.

3. The Committee provided its advice on the Illawarra–Shoalhaven subtropical rainforest of the Sydney Basin Bioregion ecological community to the Minister in 2019. The Committee recommended that:

- the ecological community merits listing as Critically Endangered; and
- a recovery plan is not required for the ecological community at this time.

3. A draft conservation advice for this ecological community was made available for expert and public comment for a minimum of 30 business days. The Committee and Minister had regard to all public and expert comment that is relevant to the consideration of the ecological community for listing.

4. In 2019 the Minister accepted the Committee's advice, adopted this document as the approved conservation advice and agreed no recovery plan is required at this time. The Minister amended the list of threatened ecological communities under Section 184 of the EPBC Act to include Illawarra–Shoalhaven subtropical rainforest of the Sydney Basin Bioregion ecological community in the critically endangered category.

5. At the time of this advice, this ecological community corresponds closely with two threatened ecological communities that are listed under the New South Wales *Biodiversity Conservation Act 2016*: the 'Illawarra Subtropical Rainforest in the Sydney Basin Bioregion' and 'Milton Ulladulla Subtropical Rainforest in the Sydney Basin Bioregion'. Further details on the relationships with these two state listed ecological communities are in Section 3.5.2 of this Conservation Advice.

Illawarra–Shoalhaven subtropical rainforest of the Sydney Basin Bioregion. Berkeley Hills. Photo credits: Department of the Environment and Energy, Canberra.

CONTENTS

TABLES

1. CONSERVATION OBJECTIVE

To prevent further loss and degradation of the ***Illawarra–Shoalhaven subtropical rainforest of the Sydney Basin Bioregion*** ecological community and help recover its biodiversity, function and extent, by 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.

This document contains information relevant to the conservation objective by:

- describing the ecological community and where it can be found
- identifying the key threats to the ecological community
- presenting evidence (listing advice) to support the ecological community being listed as nationally threatened under national environment law; and
- outlining the priority conservation and research actions that could stop decline and support recovery of the ecological community

2. DESCRIPTION OF THE ECOLOGICAL COMMUNITY AND THE AREA IT INHABITS

This section describes the assemblage of native species[1] that characterises the Illawarra–Shoalhaven subtropical rainforest of the Sydney Basin Bioregion ecological community throughout its range at the time of listing. It outlines the vegetation structure of the ecological community, including some of its characteristic vascular plants and macroscopic[2] animals. The ecological community also includes fungi and cryptogamic plants; however, these are relatively poorly documented. More comprehensive species lists are in Appendix A. However, even these do not mention all the species that make up the ecological community and many sites may have species that are not documented here.

The number and identity of species recorded at a particular site is partly due to natural variation across the range of the ecological community, historical biogeography and other environmental factors, such as disturbance. The species recorded can also be affected by sampling scale, season, effort and expertise. In general, the number of species recorded is likely to increase with the size of the site.

Characteristic species may be abundant, rare, or absent at some sites, and are only a subset of the complete list of species recorded in known examples of the community. Species presence and relative abundance (dominance) depends on many factors, such as, soil properties (e.g. moisture, chemical composition, texture, depth and drainage), topography and hydrology.

[1] The EPBC Act defines an 'ecological community' as the “extent in nature in the Australian jurisdiction of an assemblage of native species that inhabits a particular area in nature” (e.g. a group of plants, animals and other organisms interacting in a specific habitat, under relatively similar environmental conditions). The complex range of interactions between the component species provides an important level of biological diversity in addition to genetics and species.

[2] Macroscopic: Large enough to see with the naked eye (i.e. without magnifying optical instruments); not microscopic.

They also change over time, for example, in response to disturbance (by clearing, fire, logging, or grazing), or to the climate and weather (e.g. floods, drought and extreme heat or cold). Moisture is a key driver for this ecological community and its species composition (e.g. the variation in species between the drier Berkeley Hills, and the wetter escarpment benches).

This section also describes the area that the ecological community inhabits, including its location, physical environment, some key ecological processes and other factors that help determine where the ecological community occurs in nature.

2.1 Name of the ecological community

The name of the ecological community is the 'Illawarra–Shoalhaven subtropical rainforest of the Sydney Basin Bioregion' (hereafter called Illawarra–Shoalhaven subtropical rainforest, or the ecological community).

The ecological community combines two New South Wales (NSW) state listed endangered ecological communities: The 'Illawarra subtropical rainforest in the Sydney Basin Bioregion' (NSW Scientific Committee 2002a) and the 'Milton Ulladulla subtropical rainforest in the Sydney Basin Bioregion' (NSW Scientific Committee 2002b). The relationship between the Commonwealth and NSW listings is explained in section 3.5.

2.2 Location and physical environment

2.2.1 *Location*

The Illawarra–Shoalhaven subtropical rainforest ecological community occurs south of Sydney in NSW, in the Sydney Basin IBRA[3] Bioregion. It occurs in the Illawarra, Jervis and Sydney Cataract (SYB12, SYB14 and SYB10) IBRA subregions, and just over the borders into Burragorang (SYB09), Moss Vale (SYB11) and Ettrema (SYB13) subregions; it may also occur elsewhere in the Sydney Basin Bioregion, in other subregions. The majority of the ecological community occurs in the Illawarra IBRA Subregion (SYB12).

The ecological community's northern boundary of occurrence is the Port Hacking estuary. Its southern boundary is the boundary between the Sydney Basin and the South East Corner IBRA bioregions[4]. It occurs on the coastal plain, low-lying foothills and slopes, benches[5] and drainage lines of the eastern coastal escarpment (and of some coastal mountains), between the Hacking and Clyde rivers. It rarely extends onto the upper escarpment slopes. It is usually found below 350 m above sea level (ASL); but there are occurrences up to around 550 – 600 m ASL, for example around Cambewarra Mountain.

[3] Interim Biogeographic Regionalisation of Australia (IBRA) Version 7. http://www.environment.gov.au/land/nrs/science/ibra

[4] The southernmost part of the boundary between the two IBRA bioregions at this time is just south of Beagle Bay and Durras, north of Batemans Bay.

[5] Bench: A relatively level strip of land that runs along a sloped area (a shelf or step-like feature on the way down a hillside). Benches can be formed by the differential erosion of rocks or sediments of varying hardness and resistance to erosion.

Much of the ecological community occurs between Stanwell Park and Gerringong (where it was termed the Illawarra Brush[6] by Mills & Jakeman (1995)). It continues south to the Shoalhaven River; and westwards into Kangaroo Valley and around gorges of the Ettrema region and Toorooroo Plateau (Mills 2010). Further occurrences of the ecological community are found around Milton and Ulladulla (approximately 50 to 70 km to the south).

The ecological community is typically associated with the more fertile (higher nutrient)[7] soils associated with coastal Permian and Triassic igneous rocks, including: Gerringong Volcanics, Cordeaux Crinanite and exposed latite on slopes and enriched, colluvial[8] benches of the Illawarra escarpment. It also occurs on sedimentary rocks such as Budgong Sandstone on the escarpment foothills and the coastal plain and on Illawarra Coal Measures and Narrabeen Group shale on the escarpment benches and where dissected in deep, sheltered gullies (e.g. where the Hacking River has cut down from sandstone into the shale[9])[10]. In the Milton–Ulladulla district, the ecological community typically occurs on Milton Monzonite[11], as well as on deep alluvium and soils of the Conjola Formation enriched by monzonite; and it also occurs widely on skeletal exposed monzonite (Tozer et al. 2010).

At the time of this assessment (2018–19), the ecological community is known to occur in the South East Local Land Services (SE LLS) Natural Resources Management Region. It has been recorded in areas in the Local Government Areas (LGAs) of Kiama, Shellharbour, Shoalhaven, Sutherland and Wollongong; and may occur nearby, in adjacent LGAs such as Goulburn Mulwaree and Wingecarribee.

Other wet forest and rainforest vegetation communities occur in this region, and their relationships to the ecological community are detailed in Section 3.4.3 and Appendix D.

---

[6] North of Lake Illawarra on the Berkeley Hills, it is termed the 'Berkeley Brush'. The Illawarra Brush and Berkeley Brush originally covered about 13 600 ha and made up 60% of the rainforest of the Illawarra area (Mills & Jakeman, 1995).

[7] These soils are more fertile than those just derived from the sandstone substrates more prevalent in the region.

[8] Colluvial: Pertaining to colluvium (loose material, such as soil or sediments, which has accumulated at the base of a slope through the action of gravity (e.g. talus, avalanche debris and material moved by soil creep, frost action or sheet erosion). As opposed to alluvium (e.g. soil/sediments deposited by a river on a floodplain).

9 In the Hacking River catchment upstream of Audley Weir, the ecological community has been identified at sites east and south of Waterfall (including around Bola Creek/Gully and Cedar Creek/Gully).

[10] Patches also occur, albeit rarely, on Quaternary alluvium.

[11] Monzonite is a relatively uncommon intrusive/plutonic igneous rock. It contains less quartz and more plagioclase than granite. Latite is the approximate extrusive/volcanic equivalent of monzonite. Crinanites are dark coloured, fine-grained, basic rocks consisting mainly of olivine, augite, and plagioclase feldspar.

2.2.2 *Physical environment*

The ecological community is closely associated with topographically more sheltered sites and with more fertile (relatively high-nutrient) soils with greater water-holding capacity. Both of these environmental constraints are closely linked to variations in geology and drainage lines. Within this context, the ecological community occupies a number of landscape positions, including the slopes of the escarpment, on rocky scree[12] and in gully lines. It typically occurs on fertile volcanic soils; and also, on other relatively high-nutrient soils on escarpment benches and in sheltered gullies.

Structurally and floristically, patches of subtropical rainforest vary according to rainfall, geology, altitude and exposure to drier aspects or severe winds, including coastal influences. For example, in deeper more sheltered gullies, the rainforest is often taller and subtropical plant species are more obvious.

The ecological community occurs in coastal areas with a wet temperate climate, which is warm and humid, with typically higher rainfall in autumn, lower rainfall in late winter to spring and little chance of hard frosts. It typically occurs where mean annual rainfall is greater than 1000 mm (Tozer et al. 2010).

Coastal areas in the Illawarra–Shoalhaven region are at the southern limit of the coastal subtropical climate zone and experience warmer, more humid summers than coastal areas further south (Stern et al. (2000), in Tozer et al (2010)). This is reflected by the fact that many subtropical rainforest species reach their southern limit of distribution in the Illawarra and Milton regions; and the ecological community is the southernmost boundary for many of its component subtropical species (Mills 1989; Mills & Jakeman 1995).

Rainfall varies depending on altitude and distance from the coastline, with higher rainfall areas found closer to the coast or at higher elevations. Daily and annual temperature variations are smaller in coastal areas, which also experience few frost days. The air temperatures are mild, ranging between approximately 6°C (mean daily minimum for July) and 26°C (mean daily maximum for January) near the coast (Tozer et al. 2010), with some cooling as altitude increases – reaching a temperate climate at higher altitudes, beyond the range of the ecological community (Mills & Jakeman 1995).

Orographic[13] effects are substantial where the escarpment meets the coast, between Nowra and the Royal National Park, Sydney (where the ecological community mainly occurs). These result in an average of at least 1100 mm of rainfall per year, with the highest mean annual rainfall exceeding 2000 mm near Barren Grounds, just inland of Kiama (Mills & Jakeman 1995; Tozer et al. 2010).

[12] Scree: A collection of broken rock fragments that accumulate to form or cover a slope on a hill/mountain, or as a pile at its base (e.g. of cliffs or escarpments). Landforms associated with these materials are often called talus deposits.

[13] Orographic: Relating to mountains, especially their position and form; and, of clouds or rainfall resulting from the effects of mountains in forcing moist air to rise.

Lower temperatures in areas such as Kangaroo Valley play a fundamental role in the composition of the ecological community in that inland valley; i.e. many coastal species are excluded due to lower temperatures.

2.3 Vegetation structure and composition

The following description of the vegetation generally relates to the less disturbed, or 'reference' condition, occurrences of the Illawarra–Shoalhaven subtropical rainforest. The species listed in this Conservation Advice are based on those identified as characteristic of the ecological communities listed in NSW by the NSW Scientific Committee (2002a; 2002b), updated and augmented with new information that has become available since those listings. Many patches of the ecological community have been disturbed, with fire, temporary clearing, logging, grazing and 'under-scrubbing' having exerted a strong influence on the structural and floristic composition of the ecological community (Mills & Jakeman 1995; Tozer et al. 2010). Some patches, which would have been part of the ecological community, are now so modified that they no longer meet the Key diagnostic characteristics or minimum Condition thresholds (in sections 3.1 and 3.2) for the nationally protected ecological community.

The Illawarra–Shoalhaven subtropical rainforest ecological community is typically a dense, complex rainforest when mature (12 to 25 m tall), with an emergent tree layer up to 35 m or more in height (Mills & Jakeman 1995). In some circumstances, e.g. on dry, rocky sites, the canopy may be shorter.

The ecological community is characterised by its relatively high structural and floristic diversity. At a local scale, its expression/structure can vary depending on soil fertility and also moisture availability (due to either rainfall, aspect, topographic position or soil depth), or some combination of these factors.

The ecological community is generally a low to moderately tall closed rainforest. It has a dense mixed tree canopy (canopy cover typically ≥70% on average for a patch in relatively good condition) and a sparse shrub layer (Mills & Jakeman 1995). The groundcover is often sparse, except in moister areas (Tozer et al. 2010). At lowland sites, particularly on latite, the ground can be largely covered by rock, often with little soil being visible (Mills & Jakeman 1995); as opposed to bench sites on the escarpment, where ferns are usually abundant and there are few surface rocks.

Tree species with compound leaves are common and leaves are relatively large (notophyll to mesophyll). There is a relatively low abundance of species from the genera *Syncarpia*, *Acacia*, *Banksia* and *Eucalyptus* (unlike the Littoral Rainforest and Vine Thickets ecological community, where these genera may be more commonly present). Buttresses may be common and vines may be diverse and abundant.

2.3.1 *Canopy*

The canopy is often multilayered, consisting of an upper, discontinuous layer of emergents, above a typically dense rainforest canopy and subcanopy. Rainforest canopies are generally closed, but in highly disturbed stands the canopy may be irregular and open. There may also be localised open areas due to landscape and terrain, such as rocky outcrops and watercourses.

Canopy height varies considerably and structurally some stands of the ecological community may be described as scrub (NSW Scientific Committee 2002a).

The upper discontinuous layer includes canopy emergents such as *Ficus* spp. (figs), *Dendrocnide excelsa* (Giant Stinging Tree) and *Toona ciliata* (Red Cedar), which are up to 35 m or more in height when mature. Around Milton *Alphitonia excelsa* (Red Ash) is commonly an emergent. Non-rainforest species such as eucalypts (although less common) also occur as canopy emergents. Where they do occur, species such as *Eucalyptus tereticornis* (Forest Red Gum) and *Eucalyptus quadrangulata* (White-topped Box, Coast White Box) are most typical.

The canopy and subcanopy layers contain a diverse range of species. Three of the most characteristic species are: *Dendrocnide excelsa* (Giant Stinging Tree), *Streblus brunonianus* (Whalebone Tree) and *Toona ciliata* (Red Cedar); other characteristic species include: *Alectryon subcinereus* (Native Quince), *Alphitonia excelsa* (Red Ash), *Baloghia inophylla* (Brush Bloodwood), *Brachychiton acerifolius* (Flame Tree), *Citronella moorei* (Churnwood), *Claoxylon australe* (Brittlewood), *Cryptocarya glaucescens* (Jackwood), *Cryptocarya microneura* (Murrogun), *Diospyros australis* (Black Plum), *Diospyros pentamera* (Myrtle Ebony), *Diploglottis australis* (Native Tamarind), *Ehretia acuminata* var. *acuminata* (Koda), *Elaeodendron australe* (Red-fruited Olive Plum), *Ficus* spp. (figs), *Guioa semiglauca* (Guioa), *Myrsine howittiana* (Brush Muttonwood), *Myrsine variabilis* (Muttonwood), *Pennantia cunninghamii* (Brown Beech) and *Planchonella australis* (Black Apple) (Mills & Jakeman 1995; NSW Scientific Committee 2002a; 2002b; Tozer et al. 2010).

2.3.2 *Climbers and epiphytes*

Vines and lianas are typically common, such as: *Celastrus australis* (Staff Climber), *Cissus antarctica* (Kangaroo Vine), *Cissus hypoglauca* (Water Vine), *Eustrephus latifolius* (Wombat Berry), *Geitonoplesium cymosum* (Scrambling Lily), *Legnephora moorei* (Round Leaf Vine), *Pandorea pandorana* (Wonga Vine), *Parsonsia straminea* (Common Silkpod), *Piper hederaceum* (Giant Pepper Vine), *Marsdenia rostrata* (Milk Vine), *Gynochthodes jasminoides* (Sweet/Jasmine Morinda), *Smilax australis* (Sarsaparilla) and *Trophis scandens* (Burny Vine). Epiphytes such as *Asplenium australasicum* (Bird's Nest Fern) and *Platycerium bifurcatum* (Elkhorn) are often abundant on trunks and spreading branches of older rainforest trees, or on large sandstone boulders within the ecological community.

2.3.3 *Understorey*

There is typically a sparse understorey of shrubs, seedlings and groundcover plants below the canopy.

Shrub-small tree layer

Species may include: *Notelaea venosa* (Veined Mock Olive), *Elaeodendron australe* (Red-fruited Olive Plum), *Clerodendrum tomentosum* (Hairy Clerodendrum), *Pittosporum multiflorum* (Orange Thorn), *Breynia oblongifolia* (Coffee Bush), *Croton verreauxii* (Green Native Cascarilla), *Gymnostachys anceps* (Settlers Twine), *Myrsine variabilis* (Muttonwood), *Maclura cochinchinensis* (Cockspur Thorn), *Pittosporum revolutum* (Rough Fruit

Pittosporum), *Streblus brunonianus* (Whalebone Tree) and *Wilkiea hugeliana* (Veiny Wilkiea).

Ground layer

Species may include: *Gymnostachys anceps* (Settlers Twine), *Oplismenus hirtellus* (syn. *O. aemulus* and *O. imbecillis*, recognised as distinct species in NSW) (Australian Basket Grass, Creeping Beard Grass) and *Pseuderanthemum variabile* (Pastel Flower). Although not typically abundant at many sites, ferns such as *Pellaea falcata* (Sickle Fern), *Asplenium flabellifolium* (Necklace Fern), *Adiantum formosum* (Giant Maidenhair), *Pteris umbrosa* (Jungle Brake) and *Doodia aspera* (Prickly Rasp Fern) may also be present. Some sites may have a high percentage cover of ferns in the understorey, which can fluctuate with seasonal conditions from year to year.

2.3.4 *Fungi and cryptogams*

While the fungi and other cryptogams (such as liverworts, hornworts) associated with the ecological community are not well known, they contribute substantially to its diversity and function. Diverse fruiting bodies appear regularly in rainforest environments and are part of the decomposition/nutrient recycling functioning group of organisms.

2.4 Fauna

The Illawarra–Shoalhaven region is a transition zone between north and south coast mesic[14] forests and this is reflected in the diversity of rainforest fauna species. The mammals and birds of the ecological community in the Illawarra district are relatively well known. Less well known are the other vertebrate fauna groups and the invertebrates (NSW NPWS 2002b). Some of the animal species present in the ecological community are listed below and in Appendix A.

The rainforest fauna is less diverse than it was 200 years ago. The clearing of 75% of the rainforest in the Illawarra district has caused the local extinction of some species and a dramatic reduction in the populations of others. Subtropical rainforest habitat has been impacted more than any other rainforest type in the Illawarra district (Mills & Jakeman 1995).

2.4.1 *Mammals*

Pseudocheirus peregrinus (Common Ringtail Possum) and *Petaurus breviceps* (Sugar Glider) are typical of the Illawarra–Shoalhaven subtropical rainforest ecological community, along with *Pteropus poliocephalus* (Grey-headed Flying-fox) and *Wallabia bicolor* (Swamp Wallaby). Sugar gliders are more often seen in the emergent Eucalypt trees, rather than in the typical rainforest canopy tree species. Ringtail possums are mostly found in dense *Syzygium smithii* (syn. *Acmena smithii*) (Lilly Pilly, Midjuburi (Cadigal)) trees and in other small rainforest trees.

Bat species that may occur include *Chalinolobus morio* (Chocolate Wattled Bat) and *Vespadelus vulturnus* (Little Forest Bat) (Mills & Jakeman 1995; NSW NPWS 2002b).

[14] Mesic: A mesic habitat has a moderate or well-balanced supply of moisture.

Swamp wallaby are commonly seen in moist gullies and on the scrubby edges of rainforest, where they seek shelter (Mills & Jakeman 1995; NSW NPWS 2002b). In several places *Vombatus ursinus* (Bare-nosed Wombat, Common Wombat) commonly occurs on the edge of the rainforest, where it intergrades with other vegetation types. Two other common native mammal species in the area are *Antechinus stuartii* (Brown Antechinus) and *Perameles nasuta* (Long-nosed Bandicoot) (Mills & Jakeman 1995).

2.4.2 *Reptiles and amphibians*

Several species of reptiles and amphibians are closely associated with rainforest. Species such as *Anepischetosia maccoyi* (Highlands Forest-skink) are common in the ecological community, along with *Intellagama lesueurii lesueurii* (Eastern Water Dragon) and *Eulamprus quoyii* (Eastern Water Skink) which are commonly found along stream verges. Lizards are generally not common in the rainforest, particularly away from streams, because there is not enough sunshine under the dense tree canopy for them to warm up and maintain activity (Mills & Jakeman 1995; NSW NPWS 2002b). However, natural light gaps caused by the natural loss of large emergent trees such as figs are used by reptiles for thermoregulation. For example, *Intellagama lesueurii* (Eastern Water Dragon) and smaller skinks have been observed sunning on fallen logs in the twin fig light gap at Minnamurra Rainforest.

Frogs are seen, or at least heard near most water bodies, including rainforest streams. Some of the more common species in the ecological community include: *Limnodynastes peronii* (Striped Marsh-frog), *Litoria citropa* (Blue Mountains Tree-frog), *Litoria peronii* (Peron's Tree-frog), *Litoria phyllochroa* (Leaf-green Tree-frog) and *Litoria verreauxii* (Verreaux's Tree-frog).

2.4.3 *Birds*

Even small patches of rainforest can support forest-dependent bird species. For example, Mills (1984, in Mills & Jakeman 1995) recorded most of the rainforest birds of the district in small patches of rainforest in the Shoalhaven Gorge in Morton National Park. Many bird species are nomadic and can be found in remnant rainforest patches surrounded by cleared land and, in the case of pigeons in the fig trees scattered over the coastal rural parts of the district (Mills & Jakeman 1995).

Birds that have been identified as subtropical rainforest specialists in the region (i.e. predominantly found in patches of subtropical rainforest) are *Ailuroedus crassirostris* (Green Catbird), *Alectura lathami* (Australian Brush Turkey), *Chalcophaps longirostris* (Pacific Emerald-dove), *Columba leucomela* (White-headed Pigeon), *Coracina tenuirostris* (Cicadabird), *Leucosarcia melanoleuca* (Wonga Pigeon), *Lopholaimus antarcticus* (Topknot Pigeon), *Macropygia phasianella* (Brown Cuckoo-dove), *Menura novaehollandiae* (Superb Lyrebird), *Monarcha melanopis* (Black-faced Monarch), *Orthonyx temminckii* (Logrunner), *Petroica rodinogaster* (Pink Robin), *Pitta versicolor* (Noisy Pitta), *Ptilinopus superbus* (Superb Fruit-dove), *Pycnoptilus floccosus* (Pilotbird), *Sericornis citreogularis* (Yellow-throated Scrubwren), *Tyto tenebricosa* (Sooty Owl), *Zoothera lunulata* (Bassian Thrush) (Illawarra Birders, analysis of bird survey data, unpublished 2019).

Other native birds found in the ecological community include: *Gerygone mouki* (Brown Gerygone), *Pachycephala pectoralis* (Golden Whistler), *Meliphaga lewinii* (Lewin's

Honeyeater), *Acanthiza pusilla* (Brown Thornbill), *Psophodes olivaceus* (Eastern Whipbird), *Rhipidura rufifrons* (Rufous Fantail), *Sericornis frontalis* (White-browed Scrubwren), *Eopsaltria australis* (Eastern Yellow Robin), *Ptilonorhynchus violaceus* (Satin Bowerbird) and *Platycercus elegans* (Crimson Rosella) (NSW NPWS 2002b).

Pigeons and doves are an important component of the ecological community, particularly for their role in dispersing the seeds of rainforest species. For example, large flocks of *Lopholaimus antarcticus* are conspicuous occupants of large fruiting fig trees and *Livistona australis* (Cabbage Tree Palm), and *Columba leucomela* are rainforest frugivores that are seasonally common in Milton. *Leucosarcia melanoleuca* is closely linked to this subtropical rainforest in the region. Ground foraging birds include *Alectura lathami* and *Orthonyx temminckii*.

Birds of prey are not common in the rainforest, but both diurnal and nocturnal species occur there. The main birds of prey habitually associated with the ecological community by day, is *Accipiter novaehollandiae* (Grey Goshawk). At night, the birds of prey include: *Podargus strigoides* (Tawny Frogmouth), *Ninox novaeseelandiae* (Southern Boobook, Morepork), *Ninox strenua* (Powerful Owl) and the NSW-listed *Tyto tenebricosa* (Sooty Owl) (Mills & Jakeman 1995).

2.4.4 *Invertebrates*

Well-known insect groups such as the beetles, butterflies, moths, snails and flies are all well represented in the ecological community, along with springtails, which are often found in the moist leaf litter.

Butterflies are among the most prominent insect fauna in the ecological community. Species commonly found in the ecological community include: *Delias nigrina* (Common Jezebel), *Graphium macleayanum* (Macleay's Swallowtail), *Graphium choredon* (Blue Triangle), *Heteronympha mirifica* (Wonder Brown) and *Trapezites symmomus* (Symmomus Skipper) (Mills & Jakeman 1995).

The Blue Triangle and the Macleay's Swallowtail are closely associated with the ecological community, because of their preference for rainforest trees as larval food plants (e.g. they lay their eggs on the Sassafras tree). The wonder brown is common from late spring. The Symmomus Skipper, a large brown skipper with silver markings on the wings, is found in late summer or autumn, on the edges of the ecological community (Mills & Jakeman 1995).

Molluscs are an important taxonomic group of invertebrate fauna in east coast rainforests and perform important decomposition functions in wet forests. Native land snails and slugs live in the moist layers of litter on the forest floor and other moist habitats such as rotting logs, under rocks or beneath debris. In eastern Australia, they are particularly diverse in rainforest areas. Several species, including *Austrochloritis illawarra* (Illawarra Bristle Snail), *A. metuenda* (Wollongong Bristle Snail), *Meridolum gulosum* (Illawarra Forest Snail) and *Triboniophorus graeffei* (Red-triangle Slug) are particularly associated with the ecological community (Stanisic et al. 2010).

3. IDENTIFYING AREAS OF THE ILLAWARRA–SHOALHAVEN SUBTROPICAL RAINFOREST PROTECTED UNDER NATIONAL ENVIRONMENTAL LAW

The Key diagnostic characteristics, Contra-indicators, Condition thresholds and other information in this section are used to:

- identify patches of the threatened ecological community that are protected under national environment law (for example, to determine whether the referral, impact assessment, approval and/or compliance provisions of national environmental law are likely to apply to the patch);
- distinguish the ecological community from other similar vegetation types nearby and,
- distinguish between patches of different quality (to aid environmental protection and management decisions).

National listing focuses legal protection on areas or patches of the ecological community that are the most functional, in a relatively natural state and in comparatively good condition. Because the ecological community exhibits various degrees of disturbance and degradation, condition thresholds, classes and categories have been developed.

This section also includes guidance on defining a 'patch' and on sampling protocols; along with further information to have regard to when considering actions that may have a significant impact on the ecological community.

Protection as a matter of national environmental significance under national environment law, is limited to areas of the ecological community that meet the Key diagnostic characteristics and at least the minimum condition thresholds (Moderate or High Condition classes) for this ecological community. If a proposed action will, or may have, a significant impact on the protected ecological community, it must be referred to the Australian Government for approval prior to undertaking the action.

Although very degraded or modified patches are not protected under national environment law, some patches of the ecological community that do not meet the condition thresholds still have important natural values; and they may meet definitions for protection under state and local laws, or schemes. These lower quality patches should not necessarily be excluded from recovery and other management actions, because these actions could improve the condition of a patch to the point where it is protected under national environment law. Recovery and management actions should also be designed to restore patches to high condition (High Condition Class).

In some cases however, the loss and degradation are irreversible given changes in land use; or rehabilitation is impractical because too many natural characteristics have been lost. For example, most areas which have been converted to crops, exotic pasture or urban development are unlikely to be restored.

Key diagnostic characteristics (Section 3.1) summarise the main features of the ecological community. They are intended to help identify it, noting that more details are provided in the other sections of this document (for instance, where the ecological community occurs in nature and lists of species that characterise the ecological community). Species composition is

influenced by, amongst other things: geographic location, the size of the patch, recent rainfall and disturbance history, including fire and grazing. The Contra-indicators provide additional information to help distinguish the ecological community from other vegetation types.

Condition classes and thresholds (Section 3.2) are designed to help identify the relatively good quality patches for protection under national environment law (i.e. those of moderate or higher value). Because the ecological community has been heavily cleared and fragmented, many remnants are small, isolated and in a modified condition. Any remnants that remain largely intact (in terms of structure and/or diversity of characteristic species), or are connected to other native vegetation and form a large patch, are a high priority for protection and management.

Very small, isolated and/or degraded patches (e.g. those subject to permanent or ongoing high disturbance) are less likely to have the structure, composition and function of the ecological community and will not meet the minimum condition thresholds for protection under national environment law (for example, a few rainforest trees on a farm or a roadside, with limited diversity/structural elements).

The following steps outline how to identify patches of the ecological community that are protected under national environment law (e.g. for EPBC Act referral, assessments and compliance purposes). They are also useful to inform related activities, such as carrying out environmental impact assessments and projects to manage threats or restore the ecological community.

Step 1: Use the Key diagnostic characteristics and Contra-indicators to determine if the ecological community is present – Section 3.1.

Step 2: Determine the condition and size of the patch, using the criteria in Table 1 to determine whether it meets at least the minimum condition thresholds (Moderate or High Condition classes) for protection under national environment law – Section 3.2.

Note: Section 3.3 (Further information to assist in determining importance and avoiding significant impacts) must also be taken into account when considering the importance of a patch of the ecological community and how to protect it under national environment law.

Note: Boundaries for a patch may extend beyond the site boundary, or beyond the potential area of impact for a proposed action. The entire patch as a whole should be considered.

3.1 Step 1 – Key diagnostic characteristics and Contra-indicators

Nature is an intergrading continuum and its ecological classification and mapping is an evolving process, open to subjective interpretation. The ecological community persists in a number of natural, modified and disturbed states. Also, environmental variables, such as climate (and the ecological community's response to them) fluctuate or change over time. For these and other reasons there will be 'atypical' occurrences of the ecological community; and so qualifiers such as "typically", "relatively", "unlikely", "rarely" and "often" are used in the Key diagnostic characteristics. A judgement should therefore be made as to whether the ecological community is present or not, based on: the Key diagnostic characteristics and any

contra-indicators; along with the description of the ecological community and the area it inhabits in Section 2 of this advice.

3.1.1 *Key diagnostic characteristics*

The ecological community[15] that is protected under national environment law consists of areas of vegetation (and associated biota) that overall, meet the following Key diagnostic characteristics, given the considerations outlined in 3.1 above:

- It occurs in the Sydney Basin IBRA[16] Bioregion. It occurs in the Illawarra, Jervis and Sydney Cataract (SYB12, SYB14 and SYB10) subregions, and just over the borders into Burragorang (SYB09), Moss Vale (SYB11) and Ettrema (SYB13) subregions; it may occur elsewhere in the Sydney Basin Bioregion. The majority of the ecological community occurs in the Illawarra IBRA Subregion (SYB12).
- Its northern boundary of occurrence is the Port Hacking estuary. The southern boundary is the boundary between the Sydney Basin and the South East Corner IBRA bioregions[17].
- It occurs on the coastal plain, low-lying foothills and slopes, benches[18] and drainage lines of the eastern coastal escarpment (and of some coastal mountains), between the Hacking and Clyde rivers. It includes occurrences in the Hacking River catchment and the Ettrema Region, as well as in Kangaroo Valley and sites around Milton and Ulladulla.
- It rarely extends onto the upper escarpment slopes. It is usually found below 350 m above sea level (ASL); but there are occurrences up to around 550 – 600 m ASL, for example around Cambewarra Mountain.
- The ecological community is typically associated with the more fertile (higher nutrient)[19] soils derived from igneous substrates, such as Permian volcanics and the Triassic Milton Monzonite; but may occur on other substrates (such as the enriched high nutrient colluvial[20] soils on benches of the escarpment – and in deep, sheltered

[15] The EPBC Act defines an 'ecological community' as the "extent in nature in the Australian jurisdiction of an assemblage of native species that inhabits a particular area in nature" (e.g. a group of plants, animals and other organisms interacting in a specific habitat, under relatively similar environmental conditions).

[16] Interim Biogeographic Regionalisation of Australia (IBRA) Version 7. http://www.environment.gov.au/land/nrs/science/ibra

[17] The southernmost part of the boundary between the two IBRA bioregions at this time is just south of Beagle Bay and Durras, north of Batemans Bay.

[18] Bench: A relatively level strip of land that runs along a sloped area (a shelf or step-like feature on the way down a hillside). Benches can be formed by the differential erosion of rocks or sediments of varying hardness and resistance to erosion.

[19] These soils are typically more fertile than those just derived from the sandstone substrates more prevalent in the region.

[20] Colluvial: Pertaining to colluvium (loose material, such as soil or sediments, which has accumulated at the base of a slope through the action of gravity (e.g. talus, avalanche debris and material moved by soil creep, frost action or sheet erosion).

gullies, e.g. where the Hacking River has cut down from sandstone into the Narrabeen Group shale[21]).

- Relatively undisturbed stands typically have high structural complexity with a canopy and emergent trees (sometimes with buttressed trunks), epiphytes, mid-stratum trees and shrubs, vines in the canopy and on tree trunks and on the ground; and a variable ground layer, usually with abundant leaf litter. At disturbed sites structural complexity may be reduced, but there may be signs of regeneration (e.g. seedlings, saplings or other sub-mature stages of rainforest species).
- The canopy of relatively undisturbed mature patches generally forms a dense closed forest (typical canopy cover[22] of at least 70%) with some emergent trees (e.g. to 35 m high); although gaps may be present and are included in the patch. At some sites canopy cover may be reduced e.g. due to landscape features (such as large boulders or creeks) or disturbance (the condition thresholds in section 3.2 take account of natural variation and disturbance).
- Whilst the ecological community typically has a mid-stratum (mid-layer / midstorey vegetation), ground layer vegetation is often sparse (although some areas may have a high percentage cover of ferns, which can fluctuate with seasonal conditions from year to year).
- A list of diagnostic native plant species, and of some of the key native fauna that make up the ecological community is given at Appendix A; although particular species may be abundant or rare, or not necessarily present at every site.

3.1.2 *Contra-indicators*

- Rainforest characterised by a single relatively uniform canopy layer, (e.g. with no midstorey), a persistent fern-dominated ground layer and/or an absence of large vines or lianas, is unlikely to be the Illawarra–Shoalhaven subtropical rainforest ecological community[23]. For example, it could be warm temperate rainforest, which may adjoin the ecological community (e.g. higher up the escarpment). Warm temperate rainforest may be distinguished from the ecological community by its simplified canopy, which is dominated by one or more of the following species: *Ceratopetalum apetalum* (Coachwood), *Doryphora sassafras* (Sassafras), or *Syzygium smithii* (syn. *Acmena smithii*) (Lilly Pilly, Midjuburi (Cadigal)). Whilst these three species may also occur in patches of the Illawarra–Shoalhaven subtropical rainforest ecological community, they are not the dominant tree species in the ecological community.

[21] In the Hacking River catchment, upstream of Audley Weir, the ecological community has been identified, for example at sites east and south of Waterfall (including around Bola Creek/Gully and Cedar Creek/Gully).

[22] Canopy cover (measured as foliage cover): should be based on representative areas within the whole patch of the ecological community. Foliage cover is "the percentage of the sample site occupied by the vertical projection of foliage and woody branches" (National Committee on Soil and Terrain, 2009: p.81). When measuring canopy cover, include emergents, canopy and the subcanopy layer (everything above the ground layer – e.g. above 2 m).

[23] Unless the structure has been heavily modified directly or indirectly by human influences.

- The ecological community is not dominated by *Backhousia myrtifolia* (Grey Myrtle), i.e. *Backhousia myrtifolia* should account for less than half of the total canopy cover within a patch of the ecological community.
- The ecological community is not a woodland or forest characterised by eucalypts (i.e. tree species from the genera *Eucalyptus*, *Corymbia*, *Syncarpia* and *Angophora*). However, there may be variation in the eucalypt density within a patch, particularly across a disturbed patch. Emergent eucalypts, above the rainforest canopy, do not indicate a eucalypt forest and these areas can be included in the ecological community.
- The ecological community is unlikely to occur on relatively infertile, coarse-textured quartz-based geologies and soils, such as coastal sands or those of the widespread Triassic Hawkesbury and Narrabeen Group sandstones, or of the Permian Nowra Sandstone[24];

The Illawarra–Shoalhaven subtropical rainforest ecological community may occur near and can intergrade with the nationally listed 'Littoral Rainforest and Coastal Vine Thickets of Eastern Australia' ecological community (Littoral Rainforest) in some coastal areas. The ecological community differs from the Littoral Rainforest ecological community in the following features:

- The physical environments where the two ecological communities occur are differentiated by the level of coastal or estuarine influence (salt-water laden winds);
- In the Sydney Basin, Littoral Rainforest typically occurs within two km of the coast (usually within a few hundred metres in the Illawarra–Shoalhaven area) on non-volcanic substrates, such as littoral hind-dunes and has a more coastal/estuarine influence;
- Illawarra–Shoalhaven subtropical rainforest typically occurs more than 400 m from the coast and has a less coastal/estuarine influence – but it may occur closer, where volcanic substrates occur (e.g. on more elevated, rocky, latite)[25]; and
- Littoral Rainforest and Vine Thickets often has more abundance of species from the genera *Acacia*, *Banksia* and *Eucalyptus*. Diagnostic information for the Littoral Rainforest ecological community is available on the Department's website, at: http://www.environment.gov.au/cgi-bin/sprat/public/publicshowcommunity.pl?id=76

3.2 Step 2 – Determine patch condition

3.2.1 *Condition classes and thresholds for national legal protection*

The Condition thresholds for this ecological community are designed to identify the relatively good quality patches for protection under national environment law (i.e. moderate to high value). Table 1 shows the Condition classes, categories and thresholds.

Because the ecological community has been heavily cleared and fragmented, many remnants are small, isolated, and in a modified condition. Any remnants that remain largely intact (in

[24] Unless they are enriched by more fertile, finer-textured substrates (e.g. colluvium, washed/fallen down from substrates higher up the slope).

[25] For example, at Killalea and in the Kiama foothills.

terms of structure and/or diversity of characteristic species), or are connected to other native vegetation and form a large patch, are a high priority for protection and management. Very small (< 0.1 ha), isolated patches and/or those subject to high disturbance are unlikely to have the structure, composition and function of the ecological community and will not meet the minimum condition thresholds for protection under national environment law (for example, a few rainforest trees on a farm or roadside, with limited diversity/structural elements).

The ecological community that is protected under national environment law comprises patches that meet the Key diagnostic characteristics (above) and at least the **minimum condition thresholds** (Moderate and High condition categories A, B, C or D) set out in Table 1.

Note in addition:

- Sections 3.2.2 – 3.2.4: Defining a patch; Revegetated areas and areas of regeneration; and, Sampling protocols;
- Assessments of a patch should initially be centred on the area of highest native floristic diversity and/or cover, i.e. the best condition area of the patch;
- The surrounding context of a patch must be taken into account when considering factors that add to the importance of a patch that meets the minimum condition thresholds;
- A relevant expert (e.g. an ecological consultant, or local NSW state or regional NRM officer) may be useful to help identify the ecological community and its condition;

AND also refer to Section 3.3 – Further information to assist in determining importance and avoiding significant impacts.

Table 1: Condition thresholds for the Illawarra–Shoalhaven subtropical rainforest

Class, category and rationale	Patch size thresholds	Biotic thresholds
Moderate Condition Class: i.e. for patches of the ecological community that meet the minimum condition thresholds for protection under national environment law.		
Moderate Condition – Category A A larger rainforest patch with a moderate to intact canopy.	At least 1 ha.	At least 50% canopy cover[1] **AND** A minimum of 5 native plant species from Table A1 per 0.04 ha sample plot[2] on average[3] for the patch.
Moderate Condition – Category B A smaller rainforest patch with a moderate to intact canopy; AND either a higher diversity of rainforest plants, OR it is part of a larger patch of native vegetation.	Between 0.1 and 1 ha.	At least 50% canopy cover[1] **AND** A minimum of 15 native plant species from Table A1 per 0.04 ha sample plot[2] on average[3] for the patch **OR** A minimum of 10 native plant species from Table A1 per 0.04 ha sample plot[2] on average[3] for the patch **AND** The patch is contiguous[4] with another patch of native vegetation that is at least 1 ha in size.
Moderate Condition – Category C A smaller rainforest patch with a relatively intact canopy AND a moderate diversity of rainforest plants.	At least 0.1 ha.	At least 70% canopy cover[1] **AND** A minimum of 10 native plant species from Table A1 per 0.04 ha sample plot[2] on average[3] for the patch.
Regenerating rainforest – Category D A regenerating rainforest patch that has a higher diversity of rainforest species.	At least 0.1 ha.	At least 30% canopy cover[1]; **AND** A minimum of 15 native plant species from Table A1 per 0.04 ha sample plot[2] on average[3] for the patch **AND** Evidence of regeneration (e.g. seedlings, saplings or other sub-mature stages of rainforest tree species).
High Condition Class: e.g. to provide further information about higher condition patches & / or to guide management and restoration goals		
High Condition – Category A A patch with a relatively intact canopy AND a higher diversity of rainforest plants.	At least 0.1 ha.	≥ 70% canopy cover[1] **AND** A minimum of 15 native plant species from Table A1 per 0.04 ha sample plot[2] on average[3] for the patch
High Condition – Category B A patch with a relatively intact canopy AND a moderate diversity of rainforest plants AND specialist subtropical rainforest birds OR a moderate diversity of native birds (given their important role in the EC).	At least 0.1 ha.	At least 70% canopy cover[1] **AND** A minimum of 10 native plant species from Table A1 per 0.04 ha sample plot[2] on average[3] for the patch **AND** At least 2 'specialist[#] subtropical rainforest' native bird species from Table A2 in the patch **OR** At least 10 native bird species from Table A2 in the patch.
High condition – Category C A patch with a moderate canopy and an even higher diversity of rainforest plants	At least 0.1 ha.	At least 50% canopy cover[1] **AND** A minimum of 30 native plant species from Table A1 per 0.04 ha sample plot[2] on average[3] for the patch.

Notes:
Further information on **sampling protocols** is in Section 3.2.4 *Sampling protocols*.
[1] **Canopy cover** (measured as foliage cover) should be based on representative areas within the whole patch of the ecological community. Foliage cover is "the percentage of the sample site occupied by the vertical projection of foliage and woody branches" (National Committee on Soil and Terrain, 2009: p.81). When measuring canopy cover, include emergents, canopy and the subcanopy layer (everything above the ground layer – e.g. above 2m).
[2] **0.04 ha sample plot** – For example, 20 m x 20 m.
[3] This threshold should be assessed using the mean average ('species richness for species from Table A1' per sample plot) value for the patch. This is calculated by adding together the 'number of species from Table A1' result for each sample plot in the patch; this total is then divided by the number of sample plots for the patch. See also Section 3.2.2 *Defining a patch* and Section 3.2.4 *Sampling protocols*.
[4] **Contiguous** with another patch of native vegetation means the patch is continuous with, or in close proximity (within 100 m) to, another area of native vegetation. The thresholds for canopy cover and native plant species richness apply to the condition of the patch of the ecological community only (i.e. they are not relevant to the contiguous native vegetation). Native vegetation here refers to areas of vegetation where cover in each layer present is dominated by native species.

3.2.2 *Defining a patch*

A patch is a discrete and mostly continuous area of the Illawarra–Shoalhaven subtropical rainforest ecological community[26], which meets the Key diagnostic characteristics and minimum condition thresholds. It includes small-scale variations, gaps and disturbances, such as tracks, paths or breaks (including exposed soil, leaf litter, cryptogams and watercourses/ drainage lines), or localised variations in vegetation that do not significantly alter the overall functionality of the ecological community. This functionality includes processes such as the movement of wildlife and other pollinators, the dispersal of plant propagules, activities of seed and plant predators, biological water retention, and cycling and many other interactions.

Gaps in the canopy, degraded and regenerating areas of lower quality are still part of the patch, until a decision is made to the contrary. Initially, all areas should be considered together, in terms of identifying the entire patch of the ecological community and considering its protection, under national environment law. Small breaks or gaps are generally included in a patch. However, where there is a break in native vegetation cover, from the edge of the tree canopy, of 100 m or more (e.g. due to permanent man-made structures, wide roads or other barriers; or, due to wide water bodies), the two areas of the ecological community are usually treated as separate patches. Two patches of the ecological community can also be separated by a different type of native vegetation (e.g. natural grassland, or grassy woodland).

[26] Note that NSW vegetation assessment tools may define a 'patch' differently – e.g. as an area of native vegetation, of one or more different communities that occur together, separated by a gap of no greater than a set distance (usually 100 m). The national Threatened Species Scientific Committee uses the term 'patch' to describe all of a discrete area of a single ecological community (e.g. for environmental impact assessments, do not only consider the area that may be directly impacted by an activity, or the area just within the boundary of a particular activity – consider the entire patch of the ecological community as a whole – Property, lot or site boundaries should not be used to define the boundary of a patch.).

Differences in canopy cover, quality, or condition of vegetation, across a patch should not initially be thought of as evidence of multiple patches. Patches can be spatially variable and some areas of a patch, if considered in isolation, might not meet all the Key diagnostic characteristics and minimum condition thresholds. Average quality across the broadest area that meets the Key diagnostic characteristics for the ecological community should be used initially in determining overall vegetation condition (diversity and cover) and patch boundaries. Where the average quality of a larger area falls below the minimum condition thresholds for the ecological community, the next largest area that meets the Key diagnostic characteristics and at least the minimum condition thresholds should be identified and protected. This may result in more than one patch of the ecological community being identified within the larger area first considered. The patch may then be further divided into areas of high and moderate quality if that is useful to further conservation decision making.

3.2.3 *Revegetated areas and areas of regeneration*

Revegetated or replanted sites, or areas of vegetation regeneration can be included as part of the protected ecological community, provided that the revegetated area meets the Key diagnostic characteristics and at least the minimum condition thresholds. It is recognised that reconstruction/revegetation often requires long term effort and commitment and results are uncertain. Reconstructing an ecological community to a state that resembles appropriate reference sites can, at best, be extremely slow and may ultimately prove unsuccessful.

However, the Illawarra–Shoalhaven subtropical rainforest ecological community has a relatively high potential for rehabilitation and natural regeneration where threats are sufficiently reduced. Rainforests are dynamic communities that can regenerate naturally following disturbance and structural damage. Some rainforest species store viable seed in the soil (although viability varies between species) but more commonly rainforest species rely on rapid germination and seedlings in the understorey (BSRLG 2005). As canopy gaps appear, the increased availability of light removes any suppression to seedling growth. The inclusion of patches of natural and managed regeneration reflect the ecological community's ability to regenerate. Degraded patches that are actively managed (i.e. with weeds removed and/or with supplementary planting) are capable of re-establishing themselves and supporting a good ecologically functional state (as can be indicated by meeting moderate or high condition thresholds).

3.2.4 *Sampling protocols*

Evaluating/sampling a patch can involve developing a quick/simple map of the vegetation condition, diversity, landscape qualities and management history (where possible) of the site. An appropriate sampling strategy should be used that captures the diversity of the site and recognises any variation e.g. due to topography.

Thorough and representative on-ground surveys are essential to accurately assess the extent and condition of the ecological community. The Australian Soil and Land Survey Field Handbook (National Committee on Soil and Terrain 2009) provides relevant survey guidance. To identify patches of High Condition Class – Category B, bird surveys are necessary. The

Australian Government *Survey guidelines for Australia's threatened birds*[27] provides advice on the effort and methods considered appropriate for conducting a presence/absence bird survey.

Patches can vary markedly in their shape, size, condition and features. As a general principle, sampling protocols and the number of sample plots should include, or allow for:

- area(s) with the highest apparent number of different native plant species and canopy cover;
- an appropriate number of plots to provide a representative sample across the full extent of the patch (taking into consideration the shape and condition across the site, as well as providing a good representation of the species present);
  and
- sufficient survey effort should be applied to detect the range of bird species present

Recording the search effort (identifying the number of person hours spent per plot 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.

Timing of surveys is an important consideration because ecological communities may vary in their appearance through the year and between years, depending on seasonal or climatic conditions. Ideally, surveys should be held in more than one season to maximise the chance of detecting all species present. For example, flowering may be necessary to identify plant species and active growth will indicate population sizes of annual weeds. Immediately after disturbance some species, or groups of species, may not be evident for some time. The presence and detectability of some species may be affected by the time since disturbance, such as fire or storms, so surveys should be planned to occur after an adequate time for recovery. 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. Note that rainforests may take a long time to recover their structure after certain disturbances and transitional stages may persist for some time.

3.3 Further information to assist in determining importance and avoiding significant impacts

The following information must also be taken into account when considering the importance of a patch of the ecological community, and determining potential impacts and how to protect the patch under national environment law.

Land use and disturbance history will have influenced what remains of a patch of the ecological community. Its resulting structure (especially the loss of structural elements) will in turn affect species richness and diversity. The surrounding vegetation will also influence how important a patch of the ecological community is in the broader landscape. For example, whether it enables movement of native fauna or dispersal of plant material, or supports other ecological processes, such as nutrient cycling.

[27] http://www.environment.gov.au/epbc/publications/survey-guidelines-australias-threatened-birds-guidelines-detecting-birds-listed-threatened

3.3.1 *Additional buffer zone around a patch*

In addition to the patch itself, a minimum buffer zone that extends 100 m beyond the canopy of the outermost trees in the patch is essential to assist in the conservation of the patch. Its purpose is not specifically to extend the patch through regeneration, although this would be beneficial. A larger buffer zone should be applied, where practical, to protect patches that are of high conservation value, or if patches are located near drainage lines or a source of nutrient enrichment, or groundwater drawdown. Judgement should be exercised to determine an appropriate buffer distance depending on circumstances of how a patch may be impacted.

A buffer zone is an area immediately adjacent to a patch of the ecological community (but not part of the community) that is important for protecting it from likely negative impacts. Because the risk of damaging an ecological community is usually greater where actions occur close to a patch, a buffer zone helps shield the patch from nearby activity. The 100 m buffer zone encompasses an area large enough to protect the root zone of edge trees and other components of the ecological community from fertiliser, pesticide or herbicide applied or sprayed in adjacent land (e.g. spray drift), weed invasion, water runoff, soil erosion and other damage and edge effects.

The buffer zone is not part of the patch of the ecological community, but should ideally consist of other native vegetation that is retained wherever possible. Practical application of a buffer zone is strongly recommended. For instance, it is recommended that care be exercised in the buffer zone to minimise the risk of any significant adverse impacts extending into the ecological community, irrespective of the nature of the buffer zone.

To get approval under national environment law, actions/changes in land use in the buffer zone must not have a significant impact on the ecological community; but there are exemptions for continuing use (e.g. existing cropping, grazing or maintaining fire breaks). If the use of an area next to a patch of the ecological community will be intensified and this is likely to adversely impact the patch, approval under national environment law is also likely to be required to ensure adverse impacts are avoided.

The buffer zone may also be a suitable focus for revegetation or other restoration initiatives to extend the patch.

3.3.2 *Surrounding environment, landscape context and other guidance for avoiding and mitigating impacts*

The minimum condition thresholds outlined above are the minimum level at which patches are protected under national environment law. These thresholds do not represent the ideal state of the ecological community. Patches that are larger, more species rich and less disturbed are likely to provide greater biodiversity value. Additionally, patches that are spatially linked, whether ecologically or by proximity, are particularly important, both as wildlife habitat and corridors – and to the viability of the ecological community into the future.

So, in the context of actions that may have significant impacts and hence require approval under national environment law, it is important to consider the environment surrounding patches of the listed ecological community. Some patches that meet the minimum condition

thresholds occur in isolation and require protection, as well as priority actions, to link them with other patches. Other patches, which are interconnected to similar native vegetation associations, have additional conservation value.

The following indicators should be considered when assessing the impacts of actions, or proposed actions under national environment law – or when considering recovery, management and funding priorities for a particular patch.

- Large size (for a patch of the ecological community and/or other surrounding native vegetation) and/or a large area to boundary ratio – larger area/boundary ratios are less exposed and more resilient to edge effect disturbances such as weed invasion and other human impacts.
- Evidence of recruitment of key native plant species or the presence of a range of age cohorts (including through successful assisted regeneration) – for example, tree canopy species are present in a range of sizes from saplings to large trees.
- Good faunal habitat as indicated by patches containing mature (persistent residual) trees, logs, watercourses, diversity of landscape, contribution to movement corridors;
- High species richness, as shown by the variety of native species.
- Presence of nationally-listed or state-listed threatened species, or key functional species such as key pollinator and dispersal animals.
- Areas of minimal weeds and feral animals, or where these can be managed.
- Connectivity to other native vegetation remnants or restoration works. In particular, a patch in an important position between (or linking) other patches in the landscape. Areas of mosaic native vegetation provide a wider range of habitats that benefits flora and fauna diversity.
- 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 are also important due to their rarity, genetic significance, or because of the absence of some threats.

3.3.3 *Area critical to the persistence of the ecological community*

The area considered critical to the survival of the ecological community includes all patches that meet the Key diagnostic characteristics and at least the minimum condition thresholds (Moderate or High Condition classes) for the ecological community plus the buffer zone (particularly where this includes native vegetation). Additional areas, such as buffer zones around patches (see 3.3.1, above), whilst not part of the ecological community that is protected under national environment law, should be taken into consideration (e.g. to avoid adverse impacts on the patch, and as part of the broader surrounding environment and landscape context).

3.4 Relationship to other vegetation classification systems

3.4.1 *Caveat*

Any reference to vegetation and mapping units as equivalent to a national ecological community, at the time of listing, should be taken as indicative rather than definitive. There are various systems of classification and nomenclature used, many of which have been

created for a particular mapping exercise, so the descriptive units used do not fully correspond with each other.

Consideration of whether an ecological community that is protected under national environment law is present should focus on how the patch of vegetation and its faunal components meets the description, particularly the Key diagnostic characteristics and at least the minimum condition thresholds for the ecological community.

Most recently at the time of this assessment (2018–19), the NSW Office of Environment and Heritage are revising their Plant Community Types (PCT), a comprehensive state-wide vegetation scheme. PCTs build on existing studies, notably the vegetation classification and analysis undertaken by Tozer et al. (2010).

3.4.2 *NSW Vegetation Units that* correspond *to the ecological community*

Bearing in mind the limitations stated above, the ecological community corresponds entirely or partly to the following mapped vegetation types:

Tozer et al. (2010) map units[28]:

- RF p111 Subtropical Dry Rainforest; and
- RF p112 Subtropical Complex Rainforest.

NSW Plant Community Types (PCTs; as at April 2019):

- 906 Lilly Pilly – Sassafras – Stinging Tree subtropical/warm temperate rainforest on moist fertile lowlands, southern Sydney Basin Bioregion; and
- 1300 Whalebone Tree – Native Quince dry subtropical rainforest on dry fertile slopes, southern Sydney Basin Bioregion.

Details of vegetation types/units from previous studies/publications are given in *Appendix D.*

3.4.3 *Similar or related Vegetation Units (or intergrades)*

The rainforests of the Illawarra escarpment and foothills are a distinctive vegetative feature of the region. Tozer et al. (2010) describes how a number of Vegetation Units that are similar to (or related to/intergrade with) the Illawarra–Shoalhaven subtropical rainforest ecological community. Details of these are given in Appendix D.

3.5 Existing protection

3.5.1 *Protection through reservation*

Despite a number of reserves containing the ecological community, its position in the landscape (mostly lower altitude fringes) means only a small area of the ecological

[28] Tozer et al. (2010) notes that with decreasing moisture availability Subtropical Complex Rainforest (**RF p112**) intergrades with Subtropical Dry Rainforest (**RF p111**). On poorer soils Subtropical Complex Rainforest (**RF p112**) is replaced by Coastal Warm Temperate Rainforest (**RF p113**).

Also, some areas mapped as **WSF p110** Warm Temperate Layered Forest may be included in the ecological community, if they meet the Key diagnostic characteristics and at least the minimum condition thresholds (e.g. in the Hacking River Catchment (including around Bola Creek/Gully and Cedar Creek/Gully)) as long as they are not excluded on the basis of contra-indicators. Further details of **WSF p110** and **RF p113** are in Appendix D.

community is included in formal conservation reserves. Reserves include Budderoo National Park, Cambewarra Range Nature Reserve (including the Devils Glen Nature Reserve), Illawarra Escarpment State Conservation Area, Macquarie Pass National Park, Morton National Park, Rodway Nature Reserve, Royal National Park, Upper Nepean State Conservation Area and Yatteyattah Nature Reserve. Patches of subtropical rainforest are conserved in perpetuity on the Illawarra lowlands on private land dedicated as Voluntary Conservation Agreements with the NSW Minister for the Environment near Kiama, Gerringong, Toolijooa, Foxground, Berry and possibly within Kangaroo Valley. Some Local Government reserves also conserve subtropical rainforest such as Bundewallah Reserve near Berry and the rainforest reserve north of the Milton Public School.

Tozer et al. (2010) identifies a total of 130 ha of map units RF p111 and 440 ha of RF p112 vegetation present in conservation reserves. This represents only 5.4% and 10.7% respectively of remaining estimated total extent; together they have 8.8% of remaining estimated total extent protected. Estimates suggest the remaining pre-clearing RF p111 area in conservation reserves is less than 2%; for RF p112, the estimate is less than 10%.

3.5.2 *Protection through State/Territory legislation*

At the time of this advice, the ecological community includes two NSW threatened ecological communities listed under the NSW *Biodiversity Conservation Act 2016*:

- In the northern part of its range, the ecological community includes the NSW-listed Endangered 'Illawarra Subtropical Rainforest in the Sydney Basin Bioregion' (listed in 2002).
- In the southern part of its range, the ecological community includes the NSW-listed Endangered 'Milton Ulladulla Subtropical Rainforest in the Sydney Basin Bioregion' (listed in 2002).

This nationally-defined ecological community is more broadly circumscribed, grouping these two NSW-listed ecological communities and including other areas of subtropical rainforest (e.g. in the upper Hacking River catchment and in the Ettrema Region), based on information at the time of national listing (2019). Some details may therefore differ in the descriptions of this ecological community compared to those of the component ecological communities listed in NSW (e.g. species listed as being part of the assemblage). Descriptions may also differ because of the different levels of knowledge and data available at the time of listing in NSW (NSW Scientific Committee 2002a; 2002b) compared with this Advice (dated 2019).

Despite its broader circumscription, this national listing may exclude some patches of the NSW-listed ecological communities on the basis of condition thresholds (such as patch size, tree cover or native species richness).

The status of Illawarra–Shoalhaven subtropical rainforest of the Sydney Basin Bioregion currently as a Critically Endangered Ecological Community differs from the currently listed categories under which the two component ecological communities are currently listed in NSW (NSW Scientific Committee 2002a; 2002b). At the time of listing in NSW, the relevant legislation (NSW *Threatened Species Conservation Act 1995*) did not provide for listing of Critically Endangered ecological communities. Alignment of categories between Commonwealth and state jurisdictions is predicated on a re-assessment of the status of the

relevant communities under the NSW *Biodiversity Conservation Act 2016*, which now provides for listing of Critically Endangered Communities.

Details of the two NSW listed ecological communities are available on the New South Wales OEH website at: https://www.environment.nsw.gov.au/determinations/IllawarraSubtropicalRainforestSydneyBasinEndComListing.htm and https://www.environment.nsw.gov.au/determinations/MiltonUlladullaSubtropicalRainforestSydneyEndComListing.htm

3.5.3 *Other commonwealth listed threatened ecological communities*

The Illawarra–Shoalhaven subtropical rainforest ecological community occurs near and can intergrade with the nationally listed Critically Endangered *Littoral Rainforest and Coastal Vine Thickets of Eastern Australia* ecological community (aka Littoral Rainforest) in some coastal areas.

The ecological community differs from the nationally listed Littoral Rainforest ecological community in the following features:

- The physical environments where the two ecological communities occur are differentiated by the level of coastal or estuarine influence (salt-water laden winds):
- In the Sydney Basin, Littoral Rainforest typically occurs very close to the coast (usually within a few hundred metres in the Illawarra–Shoalhaven area) on non-volcanic substrates, such as littoral hind-dunes and has a more coastal/estuarine influence;
- Illawarra–Shoalhaven subtropical rainforest typically occurs more than 400 m from the coast and has a less coastal/estuarine influence – but it may occur closer, where volcanic substrates occur (e.g. on more elevated, rocky, latite[29]); and
- Littoral Rainforest often has more abundance of species from the genera *Acacia*, *Banksia* and *Eucalyptus*. Diagnostic information for the Littoral Rainforest ecological community is available in its Listing Advice, on the Department's website, at: http://www.environment.gov.au/cgi-bin/sprat/public/publicshowcommunity.pl?id=76

Also occurring nearby, and intergrading with the ecological community on the coastal plain, is the nationally listed Critically Endangered *Illawarra and south coast lowland forest and woodland* ecological community. It is a forest or woodland, with a canopy that is typically dominated by *Eucalyptus* or *Angophora* trees. Many patches are less mesic, with a sub-canopy of smaller trees as well as a shrub layer and/or a ground layer that is grassy or sedgy. Proximity to rainforest may increase the number of seedlings or saplings of mesic species. Further information about this ecological community is available in its Conservation advice at: http://www.environment.gov.au/cgi-bin/sprat/public/publicshowcommunity.pl?id=144

Geographically separate (yet similar in structure) to Illawarra–Shoalhaven subtropical rainforest, i.e. occurring further to the north (from Newcastle to Gladstone), is the nationally listed Critically Endangered *Lowland Rainforest of Subtropical Australia* ecological

[29] e.g. at Killalea and in the Kiama foothills (e.g. on the Permian volcanics in the Kiama area).

community. Further information about this ecological community is available in its Listing Advice at: http://www.environment.gov.au/cgi-bin/sprat/public/publicshowcommunity.pl?id=101

3.5.4 *Listed threatened flora and fauna species*

The ecological community provides habitat for a range of flora and fauna species listed under the NSW *Biodiversity Conservation Act (2016*) and/or the Commonwealth *Environment Protection and Biodiversity Conservation Act (1999).*

Table 2: Threatened flora and fauna that may be found in the ecological community.

Scientific Name	Common Name	EPBC Act	NSW BC Act
Flora			
Daphnandra johnsonii	Illawarra Socketwood	E	E
Cynanchum elegans	White Flowered Wax Plant	E	E
Irenepharsus trypherus	Illawarra Irene; Delicate Cress	E	E
Rhodamnia rubescens	Scrub Turpentine	–	CE
Solanum celatum	–	–	E
Zieria granulata	Illawarra (Hill) Zieria	E	E
Fauna			
Cercartetus nanus	Eastern Pygmy Possum		V
Chalinolobus dwyeri	Large-eared Pied Bat	V	V
Dasyurus maculatus	Spotted-tailed Quoll	V	E
Kerivoula papuensis	Golden-tipped Bat	–	V
Litoria aurea	Green and Golden Bell Frog	V	E
Miniopterus australis	Little Bentwing bat	–	V
Miniopterus schreibersii oceanensis	Eastern Bentwing bat	–	V
Pteropus poliocephalus	Grey-headed Flying-fox	V	V
Ptilinopus magnificus	Wompoo Fruit-dove	–	V
Ptilinopus regina	Rose-crowned Fruit-dove	–	V
Ptilinopus superbus	Superb Fruit-dove	–	V
Saccolaimus flaviventris	Yellow-bellied Sheath-tailed Bat	–	V
Tyto tenebricosa	Sooty Owl	–	V
CE = Critically Endangered; E = Endangered; V = Vulnerable			

Source: (Mills & Jakeman 1995; NSW NPWS 2002b).

4. SUMMARY OF KEY THREATS

The key threats to the Illawarra–Shoalhaven subtropical rainforest ecological community are summarised below. See *Appendix B: Description of key threats* for further details about each threat.

- Clearance of native vegetation and impacts associated with fragmentation.
- Impacts from introduced species (weeds and feral animals)
- Altered hydrology
- Nutrient enrichment and chemical drift
- Altered fire regimes
- Disease and dieback (pathogens)
- Other disturbances to patches
- Climate change

4.1 Key Threatening Processes

Table 3: Relevant national and state-listed Key Threatening Processes

EPBC Act	NSW BC Act
Competition and land degradation by rabbits	Competition and grazing by the feral European Rabbit, *Oryctolagus cuniculus* (L.)
Competition and land degradation by unmanaged goats	Competition and habitat degradation by Feral Goats, *Capra hircus* Linnaeus 1758
Land clearance	Clearing of native vegetation
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants
Loss of climatic habitat caused by anthropogenic emissions of greenhouse gases	Anthropogenic Climate Change
Novel biota and their impact on biodiversity e.g. Myrtle rust (*Austropuccinia psidii*), deer	Introduction and establishment of Exotic Rust Fungi of the order Pucciniales pathogenic on plants of the family Myrtaceae
Predation by European red fox	Predation by the European Red Fox *Vulpes vulpes* (Linnaeus, 1758)
Predation by feral cats	Predation by the Feral Cat *Felis catus* (Linnaeus, 1758)
Predation, Habitat Degradation, Competition and Disease Transmission by Feral Pigs	Predation, habitat degradation, competition and disease transmission by Feral Pigs, *Sus scrofa* Linnaeus 1758
Infection of amphibians with chytrid fungus resulting in chytridiomycosis	Infection of frogs by amphibian chytrid causing the disease chytridiomycosis
	Bushrock removal
	Herbivory and environmental degradation caused by feral deer
	High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition
	Invasion and establishment of exotic vines and scramblers

5. RECOMMENDATIONS BY THE THREATENED SPECIES SCIENTIFIC COMMITTEE

5.1 Summary of eligibility for listing against the EPBC Act criteria

The Illawarra–Shoalhaven subtropical rainforest ecological community is **eligible** for listing as **Critically Endangered**. This was the highest conservation category triggered at the time of this assessment.

For the detailed assessment of eligibility against the listing criteria, *see Appendix C*

5.1.1 *Criterion 1 – Decline in geographic distribution*

Assessed as **Endangered**, based on information in the two NSW listings and Tozer et al. (2010) indicating a severe decline in its geographic distribution. Much of the Illawarra–Shoalhaven Subtropical Rainforest ecological community has been cleared and it now often occurs as scattered fragments. Tozer et al. (2010) estimated the Subtropical Dry Rainforest (RF p111) had declined by 80 to 90% (this vegetation unit is closely related to the ecological community); while the Subtropical Complex Rainforest (RF p112) decline was estimated to be between 35 and 50% (this vegetation unit includes areas of the ecological community but does not entirely correspond with it). Decline of the two units combined ranges from between 65 and 80 % of the two combined units.

5.1.2 *Criterion 2 – Small geographic distribution coupled with demonstrable threat*

Assessed as **Critically Endangered** against this criterion. The ecological community has a *very restricted* distribution; 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.

Most remnants of the ecological community are now small, some naturally so where patches of subtropical rainforest occupied small areas of suitable habitat within other vegetation types. Available patch size data associated with the Tozer units indicate the majority of patches are less than 10 ha in size, the threshold indicative of a ***very restricted*** geographic distribution.

The ecological community is faced with a number of demonstrable threats to its long-term viability given its fragmentation. Remnant rainforest in this region suffers from edge effects, associated with grazing, light intrusion, wind and weed invasion. Other significant threats include: further clearing (for urban and hobby farm developments, quarrying, road widening and utility easements); inappropriate fire regimes; the cutting of trees for firewood; and rubbish dumping (NSW Scientific Committee 2002a; 2002b).

Available evidence suggests that a significant decrease/decline in extent or integrity is likely in the immediate future (i.e. 3 generations of any long-lived species believed to play a major role in sustaining the community, up to a maximum of 60 years - i.e. the rainforest canopy tree species).

5.1.3 *Criterion 3 – Loss or decline of functionally important species*

Whilst there has been significant overall loss of area and degradation in the Illawarra–Shoalhaven Subtropical Rainforest ecological community, evidence for loss of particular functionally important species within remnants is not available at this stage of assessment. There is **insufficient information** to indicate eligibility against any category for this criterion.

What is known is that apart from *Daphnandra johnsonii* (Illawarra Socketwood), the dominant tree canopy species and lower stratum tree species that are key structural (and functional) elements of the ecological community are not considered to be threatened in their own right. The functional roles and importance of most other species in this ecological community are, at best, poorly documented in the literature.

5.1.4 *Criterion 4 – Reduction in community integrity*

Assessed as **Critically Endangered** for this criterion. There has been a reduction in the integrity of the ecological community at both patch and landscape scales due to past and present threats outlined under *Appendix B: Description of key threats*, resulting in a ***very severe*** reduction in integrity across most of its geographic distribution.

Remaining fragments tend to be degraded and continue to be threatened by weed invasion, pathogens, grazing, fire and urban expansion (Tozer et al. 2010). Other increasing threats are from grazing and predation from feral and domestic animals and climate change. Fragmentation has caused a reduction in patch size, an increase in the distance between patches, more exposed edges and hence greater susceptibility to increased disturbance and degradation. As a result of fragmentation, the ecological community has also suffered local loss of plant and animal diversity and is also less amenable to recovery. Moreover, this increased fragmentation generates secondary processes, such as weed invasion, grazing, increased fire and storm damage and other threats associated with urban encroachment, which severely impact on the structural, compositional and functional integrity of the ecological community.

5.1.5 *Criterion 5 – Rate of continuing detrimental change*

There is **insufficient information to determine the eligibility** of the ecological community for listing under this criterion.

5.1.6 *Criterion 6 – Quantitative analysis showing probability of extinction*

There are no quantitative data available to assess this ecological community under this criterion. As such, there is **insufficient information to determine the eligibility** of the ecological community for listing under this criterion.

5.2 Recommendation on whether to have a recovery plan

The Conservation Advice for the Illawarra–Shoalhaven subtropical rainforest of the Sydney Basin Bioregion ecological community outlines priority actions needed for the conservation and recovery of the ecological community, the main threats faced by the ecological community, and the criteria by which the ecological community is eligible for listing. The Committee is required to advise the Minister as to whether the ecological community should also have a Recovery Plan.

For the Illawarra–Shoalhaven subtropical rainforest of the Sydney Basin Bioregion ecological community the Committee advises that the Conservation Advice provides sufficient guidance on the recovery of the ecological community and that a decision to have a Recovery Plan is unlikely to lead to substantial additional conservation benefits given the resources required to develop a plan. Consequently, the Committee advises that a Recovery Plan **is not recommended** at this time.

6. PRIORITY RESEARCH AND CONSERVATION ACTIONS

6.1 Conservation Objective

The conservation objective (see Section 1 above) provides the goal and rationale for the priority actions identified here. The objective is:

To prevent further loss and degradation of the ***Illawarra–Shoalhaven subtropical rainforest of the Sydney Basin Bioregion*** ecological community and help recover its biodiversity, function and extent, by 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.

6.2 Principles and standards

In undertaking priority actions to meet the conservation objective, the overarching principle is that it is preferable to maintain existing areas of the Illawarra–Shoalhaven Subtropical Rainforest ecological community that are relatively intact and of good quality. There are good, practical reasons to do so. It is typically more successful and 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 2017[30]):

> *"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."*
>
> *Standards Reference Group SERA (2017) – Appendix 2.*

The principle discourages 'offsets' where intact remnants are removed with an undertaking to set aside and/or restore other sites. The destruction of intact sites always results in 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 (2017). They outline the principles that convey the main ecological, biological, technical, social and ethical underpinnings of ecological restoration practice. More specific guidance regarding restoration of Illawarra–

[30] Society for Ecological Restoration: http://www.seraustralasia.com/standards/home.html

Shoalhaven Subtropical Rainforest, or information that is regionally specific, may also become available. As restoration ecology is continually developing, it is also important to reflect on the experience of others who have worked on restoring the ecological community or other subtropical rainforests, as well as adapting restoration projects as site-level experience accumulates.

To achieve cost-effective investments in conservation management it is important to consider the likely interaction of the various management actions being undertaken at any one site, as these may be synergistic or antagonistic. There are also likely to be interactions between sites. Additionally, when allocating management resources it is important to consider what is the minimum investment required for success and the follow-up required to secure long-term recovery (for example, for how many years should weed management be repeated).

6.3 Priority actions

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

- planning, management and restoration of the ecological community by landholders, NRM and community groups and other land managers;
- determining conditions of approval for relevant controlled actions under national environment law; and
- prioritising activities in applications for Australian Government or other funding programs.

Detailed advice on actions may be available in other documents, such as management plans for weeds, fire or certain parks or regions. The most relevant are listed in section 6.4 below.

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 Illawarra–Shoalhaven Subtropical Rainforest 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. Actions inconsistent with these actions and that are likely to significantly adversely affect the ecological community should be avoided.

6.3.1 *PROTECT the ecological community*

This key approach includes priorities intended to protect the ecological community by preventing further losses to extent and integrity – i.e. prevent vegetation clearance and direct habitat degradation.

Conserve remaining patches

- Prevent and avoid further clearance, fragmentation or detrimental modification of remnants of the ecological community and of surrounding native vegetation; for example, during residential development. High conservation value, less modified and older growth areas are particularly important for retention and management.
- Retain other native vegetation remnants, near patches of the ecological community, where they are important for connectivity, diversity of habitat and act as buffer zones between the ecological community and threats or development zones (e.g. apply recommended buffers of at least 100 m around patches of the ecological community).
- Protect patches identified as the most intact wildlife refuges, or that form important landscape connections, such as wildlife corridors, stepping stones, or access routes to water sources, or that are of regional importance in formal conservation reserves. Consider other remnants for less formal conservation tenures, preferably ones that aim for protection over the long-term. This includes investigating formal conservation arrangements, management agreements and covenants to protect patches on private land. This is particularly important for larger patches or areas that link to other patches of native vegetation and are part of wildlife corridors or migration routes.
- Protect mature trees, particularly with hollows or as fruit sources. Large and old trees, even if they are dead, may have numerous hollows and fissures that provide shelter; support diverse insects and their predators; and act as ‘stepping stones’ for fauna moving between remnants and to water sources in an otherwise cleared landscape.
- Exclude fire from patches of the ecological community.
- Prevent wood collection and illegal logging or collection of rainforest timbers that leads to loss and damage of trees and logs.
- Construct wildlife friendly fences to exclude cattle and feral species that incorporate a buffer to protect rainforest remnants and allowing for recruitment and enhanced connectivity.
- Where regrowth or regeneration is occurring, provide measures that will support the regeneration to maturity (e.g. provide fencing to minimise damage risk).
- Implement measures to prevent or control inappropriate water flows, such as from road storm water drains, and erosion.
- Plan strategically to minimise further clearing.
- Remnants 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 or large projects (e.g. road works, developments).

Manage actions to minimise impacts

- Apply the mitigation hierarchy to avoid, then mitigate, then offset potential impacts on the ecological community from development or other actions. The priority is to avoid further clearance and fragmentation of remnants with offsetting as the last resort.
- Plan projects to avoid the need to offset, by avoiding significant impacts to the ecological community.
- In circumstances where impacts cannot be totally avoided, then they should be minimised by:
    - retaining and avoiding damage to high quality patches, which should be managed to retain their benchmark state; and
    - protecting important habitat features, such as large mature trees with hollows or that provide a large supply of fruit and flower resources for fauna, as these take many decades to develop and cannot be quickly replaced.
- Where impacts are unavoidable, offsets should be used as a last resort to compensate for the adverse impacts of the action deemed unavoidable. The outcomes of offsetting activities are generally highly uncertain. Any proposals considering offsets for this ecological community should aim to:
    - minimise the need to offset the ecological community by designing development around the ecological community and applying buffers;
    - retain medium and higher quality patches of the ecological community, rather than offset them (particularly with lower quality offset sites);
    - focus on retaining remnants of the ecological community with mature trees, or remnants that provide important connections to other native bush remnants and water sources;
    - manage and protect offset areas in perpetuity in areas dedicated for conservation purposes – avoid risks that may reduce their size, condition and ecological function in the future;
    - select offset sites as close as possible to the impact site, to allow for local and regional variation in the ecological community;
    - increase the area and improve ecological function of existing patches, for example by enhancing landscape connectivity, habitat diversity and condition (e.g. through planting and regeneration with local rainforest species);
    - focus on the restoration of moderate quality patches of the ecological community to achieve high quality condition;
    - extend protection to otherwise unprotected sites (e.g. sites that are currently too small or degraded to meet the condition thresholds for national protection, but can reasonably be restored to a better, more intact condition and provide habitat and connectivity between patches); and
    - monitor offset areas and the outcomes they deliver over the long-term, to manage them adaptively and improve understanding of the best ways to manage offsets to deliver biodiversity benefits.

Minimise indirect impacts

- Minimise the risk of indirect impacts to the ecological community from actions outside but near to patches of the ecological community.
- Protect and apply appropriate buffers (i.e. at least 100 m), particularly of other native vegetation, around patches of the ecological community to minimise off-site impacts; wider buffers may be required where there is larger scale landscape change, such as changes to catchment hydrology. Buffers also serve as important landscape connections, such as wildlife corridors.

Prevent the introduction and spread of exotic species

- Support strong border biosecurity and avoid importing or accidentally introducing invasive species and pathogens into Australia that may have a serious adverse impact on this ecological community.
- Prevent planting of known or potentially invasive species (particularly known transformer species) in gardens, developments and landscaping near the ecological community.
- Avoid planting highly invasive (e.g. bird dispersed) species in or near remnants.
- When conducting activities in or around the ecological community, practise good biosecurity hygiene to avoid spreading weeds or pathogens. For example, keep vehicles and machinery to dedicated roads and out of remnants wherever possible. If vehicles must be taken into remnants ensure vehicles are washed first to remove soil, potential fungal pathogens and weed seeds. Use local rainforest plants from accredited nurseries (e.g. accredited through the Nursery and Garden Industry Australia's Nursery Industry Accreditation Scheme).
- Minimise unnecessary soil disturbance that may facilitate weed establishment.
- Prevent dumping of garden waste into bushland, especially in or near patches of the ecological community.
- If new weed incursions do occur, detect and control them early, particularly aim to locally eradicate transformer weeds. Small infestations are more likely to be able to be eradicated.
- Limit or prevent access of grazing animals to patches of the ecological community (e.g. construct fences).
- Prevent further introduction of feral animals and, where possible, contain pets in nearby residential areas.

6.3.2 *RESTORE the ecological community*

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

- Liaise with landholders and undertake and promote programs that ameliorate threats such as grazing and human disturbance.
- Work with landholders to restore and reconnect patches of the ecological community and include buffers.

Manage weeds and pests

- Implement effective integrated control and management techniques for weeds affecting the ecological community and manage sites to prevent the introduction of new, or further spread of, invasive weeds.
- Control invasive species using best practice bush regeneration techniques by qualified bush regenerators.
- Consider a strategic management approach for weeds that takes into account their potential microclimatic or habitat values of weeds (e.g. providing areas for native seedling establishment or shelter for fauna) when planning their control.
- Prioritise weed control in patches for which management is most urgent.
- Encourage appropriate use of local native 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 waterbodies.
- Control introduced pest animals through coordinated landscape-scale control programs. For example, work with relevant authorities to suppress fox, deer and goat numbers, in line with the regional pest management strategy.

Exclude trampling, browsing and grazing

- Promote regeneration by avoiding trampling, browsing and grazing.
- Strategically manage total herbivore grazing (by native and domestic animals), for instance by fencing off regrowth, revegetation areas, or high value sites to restrict grazers.

Undertake restoration

- Undertake restoration, including bush regeneration and revegetation, of poorer and medium quality patches to restore them to high quality.
- Plan and implement restoration with reference to the *National Standards for the Practice of Ecological Restoration in Australia* (Standards Reference Group SERA, 2017).
- 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 (preferably from multiple parent sources and locations), to restore native plant species. However, choosing sources of seed across their Illawarra–Shoalhaven range may increase resilience to climate change.
- Ensure commitment to follow up after planting, such as the care of newly planted vegetation by watering, mulching, weeding and use/removal of tree guards.
- Consider the landscape context and other relevant species and communities when planning restoration works. For example, ensure adjacent ecological–communities and threatened species are not adversely impacted by tree planting or other restoration activities.
- Seed collections should follow appropriate national guidelines and protocols with long-term storage of germplasm in an appropriate state facility.
- 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, relevant research or advice from local authorities.

6.3.3 *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, particularly Traditional Owner groups.

Raise awareness

- Educate landholders about the ecological values of and threats to Illawarra–Shoalhaven subtropical rainforest.

- Encourage landholders to protect patches through long term private land conservation mechanisms.
- Communicate with landholders/managers, relevant agencies and the public to emphasise the value of the ecological community, the key threats, its significance, and appropriate management. Encourage landholders to talk with local NRM organisations and other knowledgeable groups.
- Undertake effective community engagement and education to highlight the importance of minimising disturbance.
- Inform landholders about incentives, such as conservation agreements, stewardship projects, funding and government NRM programs etc. that may apply to help look after sites on private lands.

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 environmental law. This includes preparation of identification guidelines for the ecological community.
- Install signage (and where appropriate fencing, gates, bollards and formal trails) to discourage damaging activities such as the removal of rocks and 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.
- Install significant vegetation markers along roads to designate areas of the ecological community to protect and prevent inappropriate road side maintenance from occurring.
- 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.

Coordinate efforts

- Encourage local participation in restoration and 'landcare' efforts through local conservation groups, creating 'friends of' groups, field days and planting projects, etc.
- Liaise with local fire management authorities and agencies and engage their support in fire management of the ecological community. Ensure land managers are given information about how to manage fire risks to conserve any threatened species and ecological communities.
- Support opportunities for traditional owners or other members of the Indigenous community to manage the ecological community.

6.3.4 *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.

Mapping

- Collate existing vegetation mapping information and associated data for this ecological community and identify gaps in knowledge.
- Identify and map the fire interval status of surrounding fire-dependent vegetation.
- Undertake or support and enhance survey programs to:
    - Conduct targeted field surveys and ground-truth to fill data gaps and clarify the presence and condition of remnants, consistent with NSW vegetation survey guidelines (https://www.environment.nsw.gov.au/research/VISplot.htm).
    - Improve mapping of sites where the ecological community is known or likely to be present using systematic survey data.

Options for managing threats

- Research into appropriate and integrated methods to manage weeds that affect the ecological community.
- Research into potential impacts of climate change on current distribution of the ecological community.

Monitoring

- Monitor for incursions by new weeds and pest animals.
- Monitor for myrtle rust and signs of new disease outbreaks and appropriate containment actions undertaken.
- 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 changes in the composition, structure and function of the ecological community, including response to all types of management actions and use this information to increase understanding of the ecological community and inform recommendations for future management.

6.4 Existing plans relevant to the ecological community

A number of existing plans relate to management and/or recovery of the Illawarra–Shoalhaven subtropical rainforest ecological community or its component species. These prescriptions were current at the time of publishing. Please refer to the relevant agency's website for any updated versions or new information that has been published.

Plans prepared for the management and/or recovery of the ecological community (or its component vegetation units and state-listed equivalent communities, or relevant threatened species) include the following.

The NSW Government has issued a targeted strategy for managing the two state-listed endangered ecological communities (that correspond closely with the nationally defined ecological community) under the Saving Our Species program. *Help save the Illawarra Subtropical Rainforest in the Sydney Basin Bioregion* (NSW OEH 2019a) and *Help save the Milton Ulladulla Subtropical Rainforest in the Sydney Basin Bioregion* (NSW OEH 2019b)

are available at:
https://www.environment.nsw.gov.au/savingourspeciesapp/Project.aspx?ProfileID=10427 and
https://www.environment.nsw.gov.au/savingourspeciesapp/project.aspx?ProfileID=10532

From this work, the following site-scale actions are outlined (at February 2019) in the 'Action toolbox' for the state-listed endangered *Illawarra Subtropical Rainforest in the Sydney Basin Bioregion* ecological community.

- Conduct a combination of targeted physical and chemical weed control and bush regeneration activities on the site after establishing the weed management requirements based on weeds present and their coverage.
- Undertake ground-based shooting and other management actions if deemed appropriate, consistent with protocols and processes of the Northern Illawarra Deer Management Plan.
- Conduct buffer and infill planting to reduce edge effects and to improve the edge to area ratio using species consistent with the Illawarra Subtropical Rainforest. Protect plantings from damage by deer browsing.
- Assess the requirements for the installation/repairs of fencing to protect occurrences of Illawarra Subtropical Rainforest in the site from trampling and grazing by domestic stock.
- Undertake ground-based shooting and/or trapping of goats.
- Provide educational support to landholders including descriptive information regarding the Illawarra Subtropical Rainforest, its environmental values and activities, and actions that can be done to protect and improve its habitat.
- Conduct surveys for the Illawarra Subtropical Rainforest in the site to determine its extent and condition. Use research to inform management priorities.

A Priorities Action Statement is also available for the state-listed endangered *Illawarra Subtropical Rainforest in the Sydney Basin Bioregion* ecological community, at:
http://www.environment.nsw.gov.au/~/media/DC92759E815F49179AD60D0DE2F38212.ashx

Regional management plans:

Illawarra Councils (2011) *Illawarra Biodiversity Strategy*. Wollongong City Council, Shellharbour City Council, Kiama Municipal Council. Available at:
http://www.wollongong.nsw.gov.au/services/sustainability/sustainableliving/Pages/growlocalbiodiversity.aspx

Threat abatement plans include:

Department of the Environment (2015) Threat abatement plan for predation by feral cats. Commonwealth of Australia. Available at:
http://www.environment.gov.au/biodiversity/threatened/publications/tap/threat-abatement-plan-feral-cats

Department of the Environment and Heritage (2016) Threat abatement plan for infection of amphibians with chytrid fungus resulting in chytridiomycosis. Available at:

http://www.environment.gov.au/biodiversity/threatened/publications/tap/infection-amphibians-chytrid-fungus-resulting-chytridiomycosis-2016

Department of the Environment, Water, Heritage and the Arts (DEWHA) (2008 - 2016) Threat abatement plan for predation by the European red fox. DEWHA, Canberra. Available at: http://www.environment.gov.au/biodiversity/threatened/publications/tap/predation-european-red-fox

Recovery plans prepared for threatened species occurring in the ecological community include:

Department of Environment and Conservation (NSW) (2005) *Zieria granulata* (Illawarra Zieria) recovery plan. Available at: https://www.environment.nsw.gov.au/research-and-publications/publications-search/zieria-granulata-illawarra-zieria-recovery-plan

Queensland Department of Environment and Resource Management (2011) National recovery plan for the large-eared pied bat *Chalinolobus dwyeri*. Report to the Department of Sustainability, Environment, Water, Population and Communities, Canberra. Available at: http://www.environment.gov.au/biodiversity/threatened/recovery-plans/national-recovery-plan-large-eared-pied-bat-chalinolobus-dwyeri

Victorian Department of Environment, Land, Water and Planning (2016) National Recovery Plan for the Spotted-tailed Quoll *Dasyurus maculatus*. Australian Government, Canberra. Available at: http://www.environment.gov.au/biodiversity/threatened/recovery-plans/spotted-tailed-quoll

Other Resources include:

Climate-ready revegetation - A guide for natural resource managers. Version 2
http://anpc.asn.au/resources/climate_ready_revegetation

BIBLIOGRAPHY

Adam P (1992) *Australian Rainforests: Oxford Monographs on Biogeography No. 6*. Clarendon Press, Oxford.

Adam P (2009) Going with the flow? Threatened Species management and legislation in the face of climate change. *Ecological Management and Restoration* 10, 1, 44–52.

ANPWS (Australian National Parks and Wildlife Service) (1991) *Plant Invasions: The incidence of environmental weeds in Australia*. ANPWS, Canberra.

Beeton RJS, Buckley KI, Jones GJ, Morgan D, Reichelt RE & Trewin D (2006) *Australian State of the Environment 2006*, Australian State of the Environment Committee, Canberra.

Bland LM, Keith DA, Miller RM, Murray NJ and Rodríguez JP (2017) Guidelines for the application of IUCN Red List of Ecosystems Categories and Criteria, Version 1.1. Available on the internet at: https://portals.iucn.org/library/sites/library/files/documents/2016-010-v1.1.pdf

Bowman DMJS (2000) *Australian Rainforests: Islands of green in a land of fire.* Cambridge University Press, Cambridge.

BSRLG (Big Scrub Rainforest Landcare Group) (2005) *Subtropical Rainforest Restoration: A practical manual and data source for landcare groups, land managers and rainforest regenerators*. Big Scrub Rainforest Landcare Group, Bangalow NSW.

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*. Department of the Environment, Canberra. Available on the internet at: http://www.environment.gov.au/system/files/resources/773abcad-39a8-469f-8d97-23e359576db6/files/arrive-clean-leave-clean.pdf

DOE (Department of the Environment) (2019) *Pteropus poliocephalus* in Species Profile and Threats Database, Department of the Environment. Viewed on 15 February 2019. Available on the internet at: https://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=186

DOEE (Department of the Environment and Energy) (2016) *Feral Animals in Australia*, Department of the Environment and Energy, Canberra. Available on the internet at: http://www.environment.gov.au/biodiversity/invasive-species/feral-animals-australia

DOEE (2017a) *Littoral Rainforest and Coastal Vine Thickets of Eastern Australia Ecological Community Draft National Recovery Plan*. Department of the Environment and Energy, Canberra. Available on the internet at: http://www.environment.gov.au/biodiversity/threatened/recovery-plans/comment/draft-recovery-plan-littoral-rainforest

DOEE (Australian Government Department of the Environment and Energy) (2017b) *Guidelines for nominating and assessing the eligibility for listing of ecological communities as threatened according to the Environment Protection and Biodiversity Conservation Act 1999 and the EPBC Regulations 2000*. Threatened Species Scientific Committee. Available on the internet at: http://www.environment.gov.au/system/files/pages/d72dfd1a-f0d8-4699-8d43-5d95bbb02428/files/guidelines-ecological-communities.pdf

Doerr E. Doerr V, Davies M & McGinnes H (2010) Does Structural connectivity facilitate movement of native species in Australia's fragmented landscapes?: a systematic review protocol. *Environmental Evidence* 3, 9.

Dowdy A et al. (2015) *East Coast Cluster Report, Climate Change in Australia Projections for Australia's Natural Resource Management Regions: Cluster Reports*, M Ekström et al. (eds), CSIRO and Bureau of Meteorology, Australia.

Dunstan CE & Fox BJ (1996) The Effects of Fragmentation and Disturbance of Rainforest on Ground-Dwelling Mammals on the Robertson Plateau, New South Wales, *Australia. Journal of Biography* 23, 3, 187–201.

Eco Logical Australia (2007) *Shellharbour Kiama Regional Hard-rock Resource Review: Flora and Fauna Assessment*. Report prepared for Department of Planning by Eco Logical Australia Pty Ltd.

Eby P (1995) *The biology and management of flying foxes in New South Wales*. NSW National Parks and Wildlife Service.

Finn HC and Stephens (2017) *The invisible harm: land clearing is an issue of animal welfare. Wildlife Research* 44, 5, 377–391. Available on the internet at: https://www.publish.csiro.au/WR/WR17018

Fleming P, Anderson H, Prendergast A, Bretz M, Valentine L & Hardy G (2014) Is the loss of Australian digging mammals contributing to a deterioration in ecosystem function? *Mammal Review* 44, 94–108.

Floyd AG (1990) *Australian rainforests in New South Wales* (2 Volumes). Surrey Beatty and Sons, Chipping Norton.

Fox BJ, Taylor JE, Fox MD & Williams C (1997) Vegetation changes across edges of rainforest remnants. *Biological Conservation* 82, 1–13.

Gibbons P & Lindenmayer D (2002) *Tree Hollows and Wildlife Conservation in Australia*. CSIRO, Melbourne.

Hopkins MS, Kikkawa J, Graham AW, Tracey JG and Webb LJ (1976). Towards a solution: an ecological basis for the management of rainforest, in R Monroe and NC Stevens (eds), *The Border Ranges: A land use conflict in regional perspective*. The Royal Society of Queensland, St Lucia, 57–66.

Hunter RJ (1998) Fragmentation – the consequences, in Stephanie Horton (ed), *Rainforest remnants: a decade of growth. Proceedings of a conference on rainforest remnants and regeneration at Southern Cross University Conference Centre, 21–23 November 1998*. NSW National Parks and Wildlife Service, Hurstville NSW.

Illawarra Councils (2010) *Illawarra Biodiversity Strategy (Draft) Appendix 2 Weeds*. Wollongong City Council, Shellharbour City Council, Kiama Municipal Council. Available at: www.wollongong.nsw.gov.au/council/haveyoursay/Pages/IllawarraBiodiversityStrategy.aspx

Invasive Species Council (2011) *Fact Sheet: Environmental impacts of myrtle rust*. Available on the internet at: http://invasives.org.au/files/2014/02/fs_myrtle_rust.pdf

Kanowski J, Kooyman RM, Catteral CP (2009) Dynamics and Restoration of Australian Tropical and Subtropical Rainforests, in RJH & KN Suding (ed), *New Models for Ecosystem Dynamics and Restoration*. Island Press, Washington DC. pp. 206–220. Available on the internet at: https://www.researchgate.net/profile/Robert_Kooyman/publication/40854956_Dynamics_and_restoration_of_Australian_tropical_and_subtropical_rainforests/links/56cf74c208ae059e3759742e/Dynamics-and-restoration-of-Australian-tropical-and-subtropical-rainforests.pdf?origin=publication_detail

Keith DA (2004) *Ocean shores to desert dunes: the native vegetation of New South Wales and the ACT*. NSW Department of Environment and Conservation, Sydney.

Laurance WF (1991) Edge effects in tropical forest fragments: application of a model for the design of nature reserves. *Biological conservation* 57, 2, 205–219. Available on the internet at: https://www.academia.edu/34122754/Edge_effects_in_tropical_forest_fragments_Application_of_a_model_for_the_design_of_nature_reserves.

Law B, Eby P & Somerville D (2002) Tree-planting to conserve flying-foxes and reduce orchard damage, in P Eby & D Lunney (eds), *Managing the Grey-headed Flying fox as a Threatened Species in New South Wales*. Royal Zoological Society of NSW. pp. 84–90.

Makinson RO (2018) *Myrtle Rust reviewed: the impacts of the invasive pathogen Austropuccinia psidii on the Australian environment*. Plant Biosecurity Cooperative Research Centre, Canberra.

Martin L & McIlwee A (2002) The reproductive biology and intrinsic capacity for increase of the Grey-headed Flying-fox *Petropus poliocephalus* (Megachiroptera), and the implications of culling, in P Eby & D Lunney (eds), *Managing the Grey-headed Flying fox as a Threatened Species in New South Wales*. Royal Zoological Society of NSW. pp. 91–108.

Mills K (1984) Rainforest birds of the Shoalhaven Gorge, NSW. *Australian Birds* 18, 4, 76–79.

Mills K (1988) Clearing of the Illawarra rainforest: problems in reconstructing pre-European vegetation patterns. *Australian Geographer* 19, 2, 230–240.

Mills K (1989) Rainforest plants in Southern NSW and their Southern limits of distribution. Illawarra Vegetation Studies Paper No. 2

Mills K (2010) *A study of the rainforest vegetation around Toorooroo Plateau, Shoalhaven Region, Southern New South Wales, Illawarra Vegetation Studies (19).* Coachwood Publishing, Jamberoo, NSW, July.

Mills K & Jakeman J (1995) *Rainforests of the Illawarra District*. Coachwood Publishing, Jamberoo.

Moran C, Catterall CP, Green RJ and Olsen MF (2004) Functional variation among frugivorous birds: implications for rainforest seed dispersal in a fragmented subtropical landscape. *Oecologia* 141, 4, 584-595.

Murphy H (2008) *Habitat management guide—Rainforests: Ecological principles for the strategic management of weeds in rainforest habitats*. CRC for Australian Weed Management, Adelaide. Available on the internet at: https://archive.dpi.nsw.gov.au/__data/assets/pdf_file/0009/319446/rainforests-habitat_management_guide.pdf.

National Committee on Soil and Terrain (2009) *Australian Soil and Land Survey Field Handbook*. Third Edition. CSIRO Publishing. Available on the internet at: https://www.publish.csiro.au/books/series/44

Neilan W, Catterall CP, Kanowski J and McKenna S (2006) Do frugivorous birds assist rainforest succession in weed dominated oldfield regrowth of sub-tropical Australia? *Biological Conservation* 129, 393–407.

NSW DECC (Department of Environment and Climate Change) (2007) *Adaptation Strategy for Climate Change Impacts on Biodiversity. Actions to implement the National Biodiversity and Climate Change Action Plan and the NSW Biodiversity and Climate Change and Adaptation Framework.* NSW DECC, Sydney, NSW.

NSW DECCW (Department of Environment, Climate Change and Water) (2011a) *The Vertebrate Fauna of Royal & Heathcote National Parks and Garrawarra State Conservation Area*. NSW DECCW Hurstville. Available on the internet at: https://www.environment.nsw.gov.au/surveys/RoyalHeathcoteGarawarraFauna.htm https://www.environment.nsw.gov.au/resources/nature/surveys/20110249RoyalHeathcoteFauna.pdf

NSW DECCW (2011b) *Strategy for the Conservation and Management of Biodiversity in the Dunmore – Shellharbour Hills Area*. Government of NSW. Available on the internet at: www.environment.nsw.gov.au/resources/threatenedspecies/0172conservationstrategy.pdf

NSW DECCW (2011c) *The Vertebrate Fauna of Royal & Heathcote National Parks and Garawarra State Conservation Area*. Department of Environment, Climate Change and Water NSW, Hurstville.

NSW DPI (Department of Primary Industries) (2018). *NSW Weed Wise profile: Madeira vine (Anredera cordifolia)*, reviewed 2018. Available on the internet at: https://weeds.dpi.nsw.gov.au/Weeds/MadeiraVine

NSW Government (2015) *Illawarra–Shoalhaven Regional Plan*. NSW Planning and Environment. Available on the internet at: https://www.planning.nsw.gov.au/-/media/Files/DPE/Plans-and-policies/illawarra-shoalhaven-regional-plan-2015-11.pdf

NSW NPWS (National Parks and Wildlife Service) (2002a) *Wollongong Local Government Area Bioregional Assessment Study Part I: Native Vegetation of the Illawarra Escarpment and Coastal Plain*. NSW National Parks and Wildlife Service, Hurstville.

NSW NPWS (2002b) *Wollongong Local Government Area Bioregional Assessment Study Part II. Fauna of the Illawarra Escarpment, Coastal Plain and Plateau*. NSW National Parks and Wildlife Service, Hurstville.

NSW NPWS (2018) *Illawarra Escarpment State Conservation Area, Plan of Management*. State of NSW and the Office of Environment and Heritage.

NSW OEH (Office of Environment and Heritage) (undated). *Species profiles: Parma Wallaby, Sooty Owl.* Available on the internet at: www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10501 www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10821

NSW OEH (2014) *Illawarra climate change snapshot*. New South Wales Office of Environment and Heritage. Available on the internet at: https://climatechange.environment.nsw.gov.au/Climate-projections-for-NSW/Climate-projections-for-your-region/Illawarra-Climate-Change-Downloads

NSW OEH (2017) *Illawarra Subtropical Rainforest in the Sydney Basin Bioregion – profile*. Updated 7 September 2017. Available on the internet at: https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10427

NSW OEH (2019a) *Saving our Species strategies: Illawarra Subtropical Rainforest in the Sydney Basin Bioregion*. Viewed: 5 February 2019. Available on the internet at:

https://www.environment.nsw.gov.au/savingourspeciesapp/Project.aspx?ProfileID=10427

NSW OEH (2019b) *Saving our Species strategies: Milton Ulladulla Subtropical Rainforest in the Sydney Basin Bioregion*. Viewed: 5 February 2019. Available on the internet at: https://www.environment.nsw.gov.au/savingourspeciesapp/project.aspx?ProfileID=10532

NSW OEH (2019c) *Milton Ulladulla Subtropical Rainforest in the Sydney Basin Bioregion – profile*. Updated 9 January 2019. Available on the internet at: https://www.environment.nsw.gov.au/savingourspeciesapp/project.aspx?ProfileID=10532

NSW Scientific Committee (2002a) *Illawarra subtropical rainforest in the Sydney Basin Bioregion – endangered ecological community listing – Final determination*. Available on the internet at: https://www.environment.nsw.gov.au/determinations/IllawarraSubtropicalRainforestSydneyBasinEndComListing.htm

NSW Scientific Committee (2002b) *Milton Ulladulla subtropical rainforest in the Sydney Basin Bioregion – endangered ecological community listing – Final determination*. Available on the internet at: https://www.environment.nsw.gov.au/determinations/MiltonUlladullaSubtropicalRainforestSydneyEndComListing.htm

Peel B (2010) *Rainforest restoration manual for South-Eastern Australia*. CSIRO Publishing, Canberra.

PlantNET (The NSW Plant Information Network System). *Royal Botanic Gardens and Domain Trust*, Sydney. Viewed December 2018. Available on the internet at: http://plantnet.rbgsyd.nsw.gov.au

Ranney JW, Bruner MC & Levenson JB (1981) The importance of edge in the structure and dynamics of forest stands, in RL Burgess & DM Sharpe (eds) *Forest island dynamics m man-dominated landscapes*. Springer Verlag, New York, pp. 67–95.

Richardson DM, Pyšek P, Rejmanek M, Barbour MG, Panetta FD & West CJ (2000) Naturalization and invasion of alien plants: concepts and definitions. *Diversity and Distributions*, 6, 93–107https://www.jstor.org/stable/2673320?seq=1#metadata_info_tab_contents

SCC (Shoalhaven City Council) (undated) *The Bundewallah Sub-Tropical Rainforest Regeneration Project Fact Sheet.* Shoalhaven City Council, Shoalhaven Bushcare, Berry Landcare, New South Wales Environmental Trust and New South Wales Government. Available on the internet at: http://doc.shoalhaven.nsw.gov.au/Displaydoc.aspx?Record=d16/254883

SERA (Society for Ecological Restoration Australasia) (2017*) National Standards for the Practice of Ecological Restoration in Australia*. Second Edition. Society for Ecological Restoration Australia. Available on the internet at: http://www.seraustralasia.com/standards/home.html

Setter MJ and Vitelli JS (2003) Managing weeds relevant to Australian rainforests and associated ecosystems, in AC Grice and MJ Setter (eds), *Weeds of Rainforests and*

Associated Ecosystems. Cooperative Research Centre for Tropical Rainforest Ecology and Management, Cairns, Australia, pp. 19–23.

Sheppard AW, Catford JA, Daehler CC, Hardesty D, Murphy HT, Pergl J, Rejmanek M, Westcott DA & Bellingham PJ (2010) Are transformer weeds ecological rule breakers?, in SM Zydenbos (ed), *17th Australasian weeds conference. New frontiers in New Zealand: together we can beat the weeds*. Christchurch, New Zealand. pp. 158–161.

South East Local Land Services (2018) *South East Regional Strategic Pest Animal Plan 2018–2023*. State of New South Wales through Local Land Services.

Stanisic J, Shea M, Potter D & Griffiths O (2010) *Australian Land Snails Volume 1: A field Guide to eastern Australian species*. Bioculture Press, Mauritius.

Stern H, de Hoedt G & Ernst J (2000) Objective classification of Australian climates. *Australian Meteorological Magazine* 49, 87–96.

Tozer M, Turner K, Keith D, Tindall D, Pennay C, Simpson C, MacKenzie B, Beukers P & Cox S (2010) Native vegetation of southeast NSW: a revised classification and map for the coast and eastern tablelands. *Cunninghamia* 11, 3, 359–406.

TSSC (Threatened Species Scientific Committee) (2011) *Commonwealth Listing Advice on Lowland Rainforest of Subtropical Australia*. Department of Sustainability, Environment, Water, Population and Communities. Canberra, ACT. Available on the internet at: http://www.environment.gov.au/biodiversity/threatened/communities/pubs/101-listing-advice.pdf

Webb LJ (1968) Environmental relationships of the structural types of Australian rainforest vegetation. *Ecology* 49, 2, 296–311.

Wilcove D S, McLellan CH & Dobson AP (1986) Habitat fragmentation in the temperate zone, in ME Soulé (ed), *Conservation biology: the science of scarcity and diversity*. Sinauer Assoc., Inc. Sunderland, MA. pp. 237–256.

Wollongong City Council (2015) *Illawarra escarpment strategic management plan 2015*. Wollongong City Council, Wollongong. Available on the internet at: http://www.wollongong.nsw.gov.au/council/meetings/BusinessPapers/Illawarra%20Escarpment%20Strategic%20Management%20Plan%202015.pdf

APPENDIX A: SPECIES LISTS

Table A1: Flora of the Illawarra–Shoalhaven subtropical rainforest.

Diagnostic native plant species based on Final Determination lists of characteristic species for the two related NSW-listed subtropical rainforest ecological communities (NSW Scientific Committee 2002a; 2002b), in addition to other native plant species occurring in greater than 10% of sample plots across the range of the Illawarra–Shoalhaven subtropical rainforest ecological community (analysis of NSW Plant Community Type plot data most related to the ecological community, 2019 unpublished). 10% frequency was considered an appropriate threshold to identify key species of the ecological community, given the list encompasses sites with moisture gradients from drier lowland sites, to more moist sites on the escarpment, and the north-south gradient/range. This table is referred to in Section 3.2 Step 2 – Determine patch condition.

Note:

- Patches may not include all species on the list, or may include other species not listed. At any one time, above-ground individuals of some species may be absent, but the species may be represented below ground in soil seed banks or as dormant structures such as bulbs, corms, rhizomes, rootstocks or lignotubers.
- The table is ordered by scientific name. Scientific names below reflect updated nationally accepted species' taxonomy as at April 2019.
- 'Broad growth form category' – as specified in the NSW Biodiversity Assessment Methodology (as at March 2019).

Broad growth form category	Common name	Family Name	Scientific name	*Listed in NSW Milton–Ulladulla TEC	#Listed in NSW Illawarra TEC
Shrub	Straggly Lantern-bush, Lantern Bush	Malvaceae	*Abutilon oxycarpum*		
Tree	Maiden's Wattle	Mimosoideae	*Acacia maidenii*		
Tree	Blackwood	Mimosoideae	*Acacia melanoxylon*		
			Acmena smithii – see *Syzygium smithii*, below		
Shrub to Tree	White Aspen, Yellow Wood	Rutaceae	*Acronychia oblongifolia*		
Fern	Common Maidenhair	Pteridaceae	*Adiantum aethiopicum*		
Fern	Black Stem, Black Stem Maidenhair, Giant Maidenhair	Pteridaceae	*Adiantum formosum*		Yes
Fern	Rough Maidenhair Fern	Pteridaceae	*Adiantum hispidulum*		

Broad growth form category	Common name	Family Name	Scientific name	*Listed in NSW Milton–Ulladulla TEC	#Listed in NSW Illawarra TEC
Shrub	Native Quince, Wild Quince, Bird's Eye	Sapindaceae	*Alectryon subcinereus*	Yes	Yes
Tree	Red Ash	Rhamnaceae	*Alphitonia excelsa*		Yes
Forb	–	Commelinaceae	*Aneilema acuminatum*		
Other	Gum Vine	Aphanopetalaceae	*Aphanopetalum resinosum*	Yes	
Fern	–	Tectariaceae	*Arthropteris tenella*	Yes	
Fern	Bird's Nest Fern	Aspleniaceae	*Asplenium australasicum*		
Fern	Necklace fern	Aspleniaceae	*Asplenium flabellifolium*	Yes	
Shrub	Grey Myrtle, Ironwood	Myrtaceae	*Backhousia myrtifolia*		
Tree	Brush Bloodwood, Ivory Birch, Scrub Bloodwood	Euphorbiaceae	*Baloghia inophylla*	Yes	Yes
Fern	Prickly Rasp Fern	Blechnaceae	*Blechnum neohollandicum*	Yes	Yes
Tree	Flame Tree, Illawarra Flame Tree	Malvaceae	*Brachychiton acerifolius*		Yes
Shrub	Coffee Bush	Phyllanthaceae	*Breynia oblongifolia*	Yes	
Shrub	Willow Bottlebrush	Myrtaceae	*Callistemon salignus*		
Grass & grasslike	Staff Climber	Cyperaceae	*Carex longebrachiata*		
Other	Native Grape	Vitaceae	*Cayratia clematidea*		Yes
Other	Staff Climber	Celastraceae	*Celastrus australis*		Yes
Other	Kangaroo Vine, Water Vine	Vitaceae	*Cissus antarctica*	Yes	Yes
Other	Water Vine	Vitaceae	*Cissus hypoglauca*	Yes	
Shrub	Brittlewood	Euphorbiaceae	*Claoxylon australe*	Yes	
Tree	Hairy Clerodendrum, Downy Chance Tree	Lamiaceae	*Clerodendrum tomentosum*		
Forb	–	Commelinaceae	*Commelina cyanea*		
Shrub	Green Native Cascarilla	Euphorbiaceae	*Croton verreauxii*		

Broad growth form category	Common name	Family Name	Scientific name	*Listed in NSW Milton–Ulladulla TEC	#Listed in NSW Illawarra TEC
Tree	Jackwood	Lauraceae	*Cryptocarya glaucescens*		
Tree	Murrogun	Lauraceae	*Cryptocarya microneura*		
Grass & grasslike	–	Cyperaceae	*Cyperus tetraphyllus*		
Tree	Giant Stinging Tree	Urticaceae	*Dendrocnide excelsa*	Yes	Yes
Forb	Kindey Weed, Yilibili (D'harawal)	Convolvulaceae	*Dichondra repens*		
Shrub	Black Plum, Yellow Persimmon, Grey Plum	Ebenaceae	*Diospyros australis*	Yes	
Tree	Myrtle Ebony, Grey Persimmon, Black Myrtle, Grey Plum	Ebenaceae	*Diospyros pentamera*		Yes
Tree	Native Tamarind	Sapindaceae	*Diploglottis australis*		Yes
Tree	Sassafras	Atherospermataceae	*Doryphora sassafras*		
Tree	Koda, Silky Ash, Churnwood	Boraginaceae	*Ehretia acuminata* var. *acuminata*		Yes
Shrub	Red Olive Berry	Celastraceae	*Elaeodendron australe*	Yes	Yes
Tree	White-topped Box, Coast White Box	Myrtaceae	*Eucalyptus quadrangulata*		
Tree	Forest Red Gum, Buringoa (D'harawal)	Myrtaceae	*Eucalyptus tereticornis*		
Shrub	Bolwarra, Copper Laurel	Eupomatiaceae	*Eupomatia laurina*		
Other	Wombat Berry	Luzuriagaceae	*Eustrephus latifolius*	Yes	
Shrub; Tree	Figs	Moraceae	*Ficus spp.* (e.g. *Ficus coronata*, *Ficus macrophylla*, *Ficus obliqua*; but may include other *Ficus* species) **Note: If more than one *Ficus* spp. is present, each one counts towards the diversity threshold in the Condition Thesholds.**	Yes	Yes
Other	Scrambling Lily	Luzuriagaceae	*Geitonoplesium cymosum*	Yes	
Tree	Guioa	Sapindaceae	*Guioa semiglauca*		Yes
Forb	Settlers Twine/Flax, Boorgay	Araceae	*Gymnostachys anceps*	Yes	

Broad growth form category	Common name	Family Name	Scientific name	*Listed in NSW Milton–Ulladulla TEC	#Listed in NSW Illawarra TEC
Other	Sweet Morinda	Rubiaceae	*Gynochthodes jasminoides*		
Shrub	Native Rosella	Malvaceae	*Hibiscus heterophyllus* subsp. *heterophyllus*		Yes
Fern	Trim Shield-fern, Trim Shield Fern	Dryopteridaceae	*Lastreopsis decomposita*		
Fern	Creeping Shield Fern	Dryopteridaceae	*Lastreopsis microsora* subsp. *microsora*		
Other	Round-leaf Vine	Menispermaceae	*Legnephora moorei*	Yes	Yes
Other	Cabbage Fan Palm, Cabbage Tree Palm, Daranggara (Cadigal), Cabbage Palm, Fan Palm	Arecaceae	*Livistona australis*		
Other	Cockspur Thorn	Moraceae	*Maclura cochinchinensis*		Yes
Other	Hairy Milk Vine	Apocynaceae	*Marsdenia flavescens*		
Other	Milk Vine	Apocynaceae	*Marsdenia rostrata*	Yes	
Shrub	Prickly-leaved Tea Tree	Myrtaceae	*Melaleuca styphelioides*		
Shrub	Hairy-leaved Doughwood, White Euodia	Rutaceae	*Melicope micrococca*		
Shrub	Tree Violet	Violaceae	*Melicytus dentatus*		
Fern	Fragrant Fern	Polypodiaceae	*Microsorum scandens*		
Shrub	Brush Muttonwood	Primulaceae	*Myrsine howittiana*		
Shrub		Primulaceae	*Myrsine variabilis*		
Shrub	Large Mock-olive, Large-leaved Olive	Oleaceae	*Notelaea venosa*	Yes	
Grass & grasslike	Australian Basket Grass, Wavy Beard Grass	Poaceae	*Oplismenus aemulus*	Yes	
Grass & grasslike	Creeping Beard Grass	Poaceae	*Oplismenus imbecillis*		
Other	Wonga Wonga Vine	Bignoniaceae	*Pandorea pandorana* subsp. *pandorana*	Yes	
Other	Common Silkpod, Monkey Rope	Apocynaceae	*Parsonsia straminea*		
Fern	Sickle Fern	Pteridaceae	*Pellaea falcata*	Yes	
Tree	Brown Beech	Pennantiaceae	*Pennantia cunninghamii*		Yes
Other	Giant Pepper Vine	Piperaceae	*Piper hederaceum* var. *hederaceum*		Yes
Shrub	Orange Thorn	Pittosporaceae	*Pittosporum multiflorum*	Yes	Yes

Broad growth form category	Common name	Family Name	Scientific name	*Listed in NSW Milton–Ulladulla TEC	#Listed in NSW Illawarra TEC
Shrub	Wild Yellow Jasmine, Rough fruit Pittosporum	Pittosporaceae	*Pittosporum revolutum*		
Shrub	Native Daphne, Sweet Pittosporum, Snowdrop Tree (L.H.I.), Mock Orange	Pittosporaceae	*Pittosporum undulatum*	Yes	
Tree	Black Apple, Wild Plum, Yellow Buttonwood, Black Plum, Yellow Bulletwood	Sapotaceae	*Planchonella australis*		Yes
Forb	Cockspur Flower	Lamiaceae	*Plectranthus parviflorus*	Yes	
Grass & grasslike	Tussock	Poaceae	*Poa labillardierei* var. *labillardierei*		
Tree	Plum Pine, Brown Pine	Podocarpaceae	*Podocarpus elatus*		Yes
Forb	Pastel Flower	Acanthaceae	*Pseuderanthemum variabile*		
Fern	Jungle Brake	Pteridaceae	*Pteris umbrosa*		
Fern	Rock Felt Fern	Polypodiaceae	*Pyrrosia rupestris*		
Shrub	Scrub Turpentine, Brown Malletwood	Myrtaceae	*Rhodamnia rubescens*		
Shrub	Big Yellow Wood, Yellow Wood	Rutaceae	*Sarcomelicope simplicifolia* subsp. *simplicifolia*		
Other	Pearl Vine	Menispermaceae	*Sarcopetalum harveyanum*	Yes	
Tree	Flintwood, Mountain Cherry, Brown Birch, Scolopia	Salicaceae	*Scolopia braunii*		Yes
Other	Lawyer Vine, Wait-a-while, Barbwire Vine	Smilacaceae	*Smilax australis*	Yes	
Forb		Caryophyllaceae	*Stellaria flaccida*		
Shrub	Scrub Beefwood, Red Silky Oak	Proteaceae	*Stenocarpus salignus*		
Other	Snake Vine	Menispermaceae	*Stephania japonica*	Yes	
Tree	Whalebone Tree	Moraceae	*Streblus brunonianus*	Yes	Yes
Shrub	Brush Cherry	Myrtaceae	*Syzygium australe*	Yes	
Tree	Lilly Pilly, Midjuburi (Cadigal)	Myrtaceae	*Syzygium smithii* (syn. *Acmena smithii*)	Yes	
Tree	Red Cedar, Santhana Vembu	Meliaceae	*Toona ciliata*	Yes	Yes

Broad growth form category	Common name	Family Name	Scientific name	*Listed in NSW Milton–Ulladulla TEC	#Listed in NSW Illawarra TEC
Other	Burny Vine	Moraceae	*Trophis scandens*	Yes	Yes
Other	Bearded Tylophora	Apocynaceae	*Tylophora barbata*		
Forb	Stinging Nettle	Urticaceae	*Urtica incisa*		
Shrub	Veiny Wilkiea	Monimiaceae	*Wilkiea huegeliana*		Yes

* Milton–Ulladulla Subtropical Rainforest Final Determination (NSW Scientific Committee 2002b)

Listed in NSW Illawarra Subtropical Rainforest Final Determination (NSW Scientific Committee 2002a)

Table A2: Fauna of the Illawarra–Shoalhaven subtropical rainforest – Birds.

Common Name – Birds	Scientific Name
'Specialist' subtropical rainforest birds of the ecological community: Source: Illawarra Birders (analysis of bird survey data, unpublished 2019)	
Australian Brush Turkey	*Alectura lathami*
Bassian Thrush	*Zoothera lunulata*
Black-faced Monarch	*Monarcha melanopis*
Brown Cuckoo-dove	*Macropygia phasianella*
Cicadabird	*Coracina tenuirostris*
Green Catbird	*Ailuroedus crassirostris*
Logrunner	*Orthonyx temminckii*
Noisy Pitta	*Pitta versicolor*
Pacific Emerald-dove	*Chalcophaps longirostris*
Pilotbird	*Pycnoptilus floccosus*
Pink Robin	*Petroica rodinogaster*
Sooty Owl	*Tyto tenebricosa*
Superb Fruit-dove	*Ptilinopus superbus*
Superb Lyrebird	*Menura novaehollandiae*
Topknot Pigeon	*Lopholaimus antarcticus*
White-headed Pigeon	*Columba leucomela*
Wonga Pigeon	*Leucosarcia melanoleuca*
Yellow-throated Scrubwren	*Sericornis citreogularis*
Native birds of the ecological community: Source: Mills & Jakeman (1995); NSW NPWS (2002b); NSW DECCW (2011a); Illawarra Birders (analysis of bird survey data, unpublished 2019).	
Australasian Figbird	*Sphecotheres vieilloti*
Australian Brush Turkey	*Alectura lathami*
Australian King Parrot	*Alisteris scapulatis*
Australian Magpie	*Gymnorhina tibicen*
Australian Raven	*Corvus coronoides*
Barred Cuckoo-shrike	*Coracina lineata*
Bar-shouldered Dove	*Geopelia humeralis*

Common Name – Birds	Scientific Name
Bassian Thrush	*Zoothera lunulata*
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*
Black-faced Monarch	*Monarcha melanopsis*
Brown Cuckoo-dove	*Macropygia amboinensis*
Brown Gerygone	*Gerygone mouki*
Brown Thornbill	*Acanthiza pusilla*
Brush Cuckoo	*Cacomantis variolosus*
Channel-billed Cuckoo	*Scythrops novaehollandiae*
Crested Shrike-tit	*Falcunculus frontatus*
Crimson Rosella	*Platycercus elegans*
Eastern Spinebill	*Acanthorhynchus tenuirostris*
Eastern Rosella	*Platycercus adscitus*
Eastern Whipbird	*Psophodes olivaceus*
Eastern Yellow Robin	*Eopsaltria australis*
Emerald Dove	*Chalcophaps indica*
Fan-tailed Cuckoo	*Cacomantis flabelliformis*
Galah	*Eolophus roseicapilla*
Golden Whistler	*Pachycephala pectoralis*
Green Catbird	*Ailuroedus crassirostris*
Grey Butcherbird	*Cracticus torquatus*
Grey Fantail	*Rhipidura albiscapa*
Grey Goshawk	*Accipiter novaehollandiae*
Grey Shrikethrush	*Colluricincla harmonica*
Large-billed Scrubwren	*Sericornis magnirostra*
Lewin's Honeyeater	*Meliphaga lewinii*
Little Wattlebird	*Anthochaera chrysoptera*
Logrunner	*Orthonyx temminckii*
Long-tailed Cuckoo, Long-tailed Koel	*Urodynamis taitensis*
Masked Owl	*Tyto novaehollandiae*
Mistletoe Bird	*Dicaeum hirundinaceum*

Common Name – Birds	Scientific Name
Noisy Friarbird	*Philemon corniculatus*
Noisy Pitta	*Pitta versicolor*
Olive-backed Oriole	*Oriolus sagittatus*
Olive Whistler	*Pachycephala olivacea*
Pale-yellow Robin	*Tregellasia capito*
Pied Currawong	*Strepera graculina*
Pink Robin	*Petroica rodinogaster*
Pilotbird	*Pycnoptilus floccosus*
Powerful Owl	*Ninox strenua*
Rainbow Lorikeet	*Trichoglossus haematodus*
Red-browed Treecreeper	*Climacteris erythrops*
Red-browed Finch, Red-browed Firetail	*Neochmia temporalis*
Regent Bowerbird	*Sericulus chrysocephalus*
Rose Robin	*Petroica rosea*
Rose-crowned Fruit-dove	*Ptilinopus regina*
Rufous Fantail	*Rhipidura rufifrons*
Satin Bowerbird	*Ptilonorhynchus violaceus*
Scaly-breasted Lorikeet	*Trichoglossus chlorolepidotus*
Shining Bronze-cuckoo	*Chalcites lucidus*
Silvereye	*Zosterops lateralis*
Sooty Owl	*Tyto tenebricosa*
Southern Boobook	*Ninox novaeseelandiae*
Spotted Pardalote	*Pardalotus punctatus*
Spangled Drongo	*Dicrurus bracteatus*
Spectacled Monarch	*Symposiachrus trivirgatus*
Sulphur-crested Cockatoo	*Cacuata galerita*
Superb Fruit-dove	*Ptilinopus superbus*
Superb Lyrebird	*Menura novaehollandiae*
Tawny Frogmouth	*Podargus strigoides*
Topknot Pigeon	*Lopholaimus antarcticus*

Common Name – Birds	Scientific Name
White-browed Scrubwren	*Sericornis frontalis*
White-headed Pigeon	*Columba leucomela*
White-naped Honeyeater	*Melithreptus lunatus*
White-throated Treecreeper	*Cormobates leucophaea*
Wompoo Fruit-dove	*Ptilinopus magnificus*
Wonga Pigeon	*Leucosarcia melanoleuca*
Yellow-faced Honeyeater	*Caligavis chrysops*
Yellow-tailed Black-cockatoo	*Calyptorhyncus funereus*
Yellow-throated Scrubwren	*Sericornis citreogularis*

Table A3: Fauna of the Illawarra–Shoalhaven subtropical rainforest – Mammals.

Common Name – Mammals	Scientific name
Brown Antechinus	*Antechinus stuartii*
Bush Rat	*Rattus fuscipes*
Chocolate-wattled Bat	*Chalinolobus morio*
Common Brushtail Possum	*Trichosurus vulpecula*
Common Ringtail Possum	*Pseudocheirus peregrinus*
Common Wombat, Bare-nosed Wombat	*Vombatus ursinus*
Dusky Antechinus	*Antechinus swainsonii*
Eastern Bentwing-bat	*Miniopterus orianae oceanensis*
Eastern Horseshoe bat	*Rhinolophus megaphyllus*
Eastern Pygmy-possum	*Cercartetus nanus*
Eastern Quoll[31]	*Dasyurus viverrinus**
Fawn-footed Melomys	*Melomys cervinipes*
Feathertail Glider	*Acrobates pygmaeus*
Golden-tipped Bat	*Phoniscus papuensis*
Gould's Longeared Bat	*Nyctophilus gouldi*
Gould's Wattled Bat	*Chalinolobus gouldii*
Grey-headed Flying-fox	*Pteropus poliocephalus*
Large-eared Pied Bat	*Chalinolobus dwyeri*
Large-footed Myotis	*Myotis macropus*
Lesser Longeared Bat	*Nyctophilus geoffroyi*

[31] No verified sightings of live animals have occurred in NSW since 1963 (NSW Office of Environment and Heritage, Threatened Species Profile, 18 January 2019).

Common Name – Mammals	Scientific name
Little Bentwing-bat	*Miniopterus australis*
Little Forest Bat	*Vespadelus vulturnus*
Long-nosed Bandicoot	*Perameles nasuta*
Long-nosed Potoroo	*Potorous tridactylus*
Mountain Brushtail Possum	*Trichosurus caninus*
Little Red Flying-fox	*Pteropus scapulatus*
Parma Wallaby[32]	*Macropus parma*
Platypus	*Ornithorhynchus anatinus*
Red-necked Pademelon[33]	*Thylogale thetis*
Short-beaked Echidna	*Tachyglossus aculeatus*
Spotted-tailed Quoll	*Dasyurus maculatus*
Sugar Glider	*Petaurus breviceps*
Swamp Wallaby	*Wallabia bicolor*
Yellow-bellied Sheathtail-bat	*Saccolaimus flaviventris*

Source: NSW NPWS (2002b); Mills & Jakeman (1995); NSW DECCW (2011a).

[32] This species is now thought extinct in the Illawarra–Shoalhaven region.
[33] This species has not been seen in the Illawarra–Shoalhaven region since the 1890s.

Table A4: Fauna of the Illawarra–Shoalhaven subtropical rainforest – Amphibians.

Common Name – Amphibians	Scientific name
Blue Mountains Tree Frog	*Litoria citropa*
Brown Toadlet	*Pseudophryne bibronii*
Common Eastern Froglet	*Crinia signifera*
Great Barred Frog	*Mixophyes fasciolatus*
Haswell's Froglet	*Paracrinia haswelli*
Fleay's Barred Frog	*Mixophyes fleayi*
Freycinet's Frog	*Litoria freycineti*
Green and Golden Bell Frog	*Litoria aurea*
Green Tree-frog	*Litoria caerulea*
Jervis Bay Tree-frog	*Litoria jervisiensis*
Leaf-green Tree-frog	*Litoria phyllochroa*
Leaf Green River Tree-frog	*Litoria nudidigita*
Lesueur's Frog	*Litoria lesueuri*
Peron's (green) Tree-frog	*Litoria peronii*
Striped Marsh-frog (Brown-striped Frog)	*Limnodynastes peronii*
Verreaux's Tree-frog	*Litoria verreauxii*

Source: NSW NPWS (2002b); Mills & Jakeman (1995).

Table A5: Fauna of the Illawarra–Shoalhaven subtropical rainforest – Reptiles.

Common Name - Reptiles	Scientific name
(Eastern) Bandy-bandy	*Vermicella annulata*
Common / Eastern Blue-tongue Lizard	*Tiliqua scincoides*
Common / Southern Scaly-foot	*Pygopus lepidopodus*
Diamond Python	*Morelia spilota*
Eastern Water Dragon	*Intellagama lesueurii*
Eastern Water Skink	*Eulamprus quoyii*
Golden-crowned Snake	*Cacophis squamulosus*
Grass (/Dark-flecked Garden Sun-) Skink	*Lampropholis delicata*
(Pale-flecked) Garden (Sun-) Skink	*Lampropholis guichenoti*
Highlands Forest-skink	*Anepischetosia maccoyi*
Red-bellied Black Snake	*Pseudechis porphyriacus*
Rose's Shadeskink	*Saproscincus rosei*
(Eastern) Small-eyed Snake	*Rhinoplocephalus nigrescens*
(Yellow-bellied) Three-toed Skink	*Saiphos equalis*
(Eastern/mainland) Tiger Snake	*Notechis scutatus*
Weasel (Shade-) Skink	*Saproscincus mustelinus*

Source: NSW NPWS (2002b); Mills & Jakeman (1995).

Table A6: Fauna of the Illawarra–Shoalhaven subtropical rainforest – Invertebrates.

Common Name - Invertebrates	Scientific name
Anderson's Skipper	*Toxidia Andersoni*
Australian Admiral	*Vanessa itea*
Blue Triangle	*Graphium choredon*
Banks Brown	*Heteronympha banksii*
Common Australian Crow	*Euploea corinna*
Common Brown Ringlet	*Hypocysta metirius*
Common Grassblue	*Zizina otis labradus*
Common Jezebel	*Delias nigrina*
Common Red-eye	*Chaetocneme beata*
Dingy Shield Skipper	*Signeta tymbophora*
Dispar Skipper	*Dispar compacta*
Doubleday's Skipper	*Toxidia doubledayi*
Felder's Lineblue	*Prosotas felderi*
Hairy Lineblue	*Erysichton lineata*
Illawarra Bristle Snail	*Austrochloritis illawarra*
Illawarra Forest Snail	*Meridolum gulosum*
Macleay's Swallowtail	*Graphium macleayanum*
Pencilled Blue	*Candalides absimilis*
Orange Palmdart	*Cephrenes augiades*
Orchard Butterfly	*Papilio aegeus*
Red-triangle Slug	*Triboniophorus graeffei*
Spotted Brown	*Heteronympha paradelpha*
Symmomus Skipper	*Trapezites symmomus*
Wollongong Bristle Snail	*Austrochloritis metuenda*
Wonder Brown	*Heteronympha mirifica*
Yellow-banded Dart	*Ocybadistes walkeri*

Source: Mills and Jakeman (1995).

APPENDIX B: DESCRIPTION OF KEY THREATS

The key threats to the ecological community are described here. This helps explain why the Illawarra–Shoalhaven subtropical rainforest ecological community has been listed as threatened under national environment law. These threats often interact, rather than act independently, so together they have greater negative impacts on the ecological community. This threat information supports the detailed assessment against listing criteria, at Appendix C.

Clearance of native vegetation and impacts associated with fragmentation

Clearance may be total, i.e. removing entire remnants of the ecological community, or partial/ incremental tree removal or lopping, or the removal of native understorey vegetation (e.g. 'underscrubbing' for grazing). The consequences of land clearing include:

- loss of entire patches of the ecological community;
- death and suffering of native fauna (Finn & Stephens 2017);
- further fragmentation of what remains of the ecological community into smaller, more isolated patches;
- degradation, loss of habitat and reduced resources for native species;
- loss of gene pools; and,
- patches and populations becoming less resilient and more susceptible to other threats, impacts and further degradation.

In many parts throughout its range there was often continuous, dense cover of the ecological community. For example, this occurred in the 'Illawarra Brush', including areas such as the Jamberoo Valley and surrounds, and Saddleback Mountain; the 'Berkeley Brush', including the Berkeley Hills (Mills 1988; Mills & Jakeman 1995); and in the Milton region (NSW OEH 2019c). Remaining patches are now mostly restricted, either as remnants or regrowth from historical clearing, to locations less suitable for agriculture and timber harvesting, such as steep rocky gullies and outcrops of volcanic latite, or on roadsides (Mills & Jakeman 1995; NSW OEH 2019c). Where larger remnants still occur they are typically in deep ravines or on steep rocky slopes (Mills & Jakeman 1995).

Historically, clearing was mostly for forestry (including selective harvesting) and agriculture. Widespread land clearing and landscape modification in the Illawarra–Shoalhaven region since the late 18th century greatly reduced the area of native vegetation, including the extent of the ecological community. The ecological community provided one of the world's most prized cabinet timbers to early European settlers. *Toona ciliata* (Red Cedar) was in huge demand both in Australia and overseas and large areas of rainforest were cleared to provide wood (Mills & Jakeman 1995). Farming on the newly cleared land took over as the major land use in the 1880s. By the twentieth century, most rainforest had been cleared for agriculture (Keith 2004).

Rainforest trees are often long-lived and may respond slowly to fragmentation. Some species may be functionally extinct in remnants before they have actually disappeared. Co-evolved pollinators or seed dispersers may have already disappeared.

Currently the ecological community is threatened with further loss and fragmentation of habitat, particularly as a consequence of continued clearing for agriculture, hard rock quarrying, hobby farming, and further residential development (NSW OEH 2017, 2019c). Clearance of the ecological community has also been noted in some areas for the purposes of utility maintenance and construction, such as powerlines and phone towers, and for private native hardwood logging. Further clearing is likely given increasing rates of coastal development, e.g. for urban and peri-urban growth and infrastructure projects.

Fragmentation and the creation of patches with long edges results in physical and biotic changes which have major impacts on the ecology of patches of this rainforest, affecting the structure and composition of the patches. The edges of a rainforest remnant are subject to physical effects which include elevated wind turbulence and incursion, lateral light penetration (NSW OEH 2017, 2019c), temperature variability, and reduced humidity (Hunter 1998). Edges are also the principal zone of interaction for impacts from grazing, increased run-off, eutrophication from fertilisers, weed invasion and a wide range of other indirect impacts to the ecological community, such as the dumping of garden waste and other rubbish (Fox et al. 1997; NSW OEH 2017, 2019c). These changes in the physical environment of the ecological community have consequences for its plants and animals. The species diversity of some generalist species increases near edges whereas some specialist rainforest species are generally uncommon near edges (Fox et al. 1997; Hunter 1998). Predation on nesting birds and seeds may increase near edges and in fragments due to an influx of generalist predators from the surrounding matrix which influence the success of regeneration within remnants. Increased windshear forces may cause an increase in the frequency of treefall gaps (Hunter 1998).

In addition, in most areas the ecological community previously adjoined or integrated with other native forests and woodlands (typically dominated by eucalypt species). In particular, the critically endangered Illawarra and South Coast Lowland forest and woodland, which has been cleared by as much as 90%. Clearance of surrounding native vegetation also threatens the Illawarra–Shoalhaven Subtropical Rainforest through fragmentation, loss of habitat diversity for component species, edge effects and other impacts from surrounding land use.

Reduced connectivity with other patches of the ecological community or other native vegetation within the landscape means that few individual patches are large enough on their own to provide sufficient species and genetic diversity to ensure long term survival, or fully represent the characteristics of the ecological community prior to European settlement. However, for many species there may be gene flow between remnants because of movement of pollinators and seed dispersers. Remnants may therefore contribute to the genetic connectivity of a larger metapopulation and act as stepping-stones (Hunter 1998). So the loss of individual patches impacts nearby patches and the ecological community overall.

The effects of fragmentation on vertebrate fauna are better understood than effects on other faunal groups. There is often a rapid loss of some fauna species and an increase in other species, particularly generalist species, following isolation. These ecological imbalances are likely to drive the loss of additional species in isolated patches. Thus, a rainforest remnant may pass quickly through a series of unstable transient states until it reaches a biologically simplified equilibrium (Hunter 1998). Fragmentation can affect invertebrate species

dramatically as they are short-lived and sensitive to fine-scale environmental variation (Hunter 1998).

Fragmentation increases the competition for resources such as food and shelter as these become more and more limited as remnants get smaller in size (Hunter 1998). Bird species that facilitate dispersal of a large volume and variety of plants, tend to be less abundant in fragmented forests (Moran et al. 2004). This suggests that dispersal of certain plant species is limited in fragmented rainforest patches (Moran et al. 2004; Neilan et al. 2006).

The deliberate removal of the understorey beneath the tree canopy (underscrubbing) to open areas up (e.g. to stock and/or enhance grazing, or to create lawns in per-urban areas), also causes changes to the structure, composition and function of the ecological community, including habitat values for fauna, and can replace the ground layer with exotic species.

Impacts from introduced species (weeds and feral animals)

Weeds are a significant threat to the long-term viability of the Illawarra–Shoalhaven subtropical rainforest ecological community. Replacement of native ecological specialists with widespread invasive species tends to homogenise otherwise diverse communities (Murphy 2008). Weeds also cause changes to the vegetation structure, fauna composition and hence ecosystem processes and function.

Weeds compete with native species in the ecological community for space, light, water and nutrients and suppress and out-compete midstorey and canopy trees. For example, many rainforest plants are capable of germinating in low light conditions and slowing their growth rate until a gap in the canopy appears and then growing rapidly to occupy the gap. As well as weeds impacting the edges of rainforest patches, or highly disturbed areas, it is increasingly recognised that rainforest weeds can occur in relatively intact rainforest habitat (Murphy 2008).

The threat is increasing, because weed species have become more widespread and because the ecological community now tends to occur as more isolated fragmented patches that are vulnerable to weed invasion from surrounding modified environments. The risk of weed infestation typically increases where patches of the ecological community are located near human habitation and/or are subject to disturbance. Peel (2010) found a positive correlation between proximity to human activity and weed invasion in rainforest sites, with the majority of weeds recorded having been incidentally introduced through human activities such as agriculture, recreation, domestic gardening and associated refuse dumping.

Weed invasion can also occur through seed dispersal by birds and mammals. In NSW, many coastal habitats have been invaded by Bitou Bush (*Chrysanthemoides monilifera* subsp. *rotundata*) through the spread of fruit seeds by birds and flying-foxes.

The invasion and establishment of exotic vines and scramblers is noted as a Key Threatening Process to this ecological community under the NSW *Biodiversity Conservation Act 2016*. Also of relevance to this ecological community, the *Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants* as a Key Threatening Process is listed under the EPBC Act.

Key weeds threatening the ecological community

Transformer weeds are recognised for the high impact that they have on native communities through transforming ecosystem processes and function (Sheppard et al. 2010), for example by changing the character, condition, form, or nature of ecosystems over substantial areas (Richardson et al. 2000). Transformer weeds that threaten the ecological community include Madeira vine (*Anredera cordifolia*), Bitou Bush, Cape Ivy (*Delairea odorata*) and Lantana (*Lantana camara*). For example, Bitou Bush smothers canopies and may form dense growth around the edge of rainforest (Adam 1992, in DOEE 2017a). Lantana can aggressively invade disturbed rainforest patches through its habit of climbing and smothering, or prevent regrowth or expansion of patches of the ecological community around the edges of the patch (Hopkins et al 1976). The margins of subtropical rainforest patches in the Illawarra region often contain high densities of Lantana, which capitalises on disturbance and breaks in the rainforest canopy (Eco Logical Australia 2007, cited in NSW DECCW 2011b).

Exotic climbers and vines have the capacity to smother all layers of a rainforest from the canopy to the forest floor. Occurring in high or low light conditions, vines can smother both disturbed and undisturbed forest, reduce light levels and alter microclimate conditions of the understorey (ANPWS 1991). Vines are fast growing and can reduce healthy rainforests to a stand of vine-draped poles within one to two decades (ANPWS 1991; Setter and Vitelli 2003). Maderia Vine can smother shrubs and trees, and is highly efficient at reproducing, making control very difficult (NSW DPI 2018). In steeply sloping areas such as the escarpment it spreads by means of surface run off during heavy rain events, potentially leading to very large areas of impact.

Along with Madeira Vine and Lantana, other climber and vine weed species found in the ecological community include Moth Vine (*Araujia sericifera*), Balloon Vine (*Cardiospermum grandiflorum*) and Passionfruit (*Passiflora* spp, e.g. *P. subpeltata*) and Rambling Dock / Turkey Rhubarb (*Rumex sagittatus*, syn. *Acetosa sagittata*)[34].

Exotic tree weeds that threaten the ecological community include Camphor Laurel (*Cinnamomum camphora*), Large-leaved Privet (*Ligustrum lucidum*) and African Olive (*Olea europaea* subsp. *cuspidata*). These trees, along with woody shrubs such as Cape Gooseberry (*Physalis peruviana*), Small-leaved Privet (*Ligustrum sinense*), Cassia (*Senna pendula*), Arsenic Bush (*Senna septemtrionalis*), Tobacco Bush (*Solanum mauritianum*), Black-berry Nightshade (*Solanum nigrum*) and Madeira Winter (*Solanum pseudocapsicum*), shade and inhibit the growth of native plants.

While invasive herbs and grasses do not generally dominate intact rainforest habitat, herbs such as Crofton Weed (*Ageratina adenophora*), Mistflower (*Ageratina riparia*), Thickhead (*Crassocephalum crepidioides*), Ginger Lily (*Hedychium gardnerianum*) and Trad / Wandering Jew (*Tradescantia fluminensis*), are common invaders of edges or disturbed areas of the ecological community. Invasive grasses can also persist readily along the edges of the

[34] The weeds listed in the following paragraphs are compiled from information within Mills & Jakeman (1995), NSW Scientific Committee (2002a), Murphy (2008), Illawarra Councils (2010), and SCC (undated). Taxonomy is consistent with the Australian Plant Name Index, as at February 2019. Species within each paragraph are listed alphabetically in order of their scientific name.

ecological community; and may increase fire frequency and intensity at the edge of patches, promoting a progressive retreat of the rainforest margin (Murphy 2008).

Introduced and domestic animals

Grazing and trampling by livestock (NSW OEH 2017, 2019c), as well as feral animals, can reduce the quality of the vegetation and destroy plant regrowth and seedlings. Feral animals such as deer, goats and rabbits also have impact through rubbing, browsing or digging. These activities alter the ecological community's structure and composition, by opening up the understorey and creating vegetation gaps that allow weed invasion and impacting on hydrology, and by causing soil compaction and erosion problems. Domestic animals can also kill or injure native fauna and damaging native flora.

In Australia, feral animals typically have few natural predators or fatal diseases and some have high reproductive rates. So their populations have not naturally diminished and can often multiply rapidly if conditions are favourable. The impacts of some feral species often increases during drought and immediately after a fire, when food is scarce.

Deer (including the species Samba, Rusa, Red, Chital and Fallow) in particular are an increasing problem in the ecological community (Wollongong City Council 2015; South East Local Land Services 2018). Their grazing, browsing, trampling and rubbing of native vegetation can result in structural modification, soil erosion and altered species composition within rainforest remnants. Rubbing causes direct physical damage to established trees, sometimes causing ringbarking, while browsing prevents the regeneration and revegetation of rainforest canopy and understorey species and creates gaps in the vegetation allowing colonisation by weeds. 'Herbivory and habitat degradation caused by feral deer' is listed as a Key Threatening Process under the NSW *Biodiversity Conservation Act 2016.* Deer control has not been effective in eradicating populations from the region given limited resources and constraints around deer control methods, including culling, in areas around human populations.

Native fauna species inhabiting rainforest patches are threatened by predation and competition from feral animals. In particular, feral cats (*Felis catus*) and foxes (*Vulpes vulpes*) are known to prey on native mammals, birds, reptiles and insects (DOEE 2016). The most serious impact is in smaller remnants and at the edges of larger remnants. Red Fox can make dens in small rainforest remnants and forage through these and along the edges of large patches (TSSC 2011). Black Rats (*Rattus rattus*) can compete with native species such as the Bush Rat (*Rattus fuscipes*) and exclude them from even relatively undisturbed patches. In the nearby Robertson Rainforest ecological community, Dunstan and Fox (1996) demonstrated that abundance of Black Rats increases with increasing disturbance.

Altered hydrology

Altered hydrological conditions as a result of nearby human land use activities, such as residential developments or hard rock extraction (quarrying activities), cause degradation of the ecological community (NSW OEH 2017) through changes to surface and groundwater flows.

Rock extraction is a well-established activity in the region. As particular rock types, such as basalt are targeted, extraction may disproportionately affect the Illawarra–Shoalhaven subtropical rainforest and its component species such as the Endangered *Daphnandra johnsonii* (Illawarra Socketwood). As well as more direct localised changes to hydrology from rock extraction, changes to surface and groundwater hydrology can manifest at a regional scale. For example, the ecological community could also be affected by changes to local groundwater flows, such as those that support springs, as a result of the removal of basalt from upslope recharge areas (NSW DECCW 2011b).

Nutrient enrichment and chemical drift

Nutrient enrichment can occur through application of inorganic fertilisers to improved pastures or as manure from livestock, as well as runoff from roads, urban and industrial infrastructure. Pesticide/herbicide spray drift may occur from crops and pastures adjacent to a patch. The impacts of nutrients and chemicals can be the loss of flora and fauna components, promotion of weeds and hence changes in rainforest structure and function.

Altered fire regimes

Inappropriate fire regimes, and destruction or degradation of remnants by wildfire have been identified as key threats to the ecological community by NSW OEH (2017, 2019c), with accompanying management recommendations to manage sites to exclude fire and protect sites with appropriate fire-breaks. Fire exclusion and rapid detection and suppression of fires are essential to maintain the ecological and biological integrity of the community.

Changes in the frequency, seasonality, intensity and the patchiness of fires, can change vegetation composition and structure, which may contribute to species loss and structural changes to the Illawarra–Shoalhaven subtropical rainforest ecological community. Under future climate change scenarios for the region, it is likely that wetlands, moist open forest and rainforest will be under greater stress from fire and drought (NSW NPWS 2018) (also see Climate change, below).

Unlike most other vegetation types in Australia, rainforest is fire intolerant and it is not adapted to fire (Floyd 1990). Consequently, fire is an important factor in limiting rainforest boundaries (Bowman 2000). Rainforest species are capable of colonising eucalypt forests and grasslands but are only likely to survive to maturity if fire is excluded until the rainforest species have formed a closed community (Bowman 2000). However, because most rainforest species can regenerate after a single fire (Bowman 2000), it is the frequency of fires that is critical.

Increased flammability occurs as a result of adjacent grassy weeds and invasion by woody weeds such as Lantana. This is exacerbated because of changes in the nature of exposed edges of patches. Weeds can substantially change fuel characteristics at rainforest boundaries (Bowman 2000). Highly-flammable weeds increase the risk of fire, which, depending on its intensity and frequency, can then destroy the rainforest patch (and for example result in its conversion to a woodland state). Because Lantana forms dense thickets it promotes the spread of fire, readily re-establishes after fire, and can become the dominant plant of a site to the exclusion of almost all other species (Mills & Jakeman 1995). Therefore, rainforest remnants with a high woody weed component, or surrounded by land with a high woody weed

component, are more susceptible to fire. The fragmented nature of the ecological community, along with its relatively small sized patches, also increases the risk of irreversible damage from fire.

Disease and dieback (pathogens)

Exotic pathogens may impact the integrity and survival of patches of the ecological community. One of these is Myrtle Rust (*Austropuccinia psidii*). Myrtle rust affects plants in the Myrtaceae family, including native species found in the ecological community, such as *Syzygium smithii* (syn. *Acmena smithii*) (Lilly Pilly, Midjuburi (Cadigal)), *Gossia acmenoides* (Scrub Ironwood) and *Rhodamnia rubescens* (Scrub Turpentine)[35]. The fungus thrives in humid conditions so rainforests can be particularly susceptible.

Myrtle Rust is identified as potentially impacting subtropical rainforests in the Illawarra region. Rainforests in this region are suited to natural distribution of *A. psidii* spore loads (at significant levels from relatively nearby communities likely to harbour the pathogen on a continual basis), and all have significant content of myrtaceous species that are known or likely to be susceptible to some degree. Subtropical rainforests in the Shoalhaven region may be less likely to suffer serious impacts for climatic or microclimatic reasons, but this is not certain at this stage given more monitoring needs to occur (Makinson 2018).

Myrtle Rust predominantly affects new plant growth and does not appear to kill most of its host species, with the exception of some particularly susceptible species. Impacts from Myrtle Rust on native Myrtaceae species range from minor defoliation to tree death in mature plants. Given these impacts, Myrtle Rust is likely to alter the reproductive success of affected plants, such that the composition of plant species in a vegetation community can change, in favour of more resistant species and/or species favouring disturbance (Makinson 2018), including weeds.

Myrtle Rust can be managed in horticultural production systems, but is not amenable to direct management at this time in the wild (Makinson 2018). Rusts produce huge numbers of microscopic spores that spread on the wind, and are transported by animals (e.g. bees, flying-foxes, birds), humans and on goods (Invasive Species Council 2011).

The soil borne pathogen *Phytophthora cinnamomi* is present to the north of the Illawarra State Conservation Area and is a potential risk to the vegetation of the Illawarra escarpment (NSW NPWS 2018). Dieback of susceptible plants from *P. cinnamomi* infestation can lead to plant death and changes to vegetation communities, which can also lead to declines in associated faunal communities (DOE 2015).

Other disturbances to patches

These include a number of activities and impacts resulting from increased and/or unmanaged pedestrian, vehicle or other access to the ecological community. For example:

- Firewood harvesting (removal of course woody debris) can disturb and remove fauna habitat; and people and equipment can bring in weeds (seeds, spores etc.) or pathogens.
- Rubbish dumping can spread weeds and smother understorey species.

[35] Myrtle Rust is known to occur on Scrub Turpentine in the Mount Keira and Sublime Point areas (NSW NPWS 2018)

- Pet animals can predate on fauna and, damage flora and spread exotic species and disease.
- Recreational activities can degrade condition and introduce weeds, and the theft of ornamental plants such as Bird's Nest Fern (*Asplenium australasicum*) reduces native species diversity.
- Construction of trails for recreational purposes, such as walking, horse riding and mountain biking may involve canopy and understorey clearance and disturbance, and the spread of weeds.

Climate change

General expected changes to biodiversity from climate change include (NSW DECC 2007):

- Species range shifts to cooler latitudes (south) or higher elevations;
- Changes to flowering and fruiting times;
- Behavioural changes in fauna populations;
- Extinctions of local populations along range boundaries;
- Increasing invasion of highly mobile, opportunistic, weedy plant species;
- Progressive 'decoupling' (breakage) of species interactions (e.g. timing of food availability);
- Increasing threat to fresh water ecosystems through changes in water temperature and chemistry and potential saline inundation;
- Increased carbon dioxide will favour plants utilizing the C3 photosynthetic pathway of photosynthesis (rather than C4) – this will alter competitive relationships between plants and may result in substantial changes in species composition, and increased competition from weedy species (Adam 2009); and
- Decoupling of pollinator – plant relationships, leading to reduced pollination (Adam 2009).

Impacts to forest canopy from extreme weather events may become more frequent, resulting in the accelerated loss of canopy individuals such as figs. Increased edge and canopy effects from extreme dry events are also possible and have been seen in other subtropical rainforests.

Temperatures in the Illawarra and Shoalhaven regions have been increasing since about 1960, with higher temperatures experienced in recent decades. Climate change predictions for the Illawarra and Shoalhaven regions indicate: a shift to warmer minimum and maximum temperatures (more hot days and fewer cold nights); increased average fire weather in spring in the near future and increased severe fire weather in summer and spring over the longer term; and, decreased rainfall in winter (and also spring for areas south of Gerringong and closer to the escarpment) and increased rainfall in summer and autumn (NSW OEH 2014). Increased intensity of extreme rainfall events is also projected along the east coast (Dowdy et al. 2015).

These climatic changes mean that the structure and composition of the ecological community is likely to change. For example, seasonal shifts in rainfall can impact native species' reproductive cycles (NSW OEH 2014), whereby conditions becoming less favourable for some species and more favourable for others. Beyond these changes due to local climatic factors, changed disturbance regimes are also likely to cause further changes to patches of the

ecological community. For example, increased high intensity storms and rainfall events can damage trees and have secondary impacts such as water quality and soil erosion.

The effect of changing climate on Australian landscapes, such as the Illawarra and Shoalhaven regions, is of further significance because extensive land clearing and post European settlement have left fragmented remnants of native vegetation within a matrix dominated by agricultural production (Doerr et al. 2010). Smaller patches of ecological communities will be less resilient and isolated ecological communities will have difficulty shifting their ranges to track changing environments. A potential solution is to provide *structural connectivity* i.e. elements of the landscape (typically some form of native vegetation) that physically link isolated patches of habitat. These linkages will allow individuals and/or their genes to disperse between multiple small patches, allowing these subpopulations to collectively function as larger, more resilient metapopulations (Doerr et al. 2010).

APPENDIX C: ELIGIBILITY FOR LISTING AGAINST THE EPBC ACT CRITERIA

This appendix presents a detailed assessment of how the Illawarra–Shoalhaven subtropical rainforest of the Sydney Basin Bioregion ecological community meets the EPBC Act listing criteria, with reference to the relevant guidelines (DOEE 2017b). It forms the listing advice from the Threatened Species Scientific Committee (the Committee) to the Minister.

Criterion 1 – Decline in geographic distribution

Criterion 1 categories and thresholds			
Category	**Critically Endangered**	**Endangered**	**Vulnerable**
Its decline in geographic distribution is **either**:	very severe	**severe**	substantial
a) Decline relative to the longer-term (beyond 50 years ago e.g. since 1750); **or**,	≥90%	**≥70%**	≥50%
b) Decline relative to the shorter-term (past 50 years).	≥80%	≥50%	≥30%

Much of the Illawarra–Shoalhaven Subtropical Rainforest, and other surrounding native vegetation, has been cleared for primary industries such as logging and grazing, and residential development and associated infrastructure more recently. It now mostly occurs as scattered fragments. Tozer et al. (2010) provides the most consistent spatial information for vegetation units relating to the ecological community across its range. Tozer et al. (2010) estimate that the Subtropical Dry Rainforest (RF p111) had declined by 80 to 90% (this vegetation unit is closely related to the ecological community); while the Subtropical Complex Rainforest (RF p112) had declined by 35 and 50% (this vegetation unit includes areas of the ecological community but does not entirely correspond with it). Decline estimates for the two units combined ranges from between 65 and 80% (Table C1). The actual loss of the ecological community depends on what proportion of RF p112 contains the ecological community.

It is accepted that since the information used in Tozer et al (2010) was collected (using spatial information that pre-dates 2010), there have been further outright losses of the ecological community. Additionally, this information does not fully consider the likely condition of the remnants, which due to multiple threats has continued to deteriorate. So the figures suggests a best case scenario for the current extent of the ecological community. Given all of the above, it is reasonable to conclude that the ecological community is likely to have met the threshold of at least 70% decline; this represents a ***severe*** decline in geographic distribution relative to the longer term (i.e. since 1750 / non-Indigenous settlement).

Conclusion

Based on the estimates in Table C1 the ecological community is considered to have undergone a *severe* decline (at least 70%) in its geographic extent relative to the longer term and is therefore eligible for listing as ***Endangered*** under this criterion.

Table C1: Extent and decline estimates

	Area remaining (ha)	**Pre-European extent (calculated from % remaining estimates in Tozer et al. (2010))**		**% remaining**	
		Low estimate (ha)	High estimate (ha)	High estimate (%)	Low estimate (%)
RF p111	2400	12000	24000	20	10
RF p112	4100	6308	8200	65	50
Total remaining	6500	18308	32200	35	20
Decline				65%	80%

Source: Tozer et al. (2010)

Criterion 2 – Small geographic distribution coupled with demonstrable threat

Criterion 2 categories and thresholds			
Its geographic distribution is:	**Very restricted**	**Restricted**	**Limited**
2.1. Extent of occurrence (EOO)	< 100 km^2 (<10,000 ha)	<1,000 km^2 (<100,000 ha)	<10,000 km^2 (<1,000,000 ha)
2.2. Area of occupancy (AOO)	< 10 km^2 (<1,000 ha)	<100 km^2 (<10,000 ha)	<1,000 km^2 (<100,000 ha)
2.3. Patch size	**< 0.1 km^2 (<10 ha)**	< 1 km^2 (<100 ha)	–
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 [within 10 years, or 3 generations of any long-lived or key species, whichever is the longer, up to a maximum of 60 years.]	**Critically endangered**	Endangered	Vulnerable
the Near future [within 20 years, or 5 generations of any long-lived or key species, whichever is the longer, up to a maximum of 100 years.]	Endangered	Endangered	Vulnerable
The Medium term future [within 50 years, or 10 generations of any long-lived or key species, whichever is the longer, up to a maximum of 100 years.]	Vulnerable	Vulnerable	Vulnerable

Criterion 2 aims to identify ecological communities that are geographically restricted to some extent. It is recognised that an ecological community with a distribution that is small and/or fragmented, either naturally or that has become so through landscape modification, has an inherently higher risk of extinction if it continues to be subject to ongoing threats that may cause it to be lost in the future.

The indicative measures that apply to this criterion are:

- extent of occurrence, an estimate of the total geographic range over which the ecological community occurs;
- area of occupancy, an estimate of the area actually occupied by the ecological community, which generally equates with its present extent;
- patch size and distribution, an indicator of the vulnerability of small and/or isolated patches to particular threats; and
- an assessment of timeframes over which threats could result in further loss of the ecological community.

Evidence:

Extent of occurrence

The extent of occurrence for the ecological community when measured as a minimum convex polygon around mapped occurrences is around 345 000 ha, which is indicative of a ***limited*** geographic distribution (<1 000 000 ha) on the basis of extent of occurrence.

Area of occupancy

The estimated area of occupancy for the ecological community is estimated to be up to 6500 ha (Table C1). This is indicative of a ***restricted*** geographic distribution (<10 000 ha) on the basis of area of occupancy.

Patch size distribution

NSW OEH (2017, 2019c), together with patch size distribution analysis, indicate that remnants are now highly fragmented and continue to face mounting threats. Available patch size data (from Tozer et al. 2010) indicate the majority of patches are less than 10 ha in size which is indicative of a ***very restricted*** geographic distribution and potentially critically endangered status. For patches greater than 0.1 ha in size, 96% of corresponding vegetation unit RF p111 and 89% of RF p112 are less than 10 ha in size (see Table C2).

Table C2: Patch sizes distribution for the ecological community

Size of patch	Number of patches	Percentage of patches
Map unit RF p111		
Small (0.1 – ≤10 ha)	1089	96.1
Medium (>10 – ≤100 ha)	41	3.6
Large (>100 ha)	3	0.3
Total	1133	100
Map unit RF p112		
Small (0.1 – ≤10 ha)	623	89.3
Medium (>10 – ≤100 ha)	69	9.9
Large (>100 ha)	6	0.9
Total	698	100
Note: Patches <0.1 ha were excluded from the analysis, as some of these are likely to be artefacts of spatial processing errors.		

The range of threats to the ecological community are outlined fully in Appendix *B, Description of key threats*. Logging and then clearing for grazing and agriculture was extensive throughout the coastal plain, with the ecological community being further lost and fragmented through residential and associated development. This has caused remaining patches to be exposed within areas of agricultural or urban land use. Remaining patches are now mostly restricted, either as remnants or regrowth from historical clearing, to locations less suitable for agriculture and timber harvesting, such as steep rocky gullies and outcrops of volcanic latite, or on roadsides (Mills & Jakeman 1995; NSW OEH 2019c).

Due to the past clearing of the ecological community, as well as of other surrounding native vegetation, the current landscape position of remaining patches of the ecological community does not represent what was typical prior to clearing. Most patches of the ecological community are now small and fragmented. Whilst some patches were naturally small, for example where patches of this subtropical rainforest occupied small areas of suitable habitat within other vegetation types, more extensive areas were present prior to clearing. As a result, the function of the ecological community (e.g. the movement of wildlife and other pollinators, the dispersal of plant propagules, activities of seed and plant predators, biological water retention and cycling and many other interactions) across its range has been significantly compromised. In addition, smaller areas are inherently vulnerable to extinction due to being more susceptible to threats such as weed invasion and damage associated with nearby urbanisation.

The threat from residential development and associated infrastructure is expected to continue, and is one of the main contemporary pressures on Australia's coastal environment (Beeton et al. 2006). In NSW, coastal regions will continue to have the fastest growth rates in the state. The Illawarra–Shoalhaven Regional Plan (NSW Government 2015) projects the population of the Illawarra–Shoalhaven is forecast to grow to 463 150 by 2036 – an increase of 60 400 from 2016. This growth will necessitate at least 35 400 new homes between 2016 and 2036, an average of 1770 per year. In the Wollongong, Shellharbour and Kiama Local Government Areas, the average housing supply over the preceding 10 years was almost 1 100 dwellings per year.

Other threats, such as from hard rock quarries, are expected to continue and further fragment the remaining areas of the ecological community. The Dunmore–Shellharbour Hills area is a significant area for this resource, providing 5.2 million tonnes of hard rock and sand in 2010–11, and coincides with the distribution of this ecological community and also the Critically Endangered Illawarra and south coast lowland forest and woodland ecological community (NSW Government 2015).

Based on these threats and future pressures to the ecological community across its range, and due to the nature of its distribution into smaller and less connected patches, available evidence suggests that a significant decrease in extent or decline in integrity (e.g. from threatening

processes such as further clearing, and from legacy effects of fragmentation) is likely in the immediate future (i.e. up to 60 years[36] (DOEE 2017b)).

Conclusion

The ecological community has a *very restricted* distribution; 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. It is therefore eligible for listing as **Critically Endangered** under this criterion.

Criterion 3 – Loss or decline of functionally important species

Criterion 3 categories and thresholds			
Category	**Critically endangered**	**Endangered**	**Vulnerable**
For a population of a native species likely to play a major role in the community, there is a:	very severe decline (at least 80% over the last 10 years or three generations, whichever is longer)	severe decline (at least 50% over the last 10 years or three generations, whichever is longer)	substantial decline (at least 20% over the last 10 years or three generations, whichever is longer)
to the extent that restoration of the community is not likely to be possible in:	the immediate future (10 years, or 3 generations of any long-lived or key species, whichever is the longer, up to a maximum of 60 years)	the near future (20 years, or 5 generations of any long-lived or key species, whichever is the longer, up to a maximum of 100 years)	the medium-term future (50 years, or 10 generations of any long-lived or key species, whichever is the longer, up to a maximum of 100 years)

Whilst there has been significant overall loss of area and degradation of the ecological community, data to support analysis against this criterion, and its indicative thresholds, for loss of particular functionally important species of flora or fauna within remnants is not available. Rather, it is the loss or decline of suites of flora, such as the understorey or a diverse canopy layer, instead of the decline of individual species that characterises functional loss in this ecological community. This is properly addressed, below, under *Criterion 4 – Reduction in community integrity*, along with decline in functional processes.

[36] The 'immediate future' is defined as "10 years, or 3 generations of any long-lived or key species believed to play a major role in sustaining the community, whichever is the longer, up to a maximum of 60 years" (p17 of DOEE 2017b). Generation length is taken to be the average age of the trees that are producing viable seed germinating as seedlings. Since this is likely to be greater than 20 years, for many important rainforest canopy tree species, the maximum allowable time (60 years) is used.

Similar arguments apply to the faunal component of the ecological community. Whilst the loss of the vertebrate fauna has been documented for this ecological community and the region in general, there is uncertainty about the functional roles of particular species within the ecological community. There are also limited data concerning the recoverability of these species or their broad functions within the ecological community, whether through natural means or by human intervention.

The ecological functions that may have been compromised by the loss of small to medium sized ground-dwelling mammals include nutrient cycling, dispersal of fungi, seed burial and water infiltration (Fleming et al. 2014). Other functions performed by fauna, including pollination, seed dispersal and nutrient cycling, are also likely to be compromised with their decline (e.g. the decline of invertebrates, flying-foxes and nectivorous bird populations).

Conclusion

There is **insufficient information** to determine the eligibility of the ecological community against this criterion. Therefore the ecological community is **not eligible** for listing under Criterion 3.

Criterion 4 – Reduction in community integrity

Criterion 4 categories and thresholds			
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

This criterion recognises that an ecological community can be threatened with 'functional' extinction or collapse through on-going modifications that do not necessarily lead to total destruction of all its elements.

The integrity of the ecological community has been compromised, at both patch and landscape scales through various types of local degradation and broad scale vegetation clearing and landscape change. This has affected ecological processes and resulted in a subsequent decline or changes to flora and fauna within the ecological community, consistent with a ***very severe*** reduction in integrity across most of its geographic distribution. If these changes are ongoing, it could lead to the eventual loss of the ecological community.

Past, present and future threats to the ecological community are fully described in *Appendix B, Description of key threats*. Further justification how these have affected the integrity of the ecological community, using key examples, are given here.

Decline in integrity due to clearing, fragmentation and edge effects

There have been severe losses in extent of the ecological community and remaining fragments tend to be degraded and continue to be threatened by various threats. Of the remaining patches most are <10 ha in size, which represents a patch size distribution that is skewed towards smaller patches, compared with the distribution of the ecological community prior to clearing (see Criteria 1 and 2).

In its original form, where the ecological community occurred in a number of relatively contiguous 'large brush areas' that were closely associated with volcanic geology (Mills & Jakeman 1995), around 84% of the ecological community was represented by 'core area' more than 100m from the edge of the rainforest. In its current state, less than 500 ha of 'core area' remains, representing around 9% of the current ecological community. This represents a loss of over 98% of the original 'core area', with over 90% of the remaining community being impacted by edge-effects. This loss of core area since 1750 would represent a Critically Endangered status for environmental degradation under Criterion C3 of the IUCN Red List of Ecosystems (Bland et al 2017).

Fragmentation has caused a reduction in patch size, an increase in the distance between patches of the ecological community or other native vegetation, more exposed edges and hence a greater susceptibility to increased disturbance and degradation. The result is that remaining areas of the ecological community are unlikely to represent the full range of components that was present prior to European settlement. Smaller patches are generally associated with a decrease in native species richness.

The increase in distance between remaining patches of native vegetation in the landscape is likely to have limited dispersal of key canopy species (i.e. because the distances become greater than the expected gap-crossing threshold for many fauna, or the fauna may no longer be present in the region). This limits the prospects of natural recovery for the ecological community and imposes hazards for fauna, both in the immediate term (e.g. road deaths) and long term (insufficient individuals for successful breeding and genetic health). The loss of populations and reduced movement of fauna, such as birds, bats and gliders has compromised the ecological community and reduced its capacity to recover, by removing services such as pollination and seed dispersal.

Moreover, fragmentation exacerbates secondary processes, such as an altered physical environment (light, temperature, wind and storm damage), grazing and trampling, weed and feral animal invasion and increased fire risk (along with other threats associated with urban encroachment). This impacts the structural, compositional and functional integrity of the ecological community. Tropical rainforest research suggests that effects due to external microclimate and physical variables may extend 200 – 500 m into the forest interior from the edge (Laurance 1991). The edges can be a barrier to the recovery of core rainforest flora species. Seed rain into the core of small patches may be dominated by seeds of edge species (Ranney et al. 1981, in Fox et al. 1997), which can change the species composition as shade tolerant species of the interior are replaced by shade intolerant edge species (Wilcove et al. 1986, in Fox et al. 1997). In the nearby Robertson Rainforest ecological community Fox et al. (1997) found that the vegetation composition in the interior of patches was distinctly different

from that at the edge. Coloniser species were abundant in the core of many of the remnants, and mostly more abundant than the rainforest core species which are generally dominant in rainforest interiors. Increased disturbance resulted in increased edge widths, greater density and species richness of colonisers and weeds, and reduced density and species richness of core rainforest plants. The same effects are evident in the Illawarra–Shoalhaven Subtropical Rainforest ecological community with few patches containing forest unaltered by edge effects.

The deliberate removal of the understorey beneath the tree canopy (underscrubbing) to open areas up (e.g. to stock and/or enhance grazing, or to create lawns in per-urban areas, or for real-estate development), also causes changes to the structure, composition and function of the ecological community, including habitat values for fauna, and replacement of the ground layer with exotic species.

Decline in integrity due to invasive plants and animals

Disturbance of the rainforest canopy often promotes the growth of exotic vines (that smother native trees and further disrupt the canopy) and exotic groundcovers (that suppress the regeneration of other rainforest plants) (Kanowski et al. 2009). The impact of exotic weeds is likely to increase with time since fragmentation, increasing fragmentation and smaller patch sizes. The ability of the fragmented ecological community to support native flora and fauna and important ecological processes such as seed dispersal and pollination has also been reduced (Moran et al. 2004). Weeds that also impact undisturbed patches of the ecological community are mainly herbaceous (Mills & Jakeman 1995). *The invasion and establishment of exotic vines and scramblers* is noted as a Key Threatening Process to this ecological community under the NSW *Biodiversity Conservation Act 2016*.

Deer are having an increasing impact on the ecological community, and other native vegetation (Wollongong City Council 2015; South East Local Land Services 2018). Rainforest restoration efforts can be entirely damaged by grazing and soil disturbance by deer in restoration sites. Reducing the impacts of grazing through deer control is one of the key management actions identified for subtropical rainforest sites under the NSW Saving our Species program (NSW OEH 2017b).

Decline in integrity due to altered fire regimes

Repeated fires (increased frequencies) adjacent to patches of the ecological community are more likely to impact the ecological community, through drying and other changes to the ecological community and surrounding vegetation communities. The resilience of the ecological community is likely to be decreased under future climate change scenarios.

The presence of weeds can also exacerbate fires in the ecological community. For example, because Lantana forms dense thickets it promotes the spread of fire, readily re-establishes after fire, and can become the dominant plant in some areas to the exclusion of almost all other species (Mills & Jakeman 1995).

Decline in integrity due to the loss of native fauna components

One primary long term change in integrity of the ecological community has been losses of native fauna, both within the ecological community and more broadly across the landscape.

This has resulted in the local extinction of some fauna species and a dramatic reduction in the populations of others (Mills & Jakeman 1995). Population changes for many species are likely to be related to complex interactions between changes to hunting and predation, including by invasive species, the loss and degradation of vegetation and other habitat features, and reduced connectivity of native vegetation.

In the nearby Robertson Rainforest, Dunstan & Fox (1996) demonstrated that native fauna species richness and abundance decrease significantly with decreasing remnant size and increasing disturbance. In the Hacking River valley, potential threats to native fauna of subtropical rainforest are recognised as habitat loss through high intensity fire events; weed invasion, such as along some creeklines or adjacent to disturbed areas; changes to water quality of some streams flowing through this habitat; predation by feral predators; grazing and trampling by the Rusa Deer; road mortality; potential infection of frogs by Amphibian Chytrid Fungus; and feral fish populations, particularly the Mosquito Fish (NSW DECCW 2011c).

Ecological functions performed by native fauna in the ecological community include pollination and seed dispersal. These functions are likely to be compromised with population declines, for example, of Grey-headed Flying Fox. Whilst its movement is not limited by fragmentation it has declined across its range with direct loss of suitable feeding and breeding habitat. In particular, loss of reliable winter and spring food sources, such as blossom from emergent *Eucalyptus tereticornis*, to support breeding, has limited populations (Martin & McIlwee 2002; DOE 2019). Large scale restoration of habitat is required for recovery of populations and the ecological functions they provide. However, the inherently low birth rates for the flying-foxes, delay before substantial flowering of Eucalypts and inconsistency with broader patterns of landscape change make this unlikely (Eby 1995; Law et al. 2002; Martin & McIlwee 2002).

Successful re-introduction of small and medium sized native mammals is highly dependent on intensive predator control, most completely achieved by protective fencing. Construction and maintenance of this kind of fence is not likely to be feasible across the landscape at the scale required to restore function across the range of the ecological community. Further, control measures for foxes, for example, needs to be coordinated with management of other feral species such as rabbits and cats, to avoid increases in these other populations.

Another form of degradation impacting the fauna that comprise the ecological community is the loss of tree hollows. Birds use hollows seasonally for nesting, or may use them more regularly as roosting sites. Amphibians use hollows as a source of water, or as shelter, as has been observed for Peron's Tree Frog. Similarly, reptiles may also use hollows as a den and will also hunt in them. A large proportion of the bat species within the ecological community may use hollows, which can assist with thermoregulation as well as some relying on roosting sites in caves in the escarpment. Other mammal species likely to use hollows include Sugar Glider, Brown Antechinus and Dusky Antechinus (Gibbons & Lindenmayer 2002). Benefits of tree hollows to arboreal mammals include their use as daytime dens or nests to rear young, as well as providing sources of water. The occupation of hollows by fauna depends on a variety of factors including size of tree, number of fissures, crown condition and position in the landscape. However, clearing and development of areas with mature and hollow trees has

reduced their availability. Development of new hollows requires suitable environmental conditions, and sufficiently large trees for them to persist once decayed. It takes many decades for tree hollows to develop, so the restoration of this habitat feature is unlikely across the ecological community in the foreseeable future.

Conclusion

The ecological community has undergone a ***very severe*** reduction in integrity across most of its geographic distribution. Remnants do not fully represent the floristic and faunal composition that was present prior to clearing and development of the region. Much of the degradation is intractable and many of the underlying threats continue. While active interventions make some valuable contributions to conservation, there are factors associated with the existing damage that reduce the likelihood of functional restoration. These factors include losses of flora and fauna components, changes in soil and vegetation structure and function, and significant modification of the physical environment around fragmented patches. Therefore, complete restoration of the ecological functions underpinning the ecological community is unlikely in the *immediate future*. This indicates degradation of the ecological community and disruption in ecological processes that is ***very severe***. Therefore the ecological community is eligible for listing as **critically endangered** under this criterion.

Criterion 5 – Rate of continuing detrimental change

Criterion 5 categories and thresholds			
Category	**Critically Endangered**	**Endangered**	**Vulnerable**
Its rate of continuing detrimental change is:	very severe	severe	substantial
as indicated by a) degradation of the community or its habitat, or disruption of important community processes, that is:			
or b) intensification, across most of its geographic distribution, in degradation, or disruption of important community processes, that is:			
5.1 An observed, estimated, inferred or suspected *detrimental change* over the *immediate*[#] past or projected for the *immediate* future of at least:	80%	50%	30%

The ecological community is undergoing continuing detrimental change arising from threats outlined in *Appendix B, Description of key threats*. Threats associated with human disturbance are likely to increase with a growing population and coastal developments. In addition, natural disturbances, such as fires and storms, are likely to continue impacting the ecological community and to increase in severity and/or frequency due to climate change.

The ecological community has undergone a severe decline in geographic distribution, decline in condition of the ecological community continues and a significant investment in ongoing management is required, in the form of weed control and in some cases supplementary planting, to avoid a further increase in the rate of continuing detrimental change.

However, data are not available to predict quantifiable rates of future change, or to estimate the extent of past losses due to degradation and threats other than clearing since European settlement, whether measured by years or generations of key species.

Conclusion

There is insufficient information to determine the eligibility of the ecological community against this criterion. Therefore the ecological community is **not eligible** for listing under Criterion 5.

Criterion 6 – Quantitative analysis showing probability of extinction

Criterion 6 categories and thresholds			
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.

There are no quantitative data available to assess this ecological community under this criterion. Therefore, it is **not eligible** for listing under this criterion.

Overall conclusion

The Illawarra–Shoalhaven subtropical rainforest of the Sydney Basin Bioregion ecological community merits listing as Critically Endangered. This was the highest conservation category triggered in this assessment, as applied to Criteria 2 and 4. One other listing criteria was met at a lower conservation status: Criterion 1 Endangered.

APPENDIX D: FURTHER INFORMATION ON RELATED VEGETATION UNITS

This Appendix provides additional information on vegetation units, to that outlined in *Section 3.4*.

Ecological communities are complex to classify. In each state and territory different systems are used to classify ecological communities and vegetation types. The various methods of classifying and mapping ecological communities also differ in scale and accuracy, particularly if distributions are modelled.

Any reference to vegetation and mapping units as equivalent to a national ecological community, at the time of listing, should be taken as indicative rather than definitive. Consideration of whether an ecological community that is protected under national environment law is present at any site should focus on how the patch meets the description, particularly the Key diagnostic characteristics and at least the minimum condition thresholds for the ecological community.

The south coast of NSW has been the subject of several vegetation mapping exercises for a variety of purposes. Many of the maps rely on modelling of vegetation types, with the results of limited field surveys extrapolated subsequently, based on information such as aerial photographs. There are various systems of classification and nomenclature used in the maps, many of which have been created for a particular mapping exercise, so the descriptive units used do not fully correspond with each other.

NSW Vegetation Units that correspond to the ecological community

Bearing in mind the limitations stated above, the ecological community corresponds entirely or partly to the following historic mapped vegetation types:

NSW NPWS (2002a):

- MU4 Lowland Dry–Subtropical Rainforest; and
- MU1 Illawarra Escarpment Subtropical Rainforest[37].

Mills & Jakeman (1995):

- Type 1 Subtropical rainforest;
- Type 2 Moist Subtropical Rainforest; and
- Type 3 Dry subtropical rainforest.

Note. The classification of Mills & Jakeman (1995) was developed specifically for the Illawarra Region – In a broader context (historically), much of the ecological community would fall within the Dry rainforest (Suballiance 23) and Subtropical rainforest (Suballiance 14) in Floyd (1990) (NSW Scientific Committee 2002a; 2002b).

Similar or related Vegetation Units (or intergrades)

The rainforests of the Illawarra escarpment and foothills are a distinctive vegetative feature of the region. Only one other place in the Sydney Basin Bioregion has some similarities in climate, landform and vegetation – the Watagan Range in the Lake Macquarie and Lower

[37] Rainforest sites classified as MU1 that are included under Suballiance 14 (such as those at Mt Keira and Minnamurra) are the ones most likely to correspond to the ecological community.

Hunter Area. However, the Watagan range is set further back from the coast than the Illawarra Escarpment and the temperatures are correspondingly cooler. Both areas contain warm temperate rainforests and subtropical rainforests and they share a similar vegetation structure. Nevertheless, there are substantial differences in the plant species composition of the vegetation of these two areas and the Watagan rainforest is not part of the Illawarra–Shoalhaven subtropical rainforest ecological community (NSW NPWS 2002a).

Tozer et al. (2010) describes the following Vegetation Units that are similar to (or related to/intergrade with) the Illawarra–Shoalhaven subtropical rainforest ecological community within the region.

WSF p99 Illawarra Gully Wet Forest. A tall eucalypt forest with a moist open understorey, primarily distributed from the Hacking River catchment along the Illawarra escarpment south to Mt Keira, on coastal lowlands near Berry and scattered through coastal foothills and lowlands from Nowra south to Batemans Bay. Typically, Illawarra Wet Gully Forest occurs on sheltered slopes and gullies with loamy soils with an annual rainfall in the range of 1000 – 1700 mm. On the northern Illawarra escarpment, Illawarra Wet Gully Forest occupies elevations up to 400 m ASL, however south of Nowra it rarely exceeds 200 m ASL.

With increasing soil fertility Illawarra Wet Gully Forest (WSF p99) grades into Warm Temperate Layered Forest (WSF p110) and may be replaced by the Illawarra–Shoalhaven subtropical rainforest ecological community (unit RF p112) in areas of higher nutrient soils, and in areas long protected from fire (Tozer et al. 2010).

WSF p110 Warm Temperate Layered Forest. A tall eucalypt forest characterised by an open eucalypt canopy, a dense small tree sub-canopy and a moist shrubby understorey. Warm Temperate Layered Forest occurs predominantly south from the Hacking River along the Illawarra scarp, to Nowra and throughout the Kangaroo Valley. Localised occurrences are also recorded from sites as far south as Durras Mountain and as far north as Ku-ring-gai Chase National Park. Within this area it is found below 400m on sheltered slopes in gullies and on escarpments with loamy soils where mean annual rainfall exceeds 1000 mm. Warm Temperate Layered Forest frequently adjoins Subtropical and Warm Temperate rainforest map units, and contains several rainforest taxa below its eucalypt canopy.

RF p210 Temperate Littoral Rainforest. A closed forest characterised by a dense tree canopy, lianas, a sparse shrub stratum and an open groundcover. This rainforest is restricted to sand spits and coastal gullies within a few hundred metres of the ocean. Small occurrences are distributed along the coast south from Sutherland, in places where annual rainfall exceeds 950 mm. Local concentrations occur from Garie to Stanwell Park and on the Beecroft Peninsula.

Temperate Littoral Rainforest shares some species in common with the Illawarra–Shoalhaven subtropical rainforest ecological community (units RF p111 and RF p112) and replaces these units where Littoral influences predominate.

RFp113. Coastal Warm Temperate Rainforest. A closed forest with a dense tree canopy, a subcanopy of small trees, lianas, an open layer of mesic shrubs and a fern-dominated groundcover. This rainforest is widely distributed in small patches, with local concentrations along the Illawarra escarpment north from Cambewarra, along the escarpment in the Clyde

district and along the Murramarang Range on the coast north of Durras. It is found in moist sheltered gullies and on sheltered escarpment slopes on loam to clay loam soils from 0 – 400 m ASL with a mean annual rainfall greater than 900 mm. Coastal Warm Temperate Rainforest (RPF113) is related to Sandstone Scarp Warm Temperate Rainforest (RF p114) which can be differentiated from this unit by its restriction to higher elevations (above 400m ASL), and the absence of lowland taxa (e.g. *Livistona*). On poorer soils a component of the Illawarra–Shoalhaven subtropical rainforest ecological community (unit RF p112) is replaced by Coastal Warm Temperate Rainforest (RF p113).

RF p116 Intermediate Temperate Rainforest. A closed forest characterised by a dense tree canopy, lianas, a mesic shrub/small tree stratum and a sparse fern-dominated groundcover. This rainforest is scattered over a wide distribution as small occurrences on relatively fertile, moist sites between 10m ASL (in the far south) and 750m ASL (western Blue Mountains), where annual rainfall exceeds 900mm. Within this distribution this unit is restricted to moist sheltered gullies among foothills and scarps. Local concentrations occur on the footslopes of Mount Dromedary, along the southern escarpment in the Morton-Deua area, at Cambewarra and Barren Grounds, and in the western Blue Mountains. In the south of the bioregion, RF p116 is increasingly restricted to the coast and lower elevations.