

***Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) (s266B)***  
**Draft listing advice and conservation advice for the**  
**Illawarra and south coast lowland grassy woodland ecological community**

1. The Threatened Species Scientific Committee (the Committee) was established under the EPBC Act and has obligations to present 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 will provide its advice on the Illawarra and south coast lowland grassy woodland ecological community to the Minister as a draft conservation advice by 31 July 2016.
3. The Minister will decide whether to amend the list of threatened ecological communities under Section 184 of the EPBC Act to include the Illawarra and south coast lowland grassy woodland ecological community. It is noted that a portion of the ecological community is listed under the New South Wales *Threatened Species Conservation Act 1995*.
4. This draft conservation advice for the Illawarra and south coast lowland grassy woodland ecological community will be made available for expert and public comment for a minimum of 30 business days. The Committee and Minister will have regard to all public and expert comment relevant to the consideration of the ecological community.
5. This draft conservation advice has been developed based on the best available information at this time.



# ILLAWARRA AND SOUTH COAST LOWLAND GRASSY WOODLAND

## ECOLOGICAL COMMUNITY

### DRAFT LISTING ADVICE AND CONSERVATION ADVICE

MARCH 2016

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## **1 DESCRIPTION OF THE ECOLOGICAL COMMUNITY**

### **1.1 Name of the ecological community**

The name of the ecological community is the **Illawarra and south coast lowland grassy woodland**. The ecological community was placed on the 2014 Finalised Priority Assessment List as the 'Illawarra Lowlands Grassy Woodland' (hereafter referred to as 'Illawarra and south coast lowland grassy woodland', or 'the ecological community'). It comprises eucalypt woodlands; typically with a shrub layer and/or a grassy ground layer. The distribution is patchy, with the main remaining occurrences mostly on lowland sandy loam soils around Wollongong, Milton, Bawley Point and Moruya.

The ecological community encompasses the NSW listed endangered ecological community 'Illawarra Lowlands Grassy Woodland in the Sydney Basin Bioregion' (NSW Scientific Committee, 1999).

### **1.2 Location and physical environment**

The Illawarra and south coast lowland grassy woodland typically occurs within 30 km of the coast on floodplains, coastal valleys and low-lying foothills below the steep slopes of the eastern coastal escarpment on the south coast of NSW. The ecological community can occur from near sea level up to approximately 350 m above sea level (ASL), but most occurrences are at a much lower altitude; between 10 and 150 m (Tozer et al, 2010). At a local scale, the expression of the ecological community varies with aspect, with more mesic elements such as rainforest understorey plants occurring (but not dominating) on more sheltered or south-facing slopes (Mills and Jakeman, 1995).

The ecological community occurs within the Illawarra, Jervis and Ettrema subregions of the Sydney Basin Bioregion, and the Bateman subregion of the Southeast Corner Bioregion (Department of the Environment, undated) (Appendix A-Draft map of likely occurrence of the ecological community).

#### **Geology and soils**

The ecological community occurs on a variety of substrates reflecting some of the diversity in underlying geology. Along the NSW coast between Moruya and Wollongong, the outcropping geology is dominated by sedimentary rocks including sandstone, chert, mudstone, silt and claystone, conglomerate and some evaporites. Some of the sedimentary rocks have been partly metamorphosed to form quartzite, shale, slate and phyllite, as well as coal. In the south of this range, some granites and granodiorites are present and there are some areas where igneous intrusive rocks outcrop. In the north of this range, especially around Kiama there are some volcanic rocks including rhyolite, basalt and dolerite, as well as tuffs, formed from volcanic ash, often combined with other sediments. Fingers of relatively recent alluvial sediments also extend from the coast at various points throughout this range but this is not a primary substrate for the ecological community. A sharp western boundary to the range of the ecological community is provided by uplifted Triassic and Permian sandstones forming the escarpment of the Great Dividing Range (Geoscience Australia, undated; NICTA, 2014; Tozer et al, 2010).

The various substrates underlying the ecological community produce a range of sandy loam soils, which may be a driver for local variation in the ecological community's expression, including Permian sediments and volcanic rocks forming the foothills to the escarpment. Soil mapping is often incomplete, but in the Illawarra region, the ecological community may be more likely to occur on soils derived from sedimentary deposits (not primary alluvium), while rainforest may be more likely to occur on latite derived soils (Mills and Jakeman, 1995). In areas downslope of where the ecological community occurs, recent marine sediments dominate. These coastal sands and low-lying saline deposits forming swampy areas do not support the ecological community. In general, the more

northerly sites, including those with basalt substrate are better drained and more fertile, while at the southern edge of the range, the soils become more sandy, where the ecological community grades into the nationally listed 'Lowland Grassy Woodland in the South East Corner Bioregion' (Tozer et al, 2010; Threatened Species Scientific Committee, 2013a).

## Climate

The ecological community occurs in areas with a temperate climate, mainly in locations between 1150 mm and 1400 mm mean annual rainfall. The annual rainfall at the southern end of the ecological community's range is generally less than 1200 mm (Tozer et al, 2010). There is typically higher rainfall in autumn and lower in late winter to spring (Table 1).

The air temperatures are mild, ranging between approximately 5°C (mean daily minimum for July) and 25°C (mean daily maximum for January) (Tozer et al, 2010), with some cooling as altitude increases (Mills and Jakeman, 1995).

**Table 1 Mean annual rainfall for sites near where the ecological community occurs**

Weather station	Altitude (metres above sea level)	Mean annual rainfall (mm)
Albion Park (Wollongong Airport)	8	868
Dapto West	42	1192
Nowra treatment works	10	1037
Nowra RAN Air Station AWS	109	905
Milton (Sarah Claydon Village)	81	1167
Moruya Airport AWS	4	778

Source: Bureau of Meteorology (undated)

## 1.3 Vegetative components of the ecological community

The ecological community occurs as a woodland, occasionally a forest, with projected crown cover of the main canopy greater than 10%. The local expression of the community is influenced by geology and soils, drainage and aspect, site history and current management. The canopy is dominated by *Eucalyptus* or *Angophora* trees, with *E. tereticornis* (forest red gum) always present. The trees can reach a mature height of approximately 18-20 m. The composition of the understorey is variable. Many patches have a sub-canopy of smaller trees as well as a shrub layer and/or a ground layer, which is grassy or sedgy.

Many patches have been disturbed and their current state reflects this, with fire history and management involving grazing or under-scrubbing having a strong influence on the structural and floristic composition of the ecological community (Mills, 1993; NPWS, 2002a; Gellie, 2005; Miles and Kendall, 2007; Tozer et al, 2010). Some patches, which would have been part of the ecological community in the past, are now so modified that they would not meet the key diagnostic characteristics or condition thresholds for the nationally protected ecological community. For example, in derived grassland or shrubland, the canopy layer has been substantially removed, or thinned to very scattered trees (<10% canopy cover), but one or more of the understorey layers



remain largely intact. These derived grasslands or shrublands that are isolated are **not** recognised as part of this nationally protected ecological community, although they may regenerate in the future and be included in the ecological community. Small treeless areas within a patch of the ecological community may be part of that patch.

### 1.3.1 Canopy

*Eucalyptus tereticornis* (forest red gum) is always present in the mature tree canopy. Other characteristic tree species include: *Angophora floribunda* (rough-barked apple); *E. bosistoana* (coast grey box) and *E. eugenioides* (thin-leaved stringybark). *Eucalyptus globoidea* (white stringybark) and *E. longifolia* (woollybutt) may be common where drainage is slightly impeded. Amongst the other tree species commonly found in the ecological community, but not dominant are: *Corymbia maculata* (spotted gum); *E. amplifolia* ssp. *amplifolia* (cabbage gum); *E. botryoides* (bangalay); *E. paniculata* ssp. *paniculata* (grey ironbark); *E. pilularis* (blackbutt); and *E. quadrangulata* (coastal white box).

Beneath the main tree canopy there is commonly a sub-canopy of smaller trees, with height of up to 9 m. These may include tree-sized wattles such as *Acacia mearnsii* (black wattle). *Casuarina glauca* (swamp oak) is also common in the sub-canopy at some locations, particularly near drainage lines, for example at Bawley Point. Where drainage is impeded, *Melaleuca decora* (paper bark) or *M. styphelioides* (prickly leaved tea-tree) may also be common sub-canopy trees in the northern part of the range, and *M. ericifolia* (swamp paper bark) in the southern part of the range.

### 1.3.2 Understorey

In some patches, the ecological community has an understorey layer of large (height of approximately 2 m) shrubs. The density and floristic composition of the shrub layer may depend on a site's fire history, with mesic species such as *Pittosporum undulatum* (sweet pittosporum) more common at long-unburnt sites. Mesic species are also likely to be more common where rainforest communities are in close proximity, at sites with a sheltered aspect and on particular substrates, such as basanite. Other shrub species often present in the understorey include: *Breynia oblongifolia* (coffee bush); *Leucopogon juniperinus* (prickly beard-heath), *Leptospermum polygalifolium* (yellow tea tree); *Myrsine* (syn. *Rapanea*) *variabilis* (muttonwood) and *Ozothamnus diosmifolius* (rice flower).

The ground layer is often characterised by a dense cover of grasses, particularly *Microlaena stipoides* (weeping grass) and *Themeda australis* (kangaroo grass), and other grasses and forbs to a height of 1 m. At better drained sites plant species include: *Carex longebrachiata* (drooping sedge); *Commelina cyanea* (scurvy weed); *Desmodium gunnii* (southern tick-trefoil); *Dichondra* spp.; *Oplismenus imbecillis* (creeping beard grass); *Pratia purpurascens* (whiteroot); and *Poa labillardieri* (tussock grass). Other characteristic plant species include: *Arthropodium* ssp.; *Cheilanthes sieberi* (mulga fern); *Cymbopogon refractus* (barbed wire grass); *Dianella longifolia* (flax lily); *Echinopogon caespitosus* (bushy hedgehog grass); *Entolasia stricta* (wiry panic); *Eragrostis leptostachya* (paddock love grass); *Imperata cylindrica* (blady grass); *Lagenophora stipitata* (blue bottle daisy); *Lepidosperma laterale* (variable sword-sedge); and *Veronica plebeia* (trailing or creeping speedwell).

Additionally, plants with a climbing growth habit may be present, for example: *Eustrephus latifolius* (wombat berry); *Geitonoplesium cymosum* (scrambling lily); *Glycine clandestina* (twining glycine); *G. tabacina* (glycine pea); and *Pandorea pandorana* (wonga wonga vine) (Tozer et al, 2010).

For further information on plants likely to occur in the ecological community see Appendix B
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## 1.4 Faunal components of the ecological community

The ecological community includes fauna from a range of taxonomic groups. Much of the fauna of the community is shared with similar ecological communities, such as the nationally listed 'Lowland grassy woodland in the South East Corner Bioregion'. In contrast, for at least some taxa there is a clear distinction from the assemblages found in nearby rainforest, wetlands or ecological communities on the face of or above the escarpment. In the region around Wollongong, previous surveys within the coastal grassy forests found high species richness and diversity for diurnal birds, medium species richness and diversity for reptiles and arboreal mammals and high species richness and medium species diversity for bats (NPWS, 2002b).

### Mammals

The importance of *Eucalyptus tereticornis* forest in providing high quality habitat for various arboreal mammal species is noted by Mills (2004). However, in general, the mammals of the region have suffered the severe declines identified more generally for medium sized mammals across temperate Australia (Burbidge et al, 2008). Mammals that may occur in the ecological community include: *Antechinus stuartii* (brown antechinus); *A. swainsonii* (dusky antechinus); *Cercartetus nanus* (eastern pygmy possum); *Isoodon obesulus* (brown bandicoot); *Macropus giganteus* (eastern grey kangaroo); *Perameles nasuta* (long nosed bandicoot); *Petaurus breviceps* (sugar glider); *Phascolarctos cinereus* (koala); *Pseudocheirus peregrinus* (ringtail possum); *Rattus fuscipes* (bush rat); *R. lutreolus* (swamp rat); *Sminthopsis leucopus* (white-footed dunnart); *Trichosurus vulpecular* (brushtail possum); *Vombatus ursinus* (common wombat) and *Wallabia bicolor* (swamp wallaby, black wallaby) (Lunney and Leary, 1988; Friend et al, 2008; Lunney et al, 2008b; Salas et al, 2008; Office of Environment and Heritage, 2014a).

Bats are amongst the taxa recognised to have persisted within the ecological community with notable diversity, even in small remnants (NPWS, 2002b). The species are variously insectivores, frugivores and nectarivores and include: *Falsistrellus tasmaniensis* (eastern false pipistrelle); *Miniopterus shreibersii* (common bentwing bat); *Nyctophilus geoffroyi* (lesser long-eared bat); *N. gouldii* (Gould's long-eared bat); *Pteropus poliocephalus* (grey-headed flying fox); and *Vespadelus vulturnus* (little forest bat) (Lunney and Leary, 1988; NSW Scientific Committee, 2001; NPWS, 2002b; Mills, 2004).

### Reptiles

The ecological community includes reptiles from a range of groups. Species likely to be present include: *Amphibolurus muricatus* (jacky dragon); *Eulamprus quoyii* (eastern water skink); *Intellagama lesuerii lesuerii* (eastern water dragon); *Lampropholis delicata* (tiny dark-flecked sunskink); *L. guichenoti* (pale-flecked garden sunskink); *Morelia spilota spilota* (diamond python); *Pseudechis porphyriacus* (red-bellied black snake); *Pseudonaja textilis* (eastern brown snake); *Ramphotyphlops nigrescens* (blackish blind snake); *Tiliqua scincoides* (eastern bluetongue); and *Varanus varius* (lace monitor) (Atlas of Living Australia, undated a).

### Amphibians

The ecological community provides terrestrial habitat for a range of amphibian species, including retreat sites in fallen timber, rocks and standing vegetation. Any wetter areas encompassed within patches of the ecological community may also provide suitable breeding habitat for species requiring free water for this. Species that may be present include: *Crinia signifera* (common eastern froglet); *Limnodynastes peronii* (striped marsh frog); *Litoria aurea* (green and golden bell frog); *L. peronii* (Peron's tree frog); and *L. verreauxii* (Verreaux's frog); *Pseudophryne bibronii* (Bibron's Toadlet) (Atlas of Living Australia, undated b; Hero et al, 2004 a- d; Threatened Species Scientific Committee, 2014).

## Birds

Several regionally threatened owl species inhabit the ecological community and are important nocturnal predators. These include: *Ninox connivens* (barking owl); *N. strenua* (powerful owl); *Tyto novaehollandiae* (masked owl); and *T. tenebricosa* (sooty owl). *Falco peregrinus* (peregrine falcon) is amongst the diurnal raptors that may be found in the ecological community (Mills, 2004). Other predatory birds in the ecological community include *Cracticus torquatus* (grey butcherbird) and *Coracina novaehollandiae* (black-faced cuckoo-shrike).

Other bird species typical of the ecological community include: *Acanthiza nana* (yellow thornbills); *A. pusilla* (brown thornbills); *Dicaeum hirundinaceum* (mistletoe bird); *Eopsaltria australis* (eastern yellow robin); *Gerygone olivacea* (white-throated gerygone); *Lichenostomus chrysops* (yellow-faced honeyeater); *Manorina melanocephala* (noisy miner); *Pachycephala rufiventris* (rufous whistler); *Pardalotus punctatus* (spotted pardalote); *Platycercus eximius* (eastern rosella); *Rhipidura albiscapa* (grey fantail); and *Zosterops lateralis* (silvereye) (Birdlife, undated; NPWS 2002b).

For further information on animals likely to occur in the ecological community see Appendix B – Species lists

### 1.5 Key diagnostic characteristics and condition thresholds

In order to be considered a matter of National Environmental Significance under the EPBC Act, areas of the ecological community must meet:

- the key diagnostic characteristics AND
- at least the minimum condition thresholds for moderate condition (i.e. category C or D in Table 2).

National listing focuses legal protection on patches of the ecological community that are the most functional, relatively natural and in comparatively good condition.

Key diagnostic characteristics and condition thresholds assist in: identifying a patch of native vegetation as being the threatened ecological community; determining whether the referral, environment assessment and compliance provisions of the EPBC Act are likely to apply to a patch, and distinguishing between patches of different quality.

Because the ecological community exhibits various degrees of disturbance and degradation, condition categories and thresholds have been developed. These provide guidance on whether a patch retains sufficient conservation values to be considered as a matter of National Environmental Significance, as defined by the EPBC Act. This enables the EPBC Act protection provisions to be focussed on the most valuable elements of the ecological community. Very degraded patches, which do not meet the minimum condition thresholds, will be largely excluded from national protection.

Although very degraded or modified patches are not protected as part of the ecological community listed under the EPBC Act, it is recognised that some patches that do not meet the condition thresholds may still retain important natural values and may be protected through state and local laws or schemes. These patches should not be excluded from recovery and other management actions. Suitable recovery and management actions may improve a patch's condition, such that it can be included as part of the ecological community fully protected under the EPBC Act. Management actions should also be designed to restore patches to high condition.

In some cases, the loss and degradation is irreversible or rehabilitation is impractical because many natural characteristics have been removed. For instance, areas permanently converted to improved pastures are unlikely to be rehabilitated.



Species composition of this ecological community is influenced by (amongst other things) the size of the patch, proximity to other patches, recent rainfall, drought conditions and disturbance history (including fire and grazing). Plant surveys conducted during spring and early summer will more easily identify the ecological community. However, the key diagnostic characteristics and condition thresholds are designed to allow identification of the ecological community irrespective of the season.

The key diagnostic characteristics presented here summarise the main features of the ecological community. They are intended to aid its identification, noting that more details are provided in the other sections of this document. The other diagnostic considerations should also help to identify the ecological community.

### 1.5.1 Key diagnostic characteristics

For EPBC Act referral, environment assessment and compliance purposes, the national ecological community is limited to patches that meet the following key diagnostic characteristics and condition thresholds:

- The ecological community occurs within the state of New South Wales in the Jervis, Ettrema and Illawarra subregions of the Sydney Basin Bioregion and the Bateman subregion of the South East Corner Bioregion.
- The ecological community occurs between 5 and 350 m asl, on the coastal plain or foothills between the immediate coastal strip and the escarpment. The ecological community is a woodland with at least 10% canopy cover.
- *Eucalyptus tereticornis* (forest red gum) is always present in the mature tree canopy. Other characteristic tree canopy species include: *Angophora floribunda* (rough-barked apple); *E. bosistoana* (coast grey box); *E. botryoides* (bangalay); *E. eugenioides* (thin-leaved stringybark); *E. globoidea* (white stringybark); *E. longifolia* (woollybutt); and/or *E. quadrangulata* (coastal white box).
- The understorey varies between sites and contains:
  - a ground layer of grasses, herbs and sedges to a height of approximately 1 m and/or
  - a shrubby layer to a height of approximately 2 m.

### 1.5.2 Other diagnostic considerations

The ecological community may include drainage lines and periodically inundated areas but typically occurs in locations less subject to regular or long term inundation than two nearby ecological communities 'River-flat eucalypt forest on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions' (NSW Scientific Committee, 2004a) and 'Swamp sclerophyll forest on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions' (NSW Scientific Committee, 2004b).

A sub-canopy of *Melaleuca decora* (paper bark), *M. ericifolia* (swamp paper bark), *M. styphelioides* (prickly-leaved tea tree), tree-sized *Acacias* and/or *Casuarina glauca* (swamp oak) is often present.

- The ecological community occurs on a variety of substrates, most commonly fine grained sedimentary or plutonic rocks, from which sandy loam to loam soils with moderately high fertility are derived.

The ecological community is not likely to be present where there is:

- a high abundance of, or any layer dominated by rainforest-associated plant species, particularly palms or tree ferns;
- a high abundance of plant species associated with coastal sands;
- *Corymbia maculata* (spotted gum) dominant in the canopy.

It does not typically occur:

- on infertile sandy soils, basic volcanic soils or primary alluvium.

### **1.5.3 Condition thresholds for EPBC Act protection**

In order to be considered a matter of National Environmental Significance under the EPBC Act, areas of the ecological community must meet:

- the key diagnostic characteristics AND
- the minimum condition thresholds for moderate condition.

The condition thresholds for this ecological community are designed to identify the best patches for national protection (**Table 2**). As the ecological community has been heavily cleared and degraded, many of the remnants are small, isolated and modified. Any remnants that remain largely intact, include mature trees, or are connected to other native vegetation and form a large patch are a high priority for protection and management. Small, isolated patches subject to high disturbance, for example, narrow stands of trees without native understorey, either on farms or roadsides do not contribute so greatly to the conservation of the ecological community so may not meet the condition thresholds for national protection.

The listed ecological community thus comprises patches that meet the key diagnostic characteristics and also meet at least the minimum condition thresholds (**Table 2**).

- **Categories C and D are considered moderate condition and the minimum for a patch of the ecological community to be subject to the referral, environment assessment and compliance provisions of the EPBC Act.**
- **Categories A and B describe patches of the ecological community in 'high condition'. These are the highest priorities for protection and provide examples to guide restoration of lower condition patches.**

**Table 2 Condition thresholds for patches of Illawarra and south coast lowland grassy woodland**

Category and rationale	Patch size thresholds	Biotic thresholds		
A. High condition class <i>A larger patch with good quality native understorey</i>	The patch is at least 2 ha.	At least 50% of its total perennial understorey vegetation cover* is comprised of native species with at least 6 native plant species per 0.5 ha in the ground layer		
B. High condition class <i>A patch with very good quality native understorey with a species rich ground layer</i>	The patch is at least 0.5 ha.	At least 70% of the perennial understorey vegetation cover is comprised of native species with at least 10 native plant species per 0.5 ha in the ground layer		
C. Moderate condition class <i>A patch with good quality native understorey</i>	The patch is at least 0.5 ha.	At least 50% of its total perennial understorey vegetation cover* is comprised of native species with at least 6 native plant species per 0.5 ha in the ground layer		
D. Moderate condition class <i>A patch that makes other important ecological contributions</i>	The patch is at least 0.5 ha.	At least 30% of total perennial understorey vegetative cover is comprised of native species AND		
		the patch is contiguous** with another patch of native vegetation *** (at least 1 ha in area)	OR	the patch has at least one large locally indigenous tree (at least 60 cm diameter at breast height (dbh)),  or  at least one tree with hollows
*Perennial understorey vegetation cover includes vascular plant species of both the ground layer and the shrub layer (where present) with a life-cycle of more than two growing seasons. The ground layer includes herbs (graminoids and forbs) and low (≤0.5 m) shrubs, but does not include annuals, cryptogams, leaf litter or exposed soil.				
**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.				
***‘Native vegetation’ refers to areas where ≥50% of the perennial vegetation cover is comprised of native plant species.				

## 1.6 Further information to assist in determining the presence of the ecological community and significant impacts on the ecological community

Land use history influences the state of any patch of the ecological community, while the structural form of the ecological community also affects its species richness and diversity. For example, the frequency and intensity of fire may influence the level of shrubbiness, or floristic elements such as the abundance of *Pittosporum* species or *Imperata cylindrica* (blady grass). The landscape position of the patch, including its position relative to surrounding vegetation also influences how important it is in the broader landscape. For example, if it enables movement of native fauna or plant material or supports other ecological processes.

### **1.6.1 *Defining a patch***

A patch is a discrete and mostly continuous area of the ecological community. A patch may include small-scale (<50 m) variations and disturbances, such as tracks, paths or breaks (including exposed soil, leaf litter, cryptogams and watercourses/drainage lines), or localised changes in vegetation that do not significantly alter the overall functionality of the ecological community. Such breaks should not be excluded from patch size calculations.

Where there is a break in native vegetation cover, from the edge of the tree canopy of 50 m or more (e.g. due to permanent artificial structures, wide roads or other barriers; or due to water bodies typically more than 50m wide) then the gap indicates that separate patches are present.

### **1.6.2 *Buffer Zone***

A buffer zone is a contiguous area adjacent to a patch that is important for protecting the integrity of the ecological community. As the risk of damage to an ecological community is usually greater where actions occur close to a patch, the purpose of the buffer zone is to minimise this risk by guiding land managers to be aware that the ecological community is nearby and take extra care. For instance, the buffer zone will help protect the root zone of edge trees and other components of the ecological community from spray drift (fertiliser, pesticide or herbicide sprayed in adjacent land), weed invasion, water runoff and other damage.

The buffer zone is not part of the ecological community, so while having a buffer zone is strongly recommended, it is not formally protected as a matter of National Environmental Significance. For EPBC Act approval, changes in use of the land that falls within the buffer zone must not have a significant impact on the ecological community, but there are exemptions for continuing use (e.g. cropping, grazing or maintaining existing fire breaks). If the use of an area that directly adjoins a patch of the ecological community will be intensified, approval under the EPBC Act may also be required to avoid adverse impacts. The buffer zone may also be a suitable focus for revegetation or other restoration initiatives.

The recommended minimum buffer zone is between 20 and 50 m from the outer edge of the patch as this distance accounts for likely influences upon the root zone. A larger buffer zone should be applied, where practical, to protect patches that are of very high conservation value or if patches are located below drainage lines or a source of eutrophication or groundwater drawdown.

### **1.6.3 *Revegetated areas and areas of regrowth***

Revegetated or replanted sites (or areas of regrowth) are not excluded from the listed ecological community, provided that the patch meets the key diagnostic characteristics and condition thresholds above. It is recognised that reconstruction/revegetation often requires long term effort and commitment and results are uncertain. Reconstructing a woodland ecological community to a state that resembles appropriate reference sites can, at best, be extremely slow and ultimately prove unsuccessful (Wilkins et al, 2003).

### **1.6.4 *Sampling protocol***

Thorough and representative on-ground surveys are essential to accurately assess the extent and condition of the ecological community. Patches can vary markedly in their shape, size, condition and features. The size, number and spatial distribution of plots or transects must be adequate to represent variation across the patch. Sampling should address likely variation in species richness (any areas with apparently high native species richness should be included in the sample) and significant variation in the vegetation, landscape qualities and management history (where known) across the

patch. For instance, localised weed cover, drainage lines, burned or grazed areas, saline zones. Plots of 0.04 ha (quadrats of 20 x 20 m) may be suitable (Tozer, 2003; Tozer et al, 2010). It is recommended to record 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).

#### *Timing of surveys and seasonal variation*

Timing of surveys is an important consideration because the ecological community can vary in its appearance through the year and between years, depending on climatic conditions. Ideally, surveys should be held in more than one season to maximise the chance of detecting all species present. Many species are easiest to detect or identify in spring and summer to early autumn, however, for some species, such as the nationally endangered *Pterostylis gibbosa* (Illawarra greenhood orchid), late winter survey is recommended to observe flowering. When conditions are adverse, for example, during drought, this plant may not flower, or leaves may not emerge (NPWS, 2002c). In years of low rainfall, assessors should recognise that many species may not be detected. In these situations it is preferable that surveys are carried out over more than one year.

In addition to the effects of rainfall variation, presence and detectability of some species may also be affected by the time since disturbance such as fire, slashing or grazing, so surveys should be planned to occur after an adequate time for some recovery (for example, at least 6 months post fire and within two months of effective rain). 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.

#### **1.6.5 Surrounding environment, landscape context and other significant considerations**

Actions that may have 'significant impacts' on any patches of the ecological community that meet the condition thresholds require consideration under the EPBC Act. The ecological importance of a patch is influenced by its surrounding landscape, for example, if it is connected to, or near other native vegetation, the patch may contribute substantially to landscape connectivity and function. Similarly, actions beyond the boundary of any patch may have a significant impact on the patch (for example, through changes in hydrology). For this reason, when considering actions likely to have impacts on this ecological community, it is important to also consider the environment surrounding any patches of the ecological community that meet the condition thresholds.

Other patches that meet the condition thresholds may occur in isolation and in addition to requiring protection, may also require management of the surrounding area to improve their ecological function.

In some cases patches do not currently meet condition thresholds, and so are not recognised as part of the nationally protected ecological community (i.e. they are not a matter of National Environmental Significance). However, in the context of their surroundings, recovery may be possible, so these areas should be considered as a priority for management and funding.

The following indicators of the ecological context provided by the areas surrounding patches of the ecological community should be considered both when assessing the impacts of actions or proposed actions under the EPBC Act, or when considering priorities for recovery, management and funding.

- Large size and/or a large area to boundary ratio. Patches with larger area to boundary ratios are less exposed and more resilient to edge effects (such as disturbances such as weed invasion). However, 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, may also be important due to their rarity, genetic significance, or because of the absence of some threats.

- 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 hollow-bearing trees.
- Good faunal habitat as indicated by: diversity of landscape, the diversity of plant species and vegetation structure, patches containing mature trees (particularly those with hollows), logs, or rocks.
- Patches that contain a unique combination of species and/or rare or important species in the context of the particular ecological community or local region (e.g. patch with unique fauna and/or understorey flora composition; or a patch that contains flora or fauna that has largely declined in the ecological community or region).
- High native species richness, possibly including many understorey plant species or native fauna species.
- Presence of EPBC or NSW *Threatened Species Conservation Act 1995* listed threatened species.
- Areas with minimal weeds and feral animals, or where these threats can be managed.
- Presence of cryptogams, soil crust and leaf litter on the soil surface which may indicate the potential for good functional attributes such as nutrient cycling.
- Derived native grasslands or shrublands, particularly those adjacent or near to remnants of the ecological community. These can be important to the survival of the ecological community in an otherwise fragmented landscape.
- Connections to other native vegetation remnants or restoration works (e.g. native plantings) in particular, if a patch in an important position between (or linking) other patches in the landscape. This can contribute to movement of fauna and transfer of pollen and seeds. Linear road reserves often contain remnant native vegetation in at least moderate condition with a range of canopy, sub-canopy and understorey species. These areas also act as important links to larger patches of nearby vegetation. In many instances linear road reserves are the only remnant native vegetation.

#### **1.6.6 Area critical to the survival of the ecological community**

Areas that meet the minimum condition thresholds (i.e. moderate condition class in Table 2) or are within the buffer zone are considered critical to the survival of the ecological community. Additional areas such as adjoining native vegetation and areas that meet the description of the ecological community but not the condition thresholds are also considered important to the survival of the ecological community, for example, as buffers for higher condition areas, and should be considered as part of the surrounding environment and landscape context.

#### **1.6.7 Geographic extent and patch size distribution**

##### **Geographic extent**

Over 70% of the remaining extent of the ecological community occurs in the Illawarra subregion; approximately 16% is in the Jervis subregion, with small amounts in each of Ettrema and Bateman (Tozer et al, 2010; Department of the Environment, 2014). Most remnants of the ecological community are small, as clearing for grazing and agriculture has been extensive throughout the coastal plain. These activities have been concentrated within the coastal strip due to the low slopes, accessibility and good quality volcanic and alluvial soils, in comparison with the steep rocky cliffs and sandy soils of the escarpment to the west. The nature of some areas of the ecological community may



have changed structurally due to early clearing, followed by re-growth. In some locations this may also have changed the understorey from its earlier form (Mills, 1993).

As the vegetation of the region has been heavily cleared since the 19th century, the original extent of the ecological community is uncertain, but is estimated to have been between 17 667 ha and 42 667 ha (analysis of data from Tozer et al, 2010). Of this, between 10 and 24% (4200 ha) remains, of which only a portion is in good condition (**Table 3**). The most severe clearing has occurred to the lower lying vegetation with impeded drainage (Tozer et al, 2010). Information on the condition of the ecological community is very limited. In 2002, the National Parks and Wildlife Service assessed the condition of coastal grassy redgum forest (MU23), and lowland woollybutt-Melaleuca forest on the Illawarra coastal plain (MU24). These units are described as equivalent to the NSW listed ecological community (Illawarra Lowlands Grassy Woodland in the Sydney Basin Bioregion). At the time of this study approximately 5% of these three vegetation units was considered to have demonstrated only 'light' levels of disturbance, 31% 'moderate' and 22% 'heavy', with 43% present only as scattered trees. This suggests that in at least part of its range, the ecological community has been considerably damaged (NPWS, 2002a).

**Table 3 Spatial extent of the ecological community**

<b>Current extent (ha)</b>	4200
<b>Estimated maximum original area (ha)</b>	42 667
<b>Estimated minimum original area (ha)</b>	17 667
<b>Estimated maximum portion of original extent remaining (%)</b>	24
<b>Estimated minimum portion of original extent remaining (%)</b>	10

Source: Tozer et al (2010)

### **Patch size and distribution**

Where there are high levels of fragmentation, the ecological community is exposed to a range of edge effects, including damage by invasive plants and animals, contaminated runoff and harsh weather or events such as intense fires. It also inherently reduces the number of native species that can be supported within the remaining area of woodland and diminishes the ability of individual animals and plant propagules to move throughout the range of the ecological community.

Overall, the ecological community is highly fragmented (**Table 4**). The mean patch size is 4.45 ha and the median is 0.75 ha. Small patches of less than 10 ha each cover 29% of the remaining area and constitute 92% of the total number of patches. Of these small patches, the majority are very small (below 1 ha). The greatest area (53% of the total area) is comprised of medium size patches (10-100 ha), although this is only 7% of the number of patches. There are only 5 'large' patches, each above 100 ha in size, together constituting 18% of the remaining area of the ecological community.

Considering the condition class area thresholds, approximately 67% of patches are greater than the 0.5 ha minimum size for condition classes B, C and D, while approximately 27% of patches meet the 2 ha minimum size requirement for class A (analysis of data from Tozer et al, 2010).

**Table 4 Remnant patch sizes**

	Number of patches	Total area of patches in size category (ha)	% of patches	% of area
<b>Small patches <math>\leq 10</math> ha<sup>1</sup></b>	<b>834</b>	<b>1174.8</b>	<b>92</b>	<b>29</b>
<b>Medium Patches &gt;10 - <math>\leq 100</math> ha</b>	<b>67</b>	<b>2153.5</b>	<b>7</b>	<b>53</b>
<b>Large Patches &gt;100 ha</b>	<b>5</b>	<b>703.9</b>	<b>1</b>	<b>18</b>
<b>Total (&gt;0.1 ha)</b>	<b>906</b>	<b>4032.2</b>		

<b>Mean patch size ha</b>	<b>4.45</b>
<b>Median patch size ha</b>	<b>0.75</b>

Source: Tozer et al, 2010

The ecological community exists together with other types of native woody vegetation, supporting its function as part of the broader landscape. Within the Illawarra, Ettrema, Jervis and Bateman subregions, where the ecological community occurs, there are a few very large patches of woody vegetation remaining (Department of the Environment, 2014). Some of the patches of the ecological community, for example, those near Yalwal, and Bawley Point, are adjacent to extensive native woody vegetation (Tozer et al, 2010). This is likely to be their original context and support their ongoing viability. In contrast, the great majority of woody vegetation patches across each of these subregions are small, with median patch size of 1.43 ha. This reflects a history of clearing and fragmentation occurring across the area, but disproportionately affecting Illawarra and south coast lowland grassy woodland (Department of the Environment, 2014).

Many patches on the outskirts of now built up areas, for example, in the Illawarra, adjoin native woody vegetation on one side but are exposed to edge effects on the other side. Closer to intensive settlements, such as in the Illawarra, around Milton and Moruya, many patches are small isolates within a heavily cleared landscape (see Appendix D ,Figure 1).

For further information on the landscape context of the ecological community see **Appendix D- Additional information on landscape, ecology and biology**

<sup>1</sup> Patches of <0.1 ha have been excluded from this analysis as they are likely to be subject to errors of map interpretation.

## 1.7 Relationship to other vegetation classification systems

The ecological community wholly or partially corresponds with the following vegetation types:

- NPWS (2002a) map units MU23 'Coastal Grassy Red Gum Forest' and MU24 'Lowland Woollybutt-Melaleuca Forest', part of MU13 'Moist box-Red Gum Foothills Forest'.
- Tindall et al. (2004) units GW 3 'Illawarra lowland woodland' and GW 34 'South Coast Grassy Woodland'. (Priority 5 Mapping Area – known as P5MA).
- Gellie (2005) Forest Ecosystem 54 Coastal forest/red gum shrub/grass forest and possibly some overlap with Forest Ecosystem 171 Coastal shrub/grass forest-*E. tereticornis*. (Developed in the Southern Comprehensive Regional Assessment (SCRA) (Gellie, 2005; Miles and Kendall, 2007).
- Mills (2006a) Red Gum – Blue Gum Forest (TER-SAL); Red Gum – Stringybark Forest (TER-EUG). Mills (2004), citing an earlier report additionally identifies Red Gum - White Box Forest (TER-QUD), Red Gum Forest – Rainforest (TER-WRF), and Red Gum - Paperbark Forest (TER-MEL) as being associated.
- Tozer et al. (2006) map units GW p3 'South Coast Lowland Swamp Woodland' and GW p34 'South Coast Grassy Woodland'. South Coast Illawarra Vegetation Integration (SCIVI).
- Tozer et al. (2010) map units GW p3 'South Coast Lowland Swamp Woodland' and GW p34 'South Coast Grassy Woodland'.
- NSW Plant Community Type (PCT) 838 Forest Red Gum - Thin-leaved Stringybark grassy woodland on coastal lowlands, southern Sydney Basin Bioregion and PCT 1326 Woollybutt - White Stringybark - Forest Red Gum grassy woodland on coastal lowlands, southern Sydney Basin Bioregion and South East Corner Bioregion.
- Office of Environment and Heritage (2013) biometric vegetation types SR545 Forest Red Gum - Thin-leaved Stringybark grassy woodland on coastal lowlands, southern Sydney Basin, SR669 Woollybutt - White Stringybark - Forest Red Gum grassy woodland on coastal lowlands, southern Sydney Basin and South East Corner.

## 1.8 Other existing protection

The majority of the remaining area of the ecological community occurs on private land. Of the remaining area of the ecological community, approximately 275 ha (7%) is present in reserves including the following: Morton National Park, Illawarra Escarpment State Conservation Area, Yatteyattah Nature Reserve, Macquarie Pass National Park, Conjola National Park, Eurobodalla National Park and Murrumbidgee National Park. There are no private reserves known to contain the ecological community.

### 1.8.1 Relationship with other threatened ecological communities

There are several NSW listed endangered ecological communities that are commonly associated with this ecological community. In the northern part of its range, the ecological community corresponds largely with the NSW listed 'Illawarra Lowlands Grassy Woodland in the Sydney Basin Bioregion'. This listing is geographically limited to the Wollongong, Shellharbour, Kiama and Shoalhaven Local Government Areas. Qualitative differences in classification include the inclusion (in the national

ecological community) of patches where *Eucalyptus quadrangulata* (coastal white box) is present in the canopy (NSW Scientific Committee, 1999).

At the southern edge of the ecological range, near Moruya, the ecological community grades into the EPBC listed 'Lowland Grassy Woodland in the South East Corner Bioregion', and the similarly named NSW listed ecological community. Similar to Illawarra and south coast lowland grassy woodland, that ecological community frequently has a canopy dominated by *Eucalyptus tereticornis* (forest red gum), as well as a grassy and sometimes shrubby understorey (although a continuous grassy cover is more typical). In contrast, its distribution is likely to be further south and west, in drier rainshadow areas associated with coastal valleys, and on more granitic substrate with sandier soils. Floristically, it contains fewer mesic elements and does not typically contain *Corymbia maculata* (spotted gum) in the canopy or *Casuarina glauca* (swamp oak) in the sub-canopy. It may also be dominated by some *Eucalyptus* species characteristic of drier areas, further from the coast, for example, *E. melliodora* (yellow box) and *E. pauciflora* (snow gum). Unlike the Illawarra and south coast lowland grassy woodlands, this EPBC and NSW listed ecological community does not always contain *E. tereticornis* in the canopy (NSW Scientific Committee, 2007; Threatened Species Scientific Committee, 2013a).

'River-flat Eucalypt Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions' is another NSW listed ecological community that occurs throughout the latitudinal range of Illawarra and south coast lowland grassy woodland. It generally occurs in lower and more frequently wet parts of the landscape than Illawarra and south coast lowland grassy woodland; usually below 50 m, along watercourses and adjacent areas that are periodically inundated, and not on hill slopes. The two ecological communities share floristic elements such as a canopy of *Eucalyptus* and *Angophora* trees, including *E. tereticornis*, *E. amplifolia* (cabbage gum), *E. botryoides* (bangalay) and *A. floribunda* (rough-barked apple), as well as a sub-canopy including *Casuarina glauca* (swamp oak), *Melaleuca decora* (paper bark) and *M. styphelioides* (prickly leaved tea tree) and with shrubs or a grassy ground layer. Primary floristic differences in river-flat forest include the canopy species *E. baueriana* (blue box), *E. elata* (river peppermint) and *E. ovata* (swamp gum), as well as sub-canopy species including *Backhousia myrtifolia* (grey myrtle) and *Melia azaderach* (white cedar) (NSW Scientific Committee, 2004a; Miles and Kendall, 2007).

'Bangalay sand forest, Sydney Basin and South East Corner Bioregions' is listed as 'endangered' in NSW. It is dominated by the trees *Eucalyptus botryoides* (bangalay) and *Banksia integrifolia* ssp. *integrifolia* (coast banksia). It may include *E. pillularis* but does not typically include *E. tereticornis* in the canopy. It occurs on sandy substrates at low altitudes (below 100m) (NSW Scientific Committee 2005).

'Swamp sclerophyll forest on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner' is listed as endangered in NSW and occurs within the same geographic area as Illawarra and south coast lowland grassy woodland. It occurs on the more low-lying areas of the landscape, prone to flooding and longer term water-logging. It does not occur on higher slopes towards the escarpment. The main canopy species include *Melaleuca quinquenervia* (paperbark), *Eucalyptus botryoides* and *E. longifolia* (woollybutt) and *E. robusta* (swamp mahogany) however unlike in the Illawarra and south coast lowland grassy woodland, it does not typically include *E. tereticornis* (NSW Scientific Committee, 2004b).

'Swamp oak floodplain forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions' is another low-lying ecological community with a geographical distribution overlapping that of the Illawarra and south coast lowland grassy woodland. It is listed as

‘endangered’ in NSW. Within the area of overlap, the dominant canopy tree species is *Casuarina glauca* (swamp oak), rather than *Eucalyptus* species (NSW Scientific Committee, 2004c).

Similarly, the distribution of the NSW listed endangered ecological community ‘Illawarra subtropical rainforest in the Sydney Basin Bioregion’ overlaps with the northern extent of the Illawarra and south coast lowland grassy woodland, extending from the coastal plain to the foothills of the escarpment. Where adjacent, the rainforest may be more likely to occur on soils derived from volcanic, rather than sedimentary substrates (Mills and Jakeman, 1995). *Eucalyptus* and *Acacia* species may be present in the canopy but the species abundant in both the canopy and understorey are more typical rainforest species characteristic of moister areas with little disturbance by fire (NSW Scientific Committee, 2002).

### 1.8.2 Listed threatened flora and fauna species

The ecological community provides habitat for a range of flora and fauna species listed under the Threatened Species Conservation Act (NSW, 1995) or the Environment Protection and Biodiversity Conservation Act (Commonwealth, 1999) (Table 5).

**Table 5 Threatened flora and fauna that may occur in the ecological community**

Scientific names are current at October 2015

Scientific Name	Common Name	EPBC Act CE = Critically Endangered; E = Endangered; V = Vulnerable	NSW TSC Act CE = Critically Endangered; E = Endangered; V = Vulnerable
<b>Flora</b>			
<i>Chorizema parviflorum</i>	eastern flame pea		Endangered population
<i>Lespedeza juncea</i> subsp. <i>sericea</i>	Chinese lespedeza		Endangered population
<i>Pimelea curviflora</i> var. <i>curviflora</i>	curved rice flower	V	V
<i>Pterostylis gibbosa</i>	Illawarra greenhood	E	E
<i>Solanum celatum</i>			E
<b>Fauna</b>			
<i>Anthochaera (Xanthomyza) phrygia</i>	regent honeyeater	CE	CE
<i>Calyptrorhynchus lathamii</i>	glossy black cockatoo		V
<i>Cercartetus nanus</i>	eastern pygmy possum		V
<i>Chalinolobus dwyeri</i>	large eared pied bat	V	V
<i>Daphoenositta chrysoptera</i>	varied sittella		V
<i>Dasyurus maculatus maculatus</i>	spotted-tail quoll	E	V
<i>Falsistrellus tasmaniensis</i>	eastern false pipistrelle		V
<i>Glossopsitta pusilla</i>	little lorikeet		V
<i>Hieraaetus morphnoides</i>	little eagle		V
<i>Lathamus discolor</i>	swift parrot	E	E

Scientific Name	Common Name	EPBC Act CE = Critically Endangered; E = Endangered; V = Vulnerable	NSW TSC Act CE = Critically Endangered; E = Endangered; V = Vulnerable
<i>Litoria aurea</i>	green and golden bell frog	V	E
<i>Mormopterus norfolkensis</i>	eastern free-tail bat		V
<i>Myotis macropus</i>	large footed mouse eared bat; southern myotis		V
<i>Ninox strenua</i>	powerful owl		V
<i>Ninox connivens</i>	barking owl		V
<i>Petroica boodang</i>	scarlet robin		V
<i>Phascolarctos cinereus</i>	koala	V	V
<i>Pteropus poliocephalus</i>	grey headed flying fox	V	V
<i>Saccolaimus flaviventris</i>	yellow bellied sheath tailed bat		V
<i>Scoteanax rueppellii</i>	greater broad-nosed bat	V	V
<i>Stagonopleura guttata</i>	diamond fire tail		V



*Pterostylis gibbosa* (Illawarra greenhood orchid),  
Croome Reserve



## 2 SUMMARY OF THREATS

The ecological community occurs within a landscape that has mixed uses, including agriculture, industrial use and housing. In the past, clearing was primarily for agriculture, and actions such as culling of native fauna were taken largely to support agricultural productivity. Many of the current and future threats to the community are associated with clearing and fragmentation for the rapid development of housing and associated infrastructure, which is causing substantial landscape change along the NSW south coast. The range of threats faced by the ecological community are briefly described in a list here, but in practice, these threats may interact, rather than acting independently. The primary known threats to the ecological community are:

### **Clearing and fragmentation of vegetation and associated changes to hydrology**

This is currently occurring primarily for housing and light industrial developments and associated infrastructure such as roads, for example, the upgrade of the Princes Highway. In addition, urban development and the associated increase in human populations have increased pressure on nearby natural areas, with impacts including bike trails, rubbish dumping and firewood collection.

### **Weeds**

Agricultural weeds and garden escapees contribute to the total weed load, causing competition for light, space, water and nutrients. One of the most problematic species is common lantana (*Lantana camara*), although this can provide protective habitat for some fauna (NPWS, 2002b; Mills, 2004). African olive (*Olea europaea* ssp. *cuspidata*) is an emerging threat in some areas (Department of Environment, Climate Change and Water, 2011).

### **Feral animals**

Feral animal species present, and likely to affect the ecological community by predation and competition to native fauna include cats, foxes, introduced rats and mice and honey bees (Birdlife, undated). Goats may be a problem in some areas (Department of Climate Change and Water, 2011).

### **Fire**

Fire regimes have been changed throughout the region, in association with agriculture and urban development. These changes are likely to have affected the composition and structure of the ecological community. In particular, reduced fire frequency facilitates the spread of shrubby mesic species from adjacent rainforest ecological communities, and can reduce ground layer diversity, while more frequent fire may reduce the ability of some plants to regenerate.

### **Agriculture and grazing**

Many of the low-lying areas along the NSW coast have been grazed since the 19<sup>th</sup> century, with activities such as tree removal, converting to exotic pastures and ‘underscrubbing’ of vegetation also associated (Lunney and Leary, 1988; Mills and Jakeman, 1995). Effects of ongoing grazing include changes to the nutrient status and structure of soils, affecting species composition and preventing regeneration of vegetation.

### **Logging and timber removal**

Within the range of the ecological community, native forest logging has impacts including direct clearance of vegetation, construction of roads and regional changes to hydrology. Logging activities include small scale removal of trees for fencing, removal of dead trees and timber for firewood. This extraction impacts directly on the regional populations of native fauna and indirectly, by reducing ecological connectivity. This is likely to impede ecological processes such as transfer of pollen and seeds.

## **Climate change**

Climate change is likely to change the character of the community by altering resource availability and the competitive relationships between species. Likely changes include increases in temperatures, changes to the seasonality and intensity of rainfall, with unknown compounding effects on other disturbances such as fire.

## **Quarrying**

In some areas, particularly in the Illawarra, where most remnants of the ecological community occur, extraction of hard rock may cause clearing and fragmentation of vegetation as well as regional impacts such as changes to hydrology (Department of Environment, Climate Change and Water, 2011)



Rubbish dumping affecting an urban remnant containing the ecological community in Wiseman's Park, Gwynneville

## 2.1 Key Threatening Processes

Key threatening processes have been defined at the national level under the EPBC Act and for NSW under the NSW Threatened Species Act. Those most relevant to Illawarra and south coast lowland grassy woodland are listed in Table 6.

**Table 6 Potentially relevant key threatening processes identified in the Threatened Species and Communities Act (NSW) and the EPBC Act.**

NSW TSC Act	EPBC Act
Clearing of native vegetation	Land clearance
Invasion, establishment and spread of <i>Lantana camara</i>	
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
Removal of dead wood and dead trees	
Predation by the feral cat ( <i>Felis catus</i> )	Predation by feral cats
Predation by the European red fox ( <i>Vulpes vulpes</i> )	Predation by European red fox
Loss of hollow-bearing trees	
Anthropogenic climate change	Loss of climatic habitat caused by anthropogenic emissions of greenhouse gases
High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition	
Invasion of native plant communities by exotic perennial grasses	
Herbivory and environmental degradation caused by feral deer	
Invasion of native plant communities by <i>Chrysanthemoides monilifera</i> (bitou bush and boneseed)	
Invasion of native plant communities by African Olive <i>Olea europaea</i> L. subsp. <i>cuspidata</i>	
Competition from feral honey bees ( <i>Apis mellifera</i> )	

Sources: Office of Environment and Heritage (2015b); Australian Government Department of the Environment (2015a).

**MORE INFORMATION ON THREATS TO THE ECOLOGICAL COMMUNITY IS PROVIDED IN APPENDIX E**

### 3 SUMMARY OF ELIGIBILITY FOR LISTING AGAINST EPBC ACT CRITERIA

#### Criterion 1 – Decline in geographic distribution

Illawarra and south coast lowland grassy woodland originally occupied much of the relatively fertile, low-lying coastal strip between the north of Wollongong and south of Moruya. This area was attractive for primary industries such as logging, agriculture and grazing, and so was quickly cleared following non-Indigenous settlement. More recently, patches have also been cleared for housing and commercial development and associated infrastructure such as roads. The area occupied by the ecological community is estimated to have declined by 76-90% (Tozer et al, 2010). As the ecological community is considered to have undergone a severe decline (at least 70%) in its geographic extent it is eligible for listing as **endangered** under this criterion.

#### Criterion 2 – Limited geographic distribution coupled with demonstrable threat

The current area of occupancy of the ecological community is estimated to be up to 4 200 ha (Tozer et al, 2010). This is considered to be ‘restricted’ (being <10 000 ha). The area is also highly fragmented. Although there are several patches greater than 100 ha, 92% of patches are smaller than 10 ha. The mean patch size for the ecological community is 4.45 ha and the median size is 0.75 ha, which is considered to be ‘very restricted’ (analysis of data from Tozer et al, 2010).

The ecological community is subject to a range of threats, both due to past land practices and current and future activities such as development of land for housing, commercial activities and supporting infrastructure. Given the very restricted nature of the ecological community, the decline in area likely to meet the condition thresholds for the nationally protected ecological community will plausibly lead to its complete loss within the immediate future (considered to be 60 years for this ecological community)<sup>2</sup>. Therefore the ecological community is eligible for listing as **critically endangered** under this criterion.

#### Criterion 3 – Loss or decline of functionally important species

The loss of fauna species from the ecological community is likely to have a negative effect on ecological function, through the reduction of pollination, seed dispersal and soil engineering. However, specific data related to the decline of functionally important species is not available. As such, **insufficient information** is available to determine eligibility against any category for this criterion.

#### Criterion 4 – Reduction in community integrity

The integrity of the ecological community has been substantially compromised through various types of local damage and broad scale landscape change. Much of the damage is intractable and many of the underlying threats continue. While active interventions may make some valuable contributions to conservation, complete restoration of the ecological functions underpinning the ecological community is unlikely in the near future. Therefore the ecological community is eligible for listing as **critically endangered** under this criterion.

#### Criterion 5 – Rate of continuing detrimental change

The ecological community has experienced substantial clearing and fragmentation due to agriculture and grazing. Pressures associated with these land uses continue, while additional pressures are associated with urbanisation of the NSW south coast. While detrimental change is likely to continue,

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<sup>2</sup> One of the key diagnostics of the ecological community is the presence of *Eucalyptus tereticornis* in the mature canopy. The generation time of this species is used here to define the ‘immediate future’ for the ecological community. The species is widely distributed and highly variable (Boland et al, 1984), however, the average age of the trees producing viable seed germinating as seedlings is likely to be greater than 20 years (Jacobs, 1955; Florence, 1996; Law et al, 2000). The maximum allowable time for three generations of this species (60 years) is thus applied.

there is **insufficient information** available on the rates of loss in the recent past, or planned for the immediate future to determine eligibility against any category for this criterion.

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

No quantitative analysis has been undertaken showing likelihood of extinction for this ecological community. Therefore there is **insufficient information** available to determine eligibility against any category for this criterion.

More information on eligibility of the ecological community against the EPBC listing criteria can be found at Appendix F – Eligibility for listing against EPBC Act criteria.



*Daviesia ulicifolia* (Bitter gorse pea), Guerilla Bay.

## 4 PRIORITY RESEARCH AND CONSERVATION ACTIONS

### 4.1 Conservation Objective

The conservation objective provides the goal and rationale for the priority actions identified here.

The conservation objective is to mitigate the risk of extinction of the Illawarra and south coast grassy woodland ecological community, and help recover its biodiversity and function, through:

- protecting it using the *Environment Protection and Biodiversity Conservation Act 1999*; and
- implementing priority conservation actions (as outlined in Sections 4.2-4.4 below).

### 4.2 Priority protection and restoration actions

It is more practical and cost-effective to maintain existing high quality remnants than to allow their degradation and then attempt rehabilitation of these or other areas. The more disturbed and modified a patch of the ecological community, the greater is the recovery effort required. To gain the most cost-effective outcomes of investments in management it is important to consider the likely interaction of management actions at any one site, as these may be synergistic or antagonistic. There are also likely to be interactions between sites (Auerbach et al, 2015). Additionally, when allocating resources it is important to consider the minimum investment required for success and the follow up required to secure long term recovery.

Priority actions are recommended for the abatement of threats and supporting recovery of the ecological community. Actions inconsistent with these recommendations that are likely to significantly affect the ecological community should not be undertaken.

In assessment of activities that may have a significant impact on the ecological community, incorporate relevant actions listed below when determining recommendations including conditions of approval. Applications to Australian Government funding programs should also consider prioritising these restoration activities. Also take into consideration the information outlined in section 1.6 'Further information to assist in determining the presence of the ecological community and significant impacts'.

The three key approaches to achieve the conservation objective are:

- 1) **PROTECT** the ecological community to prevent further loss of extent and condition;
- 2) **RESTORE** the ecological community within its original range by active abatement of threats, re-vegetation and other conservation initiatives;
- 3) **COMMUNICATE WITH AND SUPPORT** researchers, land use planners, landholders, land managers, community members, including the Indigenous community, and others to increase understanding of the value and function of the ecological community and encourage their efforts in its protection and recovery.



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



## **PROTECT**

### ***Vegetation clearance and direct habitat damage***

#### Highest priorities

- Prevent further clearance, fragmentation or detrimental modification of remnants of the ecological community and of surrounding native vegetation. High conservation value, unmodified and older regrowth areas are particularly important for retention and management.
  - Identify high quality remnants in advance of zoning and development planning decisions. These high quality patches should not be reduced or damaged.
  - Recognise the landscape position of remnants of the ecological community and ensure that planning supports increased resilience within the landscape (for example, by retaining appropriate connectivity between remnants of all naturally occurring ecological communities).
  - Apply recommended buffers of at least 20-50 m around patches of the ecological community.
  - Protect mature trees with hollows, even if they are dead.
  - Retain other native vegetation remnants, derived native grasslands or shrublands and mature paddock trees near patches of the ecological community where they are important for connectivity.
  - Prevent loss and damage of trees through cutting for firewood and fencing.
  - New walking or bike tracks should be near, rather than through patches of the ecological community
- Ensure that areas that form important landscape connections, such as wildlife corridors or other patches of particularly high quality or regional importance are considered for inclusion in formal reserve tenure or other conservation related tenure for protection and management in perpetuity.
- Avoid offsetting. Further, it is not appropriate to offset losses to this ecological community with any other ecological community. Further information is in Section 4.5 'Offsets'.

#### Other priorities

- Protect the soil seed bank by minimising soil disturbance and removal.
- Prevent impacts to native vegetation, native fauna, hydrology or soil structure from any developments and activities adjacent to or near patches of the ecological community by planning for and appropriately mitigating off-site effects. For instance, apply buffer zones and avoid activities that could cause significant hydrological change or eutrophication.
- Retain habitat features for fauna, noting species requirements (e.g. rocks, logs embedded in the soil or hollow logs). If necessary, supplement, (but do not replace) habitat by placing artificial hollows (e.g. various sized nest boxes) in, or near to, the ecological community. Maintain the boxes and monitor outcomes.

### ***Weeds, disease and feral animals***

#### Highest priorities

- Do not plant (or spread) known, or potential, environmental weeds within or near the ecological community:

- prevent activities such as dumping garden waste in patches of the ecological community.
- control runoff, eg. urban runoff to prevent movement of weed material into natural areas.
- Prevent further introduction of feral animals and contain domestic animals within new residential areas (e.g. ACT Government, 2016).
- Monitor for signs of new disease or incursions by new weeds for example, African olive, gorse, African boxthorn or blackberry (Department of Environment, Climate Change and Water, 2011) or pest animals, for example goat and deer, and manage early for local eradication.

#### Other priorities

- Ensure stock do not carry weeds into patches of the ecological community by using holding paddocks to purge seeds.
- Use appropriate hygiene to minimise the introduction or spread of weeds and diseases at susceptible sites. 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 and weed seeds.
- Implement strategic responses to rural tree dieback, in particular, implement preventative measures.

#### *Fire*

- Use a landscape-scale approach and available knowledge on fire histories and age of stands, to identify appropriate fire regimes. For example, in the Shellharbour Local Government Area 5-40 years has been recommended as an appropriate fire interval for the ecological community: no more frequent than every five years for the 'grassy woodland sub-community' with a longer period (25-40 years) suggested for 'moist forest sub-community' areas (Shellharbour City Council, 2010; Department of Environment, Climate Change and Water, 2011).
- Implement appropriate fire management regimes for the ecological community taking into account results from research. These may include some of the following actions:
  - burning to control annual weeds, or reduce dominance by some species, such as *Pittosporum* species taking into consideration the likely requirements of other species;
  - do not burn during reproductive seasons of threatened or other high priority native flora, and fauna species (e.g. Illawarra greenhood orchid);
  - avoid burning roost sites for threatened bats and protect tree hollows (Department of Environment, Climate Change and Water, 2011);
  - do not burn if soil moisture is very low, or dry conditions are predicted for the coming season;
  - within large patches burn different parts in rotation, rather than the whole area in any one season. In Shellharbour it has been recommended that no more than 50% of a patch is burnt at any one time (Shellharbour City Council 2010); more generally it has been recommended that in any Local Government Area, at least 50% of the ecological community is in a state burned less frequently than the minimum fire interval (Department of Environment, Climate Change and Water, 2011).
  - avoid slashing or tree removal as part of fire management

- consider fire regimes appropriate for nearby ecological communities when planning burning (for example, where rainforests are adjacent).
- Monitor outcomes of fire and manage consequences (e.g. weeds and feral predators).

### **Grazing**

- Occasional grazing may be beneficial for reducing grass cover, encouraging herb growth and minimising shrub regeneration. It can be particularly helpful in managing some weeds such as African olive. However, it can also negatively affect understorey species composition (Department of Environment, Climate Change and Water, 2011). Strategically manage total herbivore grazing (by native and domestic animals), for instance by:
  - fencing of regrowth, revegetation areas, or sites with threatened, regionally important or diverse understorey species;
  - ensuring that timing allows regeneration of plants: allow moderate to high intensity grazing for a short period of time, usually in early spring, and wherever possible avoid grazing during peak native plant flowering and seeding times for many species (late spring and summer);
  - ensuring that stock do not introduce weed seeds to the patch (see weeds section)
  - using permanent or temporary fences to protect some areas from grazing.
- Integrate appropriate grazing management regimes with fire management requirements.
- Provide alternative shelter areas for stock, for example, by planting shade trees in nearby cleared areas
- Manage populations of feral animals that damage native vegetation, including deer and rabbits.

## **RESTORE**

### **Re-vegetation**

#### Highest priorities

- Implement optimal regeneration, revegetation and restoration strategies for the ecological community, across the landscape. In general, use locally collected seed where available to create an appropriate canopy and diverse understorey, however, choosing sources of seed closer to the margins of their range may increase resilience to climate change. Consider particularly the needs of species of conservation concern or known to be of functional importance for the ecological community. For example, ecological restoration plantings including *Eucalyptus tereticornis* are recommended to support grey-headed flying fox populations, providing reliable winter food and relieving a bottleneck that affects these populations in their breeding season (Law et al, 2002).
- Restore wildlife corridors and linkages (where appropriate) between remnants of the ecological community and other areas of native vegetation or reconstructed habitat, to reduce fragmentation and isolation.

#### Other priorities

- Encourage appropriate use of local native species in developments and revegetation projects through local government and industry initiatives.

- Implement effective adaptive management regimes using information from relevant research. Refer to the National Standards for the Practice of Ecological Restoration in Australia to assist in setting goals, planning actions and monitoring outcomes (Society for Ecological Restoration Australasia, 2015).

### ***Control invasive species and diseases***

#### Highest priorities

- Map weed occurrence and prioritise management of weeds in high quality patches or where threatened or regionally significant species are known to occur.
- Implement effective control and management techniques for weeds currently affecting the ecological community, such as *Lantana camara*, integrating this with alternative habitat provision and predator control.

#### Other priorities

- Where feasible, control introduced pest animals through consolidated landscape-scale programs.
- Manage weeds before and after fire, and during revegetation works to maximise success of restoration.
- Ensure actions to control invasive or other pest species avoid impacts on non-target species and do not have any long-term adverse impacts upon the ecological community:
  - ensure workers are appropriately trained in the use of relevant herbicides, pesticides and what to target;
  - avoid chemical spray drift and off-target damage within or near to the ecological community, having regard to minimum buffer zones.

## **COMMUNICATION AND SUPPORT**

### ***Education, information and local regulation***

- Develop a communication strategy, education programs, information products and signage to help local communities, planners and managers recognise:
  - the presence and importance of the ecological community;
  - the appropriate management of patches of the ecological community;
  - responsibilities under state and local regulations and the EPBC Act.
- Promote knowledge about local weeds, means to control these and appropriate alternative species to plant.
- Develop education programs to discourage damaging activities such as the removal of dead timber, the dumping of rubbish (particularly garden waste), creation of informal paths and the use of off-road vehicles in patches of the ecological community.
- Encourage local participation in recovery efforts, removing threats and actively restoring existing patches, as well as supplementing these. This may be achieved through adoption of patches by local conservation groups or encouraging short term involvement through field days and planting projects, with appropriate follow-up.

- Ensure planners and participants are aware of appropriate species to plant across the range of the ecological community, the best opportunities to restore landscape connectivity and encourage natural regeneration and the best known techniques for the site conditions and species being planted.
- Ensure commitment to follow-up after planting, such as care of newly planted vegetation by watering, mulching, weeding and removal of tree guards.
- Promote awareness and protection of the ecological community with relevant agencies and industries. For example with:
  - state and local government planning authorities, to ensure that planning takes the protection of remnants into account, with due regard to principles for long-term conservation;
  - land developers and construction industries, to minimise threats associated with land development;
  - local councils and state authorities, to ensure road widening and maintenance activities (or other infrastructure or development activities) involving substrate or vegetation disturbance do not adversely impact the ecological community. This includes avoiding the introduction or spread of weeds and avoiding planning new roads or paths through patches of the ecological community;
  - the use of signs to identify good examples of the ecological community.
- In new residential developments include measures to limit additional impacts from domestic animals and invasive plants. These may include:
  - public education;
  - cat exclusion areas;
  - requirements for registering and sterilising cats;
  - requirements for dogs to remain on leash in natural areas;
  - lists of suitable species for gardens to provide habitat and complement natural areas;
  - lists of invasive plant species to avoid planting in gardens.
- Liaise with local fire management authorities and agencies and engage their support in fire management of the ecological community.

### ***Incentives and support***

- Support opportunities for traditional owners or other members of the Indigenous community to manage the ecological community.
- Implement formal conservation agreements (for example, covenants) for sites containing the ecological community.
- Develop coordinated incentive projects to encourage conservation and stewardship on private land, and link with other programs and activities, especially those managed by Local Land Services.

### 4.3 Research and monitoring priorities

Relevant and well-targeted research and other information gathering activities are important in informing the protection and management of the ecological community. Coordination with individuals and groups with responsibilities for planning and on ground management is important to ensure that research questions and methods are well chosen, and that the information gathered can be applied to the benefit of the ecological community. Research and ongoing management activities can often be integrated to achieve the best results in the face of ongoing change. It is important that any monitoring is planned before management commences, considering data requirements to address research questions. Monitoring must also be resourced for the duration of the management activities, especially for those using a novel approach.

High priority research and monitoring activities to inform protection, management and restoration of the Illawarra and south coast grassy woodland ecological community include the following:

- Improve and update maps of the ecological community across its range:
  - support field survey and interpretation of other data such as aerial photographs and satellite images to more accurately document current extent, condition, threats, function, presence and use by regionally significant or threatened species.
  - support and enhance existing programs to model the pre-1750 extent across the entire range of the ecological community to inform restoration; identify the most intact, high conservation value remnants and gain a better understanding of variation across the ecological community.
- Determine priority areas for restoration to enhance connectivity and landscape resilience.
- Conduct research leading to the development of effective landscape-scale restoration techniques for the ecological community. Investigate the interaction between disturbance types such as fire, grazing and invasion by weeds and feral animals to determine how an integrated approach to threat management can be implemented.
- Research the effects of fire on floristics and structure of vegetation, and fauna in patches and across the broader landscape. Identify and publish appropriate fire management regimes to conserve key species and the broader ecological community.
- Undertake or support ongoing research aimed at managing feral animals and major weeds, such as *Lantana camara* (while recognising that this weed also plays a role in providing protective habitat).
- Assess the vulnerability of the ecological community to climate change and investigate ways to improve resilience through other threat abatement and management actions.
- Investigate key ecological interactions, such as the role of fauna in pollination, seed dispersal and nutrient cycling.
- Investigate the most cost-effective options for restoring landscape function, including:
  - re-vegetation of priority areas, potentially buffering, connecting and protecting existing remnants.
  - predator control options such as trapping and baiting, urban containment, exclusion fencing;
  - re-introduction of key fauna



- Monitor changes in condition, 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.

#### 4.4 Derived grassland and shrublands conservation actions

Some patches, which would have been part of the ecological community in the past, are now in modified states that do not meet the typical vegetation description above. For example, in derived grassland or shrubland, the canopy layer has been substantially removed, or thinned to very scattered trees (<10% canopy cover), but one or more of the understorey layers remain largely intact.

Derived grasslands or shrublands that are isolated are **not** recognised as part of this nationally protected ecological community, although small treeless areas within a patch of the ecological community may be part of that patch. Nonetheless, these grasslands and shrublands are an important part of the broader ecosystem and may have potential for restoration, possibly to a condition that will make them eligible for later inclusion in the nationally protected ecological community. They may contain much of the native plant biodiversity of the ecological community and act as a seed bank and source of genetic material. Derived grasslands and shrublands can act as buffers that protect the ecological community from activities in adjacent areas, and may also act as stepping stones enabling the movement of some species between remnant woodlands. For this reason they should also be considered as part of the surrounding environment and national context for patches of the ecological community.

Evidence that a patch of derived grassland or shrubland formerly contained the ecological community can include tree stumps, fallen logs, historical records, photographs, surrounding vegetation remnants, or reliable modelling of vegetation present before 1750.

#### 4.5 Offsets

Offsetting is a last resort, used as an attempt to compensate for damage to the ecological community which is deemed unavoidable. The ecological outcomes of offsetting activities are generally uncertain. With regard to any proposals involving offsets for this ecological community, which has been greatly reduced in spatial extent and condition, the aims should be to:

- avoid the need to offset;
- retain remaining areas with mature trees and other high quality patches rather than offset;
- manage and protect offset areas in perpetuity in areas dedicated for conservation purposes; avoid reducing their size, condition and ecological function;
- increase the area and improve ecological function of the woodlands, for example by enhancing landscape connectivity, habitat diversity and condition;
- focus on the restoration of moderate condition patches to achieve high condition (see the high condition classes in the condition thresholds in Table 2);
- extend protection to otherwise unprotected sites. This may include patches that do not meet the condition thresholds for national protection but can reasonably be restored to a better, more intact condition;
- avoid the location of offsets distant from the site of impact, as there is local variation of the ecological community.

#### 4.6 Existing plans/management prescriptions

The NSW Government has issued an Action Statement for the state-listed Illawarra lowlands grassy woodland in the Sydney Basin Bioregion. The management objective is to “maximise the extent of occurrence and condition of the ecological community across NSW” (Office of Environment and Heritage, undated b).

Other threat abatement plans and recovery plans relevant to the ecological community include:

Department of the Environment (2015). Threat abatement plan for predation by feral cats, Commonwealth of Australia.

Available on the internet at:

<http://www.environment.gov.au/system/files/resources/78f3dea5-c278-4273-8923-fa0de27aacfb/files/tap-predation-feral-cats-2015.pdf>

Department of Environment and Climate Change (NSW) (2008). Recovery plan for the koala (*Phascolarctos cinereus*).

Available on the internet at:

[www.environment.nsw.gov.au/resources/threatenedspecies/08450krp.pdf](http://www.environment.nsw.gov.au/resources/threatenedspecies/08450krp.pdf)

Department of Environment and Conservation (NSW) (2005). *Zieria granulata* (Illawarra Zieria) recovery plan.

Available on the internet at:

[www.environment.gov.au/system/files/resources/b39f50e4-0e21-432e-9873-f3e18e319b0d/files/zieria-granulata.pdf](http://www.environment.gov.au/system/files/resources/b39f50e4-0e21-432e-9873-f3e18e319b0d/files/zieria-granulata.pdf)

Department of Environment and Conservation (NSW) (2006). Southern Brown Bandicoot (*Isoodon obesulus*) Recovery Plan. NSW DEC, Hurstville NSW.

Available on the internet at:

[www.environment.nsw.gov.au/resources/nature/SouthernBrownBandicootFinalRecoveryPlan.pdf](http://www.environment.nsw.gov.au/resources/nature/SouthernBrownBandicootFinalRecoveryPlan.pdf)

Department of the Environment and Heritage (2006). Threat abatement plan for infection of amphibians with chytrid fungus resulting in chytridiomycosis.

Available on the internet at

[www.environment.gov.au/biodiversity/threatened/publications/tap/infection-amphibians-chytrid-fungus-resulting-chytridiomycosis](http://www.environment.gov.au/biodiversity/threatened/publications/tap/infection-amphibians-chytrid-fungus-resulting-chytridiomycosis)

Department of Environment and Heritage Protection (2012). Koala-sensitive design guideline. A guide to koala-sensitive design measures for planning and development activities.

Available on the internet at:

[www.ehp.qld.gov.au/wildlife/koalas/legislation/pdf/koala-sensitive-design-guideline.pdf](http://www.ehp.qld.gov.au/wildlife/koalas/legislation/pdf/koala-sensitive-design-guideline.pdf)

Department of the Environment, Water, Heritage and the Arts (DEWHA) (2008). Background document for the threat abatement plan for predation by the European red fox, DEWHA, Canberra.

Available on the internet at:

[www.environment.gov.au/system/files/resources/1846b741-4f68-4bda-a663-94418438d4e6/files/tap-fox-background.pdf](http://www.environment.gov.au/system/files/resources/1846b741-4f68-4bda-a663-94418438d4e6/files/tap-fox-background.pdf)

NSW National Parks and Wildlife Service (2002). *Pterostylis gibbosa* (R.Br.) Illawarra Greenhood Orchid Approved Recovery Plan

Available on the internet at

[www.environment.nsw.gov.au/resources/nature/approvedPterostylisGibbosa.pdf](http://www.environment.nsw.gov.au/resources/nature/approvedPterostylisGibbosa.pdf)

Office of Environment and Heritage (undated). Action Statement *Chorizema parviflorum* Benth. in the Wollongong and Shellharbour Local Government Areas (*Chorizema parviflorum* - endangered population).

Available on the internet at:

[www.environment.nsw.gov.au/savingourspeciesapp/project.aspx?ProfileID=10167](http://www.environment.nsw.gov.au/savingourspeciesapp/project.aspx?ProfileID=10167)

Illawarra Councils (2010) Illawarra Biodiversity Strategy (draft). Wollongong City Council, Shellharbour City Council, Kiama Municipal Council  
Available on the Internet at  
[www.wollongong.nsw.gov.au/council/haveyoursay/Pages/IllawarraBiodiversityStrategy.aspx](http://www.wollongong.nsw.gov.au/council/haveyoursay/Pages/IllawarraBiodiversityStrategy.aspx)  
This document identifies 'Illawarra grassy woodland' as being one of the highest priority vegetation types in the region.

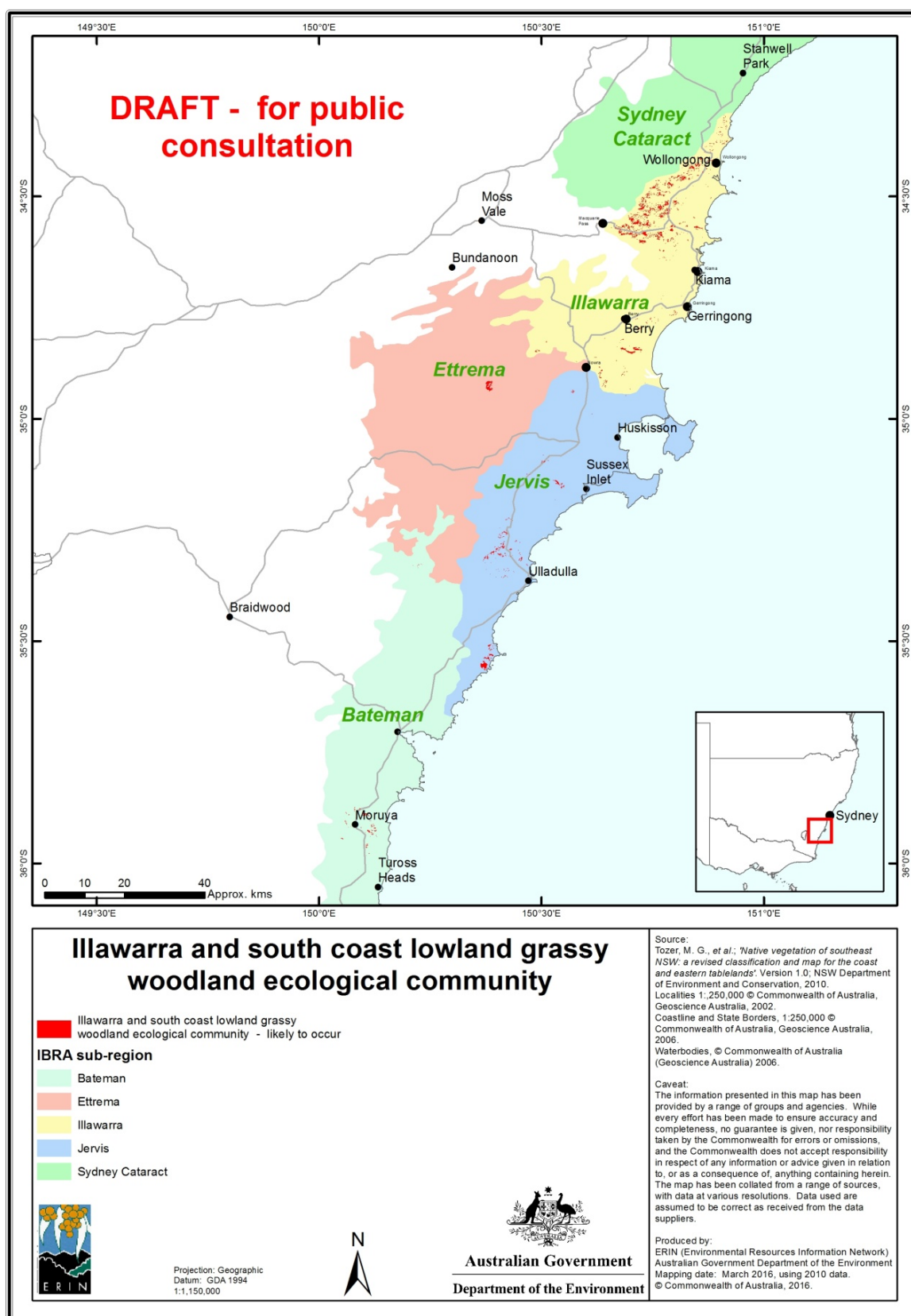
#### **4.7 Recovery Plan Recommendation**

To be made following completion of the listing assessment.



## APPENDICES

### APPENDIX A-DRAFT MAP OF LIKELY OCCURRENCE OF THE ECOLOGICAL COMMUNITY



## APPENDIX B – SPECIES LISTS

**Table 7 Fauna that may be present in the ecological community**

Species name	Common name	D'harawal name	Likely to use hollows?
<b>Birds</b>			
<i>Acanthiza pusilla</i>	brown thornbill		
<i>Acanthiza nana</i>	yellow thornbill		
<i>Anthochaera phrygia</i>	regent honeyeater		
<i>Cacomantis pallidus</i>	pallid bronze cuckoo		
<i>Caligavis chrysops</i>	yellow faced honeyeater		
<i>Callocephalon fimbriatum</i>	gang-gang cockatoo		Y
<i>Calyptorhynchus funereus</i>	yellow-tailed black cockatoo		Y
<i>Calyptorhynchus lathami</i>	glossy black cockatoo		Y
<i>Chalcites basal</i>	Horsfield's bronze cuckoo		
<i>Coracina novaehollandiae</i>	black faced cuckoo shrike		
<i>Cracticus torquatus</i>	grey butcherbird		
<i>Dacelo novaeguineae</i>	laughing kookaburra	kookaaraa	Y
<i>Daphoenositta chrysoptera</i>	varied sittella		
<i>Dicaeum hirundinaceum</i>	Mistletoebird		
<i>Eolophus roseicapillus</i>	Galah		Y
<i>Eopsaltria australis</i>	eastern yellow robin		
<i>Falco peregrinus</i>	peregrine falcon		
<i>Gerygone olivacea</i>	white throated gerygone		
<i>Glossopsitta pusilla</i>	little lorikeet		y
<i>Gymnorhina tibicen</i>	magpie	karungang	
<i>Hieraaetus morphnoides</i>	little eagle		
<i>Lathamus discolor</i>	swift parrot		<sup>3</sup>
<i>Manorina melanocephala</i>	noisy miner		
<i>Ninox connivens</i>	barking owl		y
<i>Ninox strenua</i>	powerful owl		y
<i>Pachycephala (Alisterornis) rufiventris</i>	rufous whistler		
<i>Pardalotus punctatus</i>	spotted pardalote		y
<i>Petroica boodang</i>	scarlet robin		y
<i>Platycercus eximius</i>	eastern rosella	boondelook	y
<i>Platycercus elegans</i>	crimson rosella	boondelook	y
<i>Rhipidura albiscapa albiscapa</i>	grey fantail		
<i>Rhipidura leucophrys</i>	willie wagtail	dinggan	
<i>Stagonopleura guttata</i>	diamond firetail		
<i>Strepera graculina</i>	pied currawong		
<i>Tyto tenebricosa</i>	sooty owl		y
<i>Tyto novaehollandiae</i>	masked owl		y
<i>Zosterops lateralis</i>	Silvereye		
<b>Mammals</b>			
<i>Antechinus stuartii</i>	brown antechinus		y
<i>Antechinus swainsonii</i>	dusky antechinus		y
<i>Canis lupus dingo</i>	dingo		
<i>Cercartetus nanus</i>	eastern pygmy possum		y
<i>Chalinolobus gouldii</i>	Gould's wattled bat		y
<i>Chalinolobus morio</i>	chocolate wattled bat		y
<i>Dasyurus maculatus</i>	spotted-tail quoll		y
<i>Dasyurus viverrinus</i>	eastern quoll	wagara	
<i>Falsistrellus tasmaniensis</i>	eastern false pipistrelle		y
<i>Isodon obesulus</i>	brown bandicoot		

<sup>3</sup> Swift parrots are hollow users in their breeding territories in Tasmania, but less likely to use hollows in Illawarra and south coast lowland grassy woodland.

<i>Macropus giganteus</i>	eastern grey kangaroo		
<i>Macropus rufogriseus</i>	red-necked wallaby		
<i>Miniopterus shreibersii</i>	common bentwing bat		
<i>Mormopterus norfolkensis</i>	Eastern freetail bat		y
<i>Myotis macropus</i>	large footed mouse eared bat		y
<i>Nyctophilus geoffroyi</i>	lesser long-eared bat		y
<i>Nyctophilus gouldi</i>	Gould's long-eared bat		y
<i>Perameles nasuta</i>	long nosed bandicoot		
<i>Petaurus breviceps</i>	sugar glider		y
<i>Phascolarctos cinereus</i>	Koala		
<i>Pseudocheirus peregrinus</i>	common ringtail possum		y
<i>Rattus fuscipes</i>	bush rat		y
<i>Rattus lutreolus</i>	swamp rat		
<i>Scoteanax ruepellii</i>	greater broad-nosed bat		y
<i>Sminthopsis leucopus</i>	white-footed dunnart		y
<i>Tachyglossus aculeatus</i>	Echidna		
<i>Trichosurus vulpecula</i>	common brushtail possum	gurauara	y
<i>Vespadelus darlingtoni</i>	large forest bat		y
<i>Vespadelus regulus</i>	southern forest bat		y
<i>Vespadelus vulturnus</i>	little forest bat		y
<i>Vombatus ursinus</i>	bare-nosed wombat		
<i>Wallabia bicolor</i>	swamp wallaby; black wallaby		
<b>Amphibians</b>			
<i>Crinia signifera</i>	common eastern froglet		
<i>Limnodynastes peronii</i>	striped marsh frog		
<i>Litoria aurea</i>	green and golden bell frog		
<i>Litoria dentata</i>	bleating tree frog		y
<i>Litoria fallax</i>	eastern dwarf tree frog		y
<i>Litoria jervisiensis</i>	Jervis Bay tree frog		y
<i>Litoria peronii</i>	peron's tree frog		y
<i>Litoria verreauxii</i>	Verreaux's frog		y
<i>Paracrinia haswelli</i>	Haswell's frog		
<i>Pseudophryne bibronii</i>	Bibron's toadlet		
<i>Uperoleia laevisgata</i>	smooth toadlet		
<i>Uperoleia tyleri</i>	Tyler's toadlet		
<b>Reptiles</b>			
<i>Amphibolurus muricatus</i>	jacky lizard		
<i>Cacophis squamulosus</i>	golden-crowned snake		
<i>Cryptophis nigrescens</i>	eastern small-eyed snake		
<i>Eulamprus heatwolei</i>	yellow-bellied water-skink		y
<i>Eulamprus quoyii</i>	eastern water-skink		
<i>Eulamprus tenuis</i>	barred-sided skink		y
<i>Hemiaspis signata</i>	black-bellied swamp snake		
<i>Intellagama lesueurii</i>	eastern water dragon		
<i>Lampropholis delicata</i>	dark-flecked garden sunskink		
<i>Lampropholis guichenoti</i>	pale-flecked garden sunskink		
<i>Morelia spilota spilota</i>	diamond python	mokka	y
<i>Pseudechis porphyriacus</i>	red-bellied black snake		
<i>Pseudonaja textilis</i>	eastern brown snake		
<i>Ramphotyphlops nigrescens</i>	blackish blind snake		
<i>Rhinoplocephalus nigrescens</i>	-		
<i>Saiphos equalis</i>	three-toed skink		
<i>Saproscincus mustelinus</i>	weasel skink		
<i>Tiliqua scincoides</i>	eastern blue-tongue	bunburrang	
<i>Varanus varius</i>	lace monitor	gindoala	y

Sources: Gibbons and Lindenmayer, 2002; NPWS, 2002b; Kevin Mills, 2004; Wesson, 2005; Kiama and Shellharbour City Councils, Wollongong Municipal Council, undated; Atlas of Living Australia, undated a and b.

**Table 8 Plants that may occur in the ecological community**

Dominant canopy species are indicated with†

Scientific name	Common name	D'harawal name	Notes (including some traditional ecological knowledge and uses)
<i>Acacia binervata</i>	two-veined hickory	Giji	
<i>Acacia brownii</i>	heath wattle	Buri	
<i>Acacia falcata</i>	sickle wattle	Giji	Pieces of the bark were pounded, then placed in waterholes to stun fish. The bark was soaked overnight in warm water, then the liquid applied to skin rashes.
<i>Acacia implexa</i>	hickory wattle	Weetjellan	The fresh gum was eaten once flowering had finished. The seeds were parched on hot coals, winnowed, the moistened with a little water, ground to a paste, wrapped in paperbark and cooked as for damper. In the springtime the young roots were roasted and eaten. The bark was used for the tanning of animal hides. The leaves were used to dye plant fibres.
<i>Acacia linifolia</i>	white wattle	Giji	The wood was used for the making of implements and weapons
<i>Acacia maidenii</i>	maiden's wattle	Giji	The wood was used for the making of weapons, ornaments and implements. The hardened gum was ground to a powder, mixed with warm water and wood ash to make a waterproof sealant for containers and canoes.
<i>Acacia mearnsii</i>	black wattle	Bookerrikin	Seed eaten by Gang Gang Cockatoo Leaves eaten by Crimson Rosella and various moth caterpillars
<i>Acacia stricta</i>	hop wattle		The hardened gum was ground to a powder, mixed with water and smoothed over weapons and implements to enhance their water resistance. The wood was used for the making of weapons and implements
<i>Acacia ulicifolia</i>	prickly Moses		This plant was encouraged to grow near special sites to deter trespassers.
<i>Adiantum aethiopicum</i>	common maidenhair		The leaves were sundried, then, when required, soaked in hot water which had been sweetened with honey, and taken to reduce fever. The fresh leaves were bruised, soaked in warm water overnight, the liquid sweetened with honey and taken to relieve colds and fevers. The leaves were chewed and the pulp packed into wounds.
<i>Allocasuarina littoralis</i>	black sheoak	Dahlwah	The branchlets were used as bedding for sleeping in damp places. Children were taught to seek out these trees when lost These trees indicate a safe place to camp.
<i>Alphitonia excelsa</i>	red ash		
<i>Alternanthera denticulata</i>	lesser joyweed		
<i>Amyema congener</i>	a mistletoe		
<i>Amyema gaudichaudii</i>	a mistletoe		
<i>Angophora floribunda</i> †	rough-barked apple		



<i>Aristida ramosa</i>	cane speargrass		
<i>Arthropodium milleflorum</i>	pale vanilla-lily		
<i>Rytidosperma pilosum</i>	smooth-flower wallaby grass		
<i>Austrodanthonia racemosa</i>	wallaby grass		
<i>Backhousia myrtifolia</i>	grey myrtle		The wood of the young trees or slender branches was used to make fishing rods. The leaves were bruised and soaked in warm water. When cooled it was given to babies with colic.
<i>Blechnum ambiguum</i>	a fern		rhizomes were sun dried, pounded and roasted before being eaten.
<i>Boronia polygalifolia</i>	dwarf boronia		
<i>Bossiaea stephensonii</i>	-		
<i>Bothriochloa macra</i>	red grass		
<i>Brachychiton acerifolius</i>	Illawarra flame tree		The seeds were carefully cleaned and eaten raw or roasted. The fibre from the inner bark was used to weave hunting and fishing nets Rainbow Lorikeets Butterfly larvae <i>Pyrrhus sempronius</i> and <i>Candalides absimilis</i>
<i>Brachychiton populneus</i>	kurrajong	Kooritjong	This plant has mythological values. The gum from the bark was rubbed into sores and cuts The inner bark was used as a bandage to keep dressings and poultices in place. The inner bark was chewed to relieve thirst
<i>Breynia oblongifolia</i>	coffee bush		
<i>Brunoniella pumilio</i>	dwarf blue trumpet		
<i>Bulbine bulbosa</i>	bulbine lily		
<i>Bursaria spinosa</i>	native blackthorn	Kurwan	Mature plants sprout from base after fire
<i>Caesia parviflora</i> var. <i>parviflora</i>	pale grass lily		The tubers were eaten raw or cooked
<i>Caladenia fuscata</i>	dusky fingers		
<i>Callistemon salignus</i>	willow bottlebrush		
<i>Carex inversa</i>	knob sedge		The leaves and stems were used to make yabby traps.
<i>Carex longebrachiata</i>	drooping sedge		
<i>Cassinia aculeata</i>	dolly bush		
<i>Casuarina glauca</i>	swamp oak	Dahlwah	The needles were used as padding to sleep in damp places. The wood was used for the making of implements, weapons and ornaments. The wood was favoured for cooking fires. The bark was carefully removed to make canoes. Resprouts from root suckers after fire, with vigorous regeneration from trunk and branches.
<i>Cayratia clematidea</i>	native grape		
<i>Centella asiatica</i>	Indian pennywort		
<i>Cheilanthes austrotenuifolia</i>	rock fern		
<i>Cheilanthes sieberi</i> subsp. <i>sieberi</i>	mulga fern		
<i>Chorizema parviflorum</i>	-		
<i>Commelina cyanea</i>	scurvy weed		
<i>Corymbia maculata</i>	spotted gum	Boo'angi	Does not occur on sandstone



			<p>The leaves were used to relieve asthma symptoms.</p> <p>The gum was completely dissolved in hot water, colled, strained and applied to sores, cuts, burns and aching muscles and sore eyes.</p> <p>A 2m length of near surface root, about the thickness of a child's wrist, was cut and sealed at both ends with clay. This was carried, whilst travelling, and when thirsty, the travellers would remove the clay and drink the water from the root.</p>
<i>Craspedia variabilis</i>	bachelor's buttons, Billy buttons		
<i>Crassula sieberiana</i> subsp. <i>tetramera</i>	Austral crassula		
<i>Croton verreauxii</i>	native cascarilla		Fruit eaten by parrots
<i>Cyanicula caerulea</i>	blue caladenia		
<i>Cymbopogon refractus</i>	barbed wire grass		
<i>Cyperus sphaeroideus</i>	globe kyllinga		
<i>Daviesia genistifolia</i>	broom bitter pea		The branches and leaves were placed on a low fire and the vapour inhaled to relieve breathing difficulties.
<i>Daviesia ulicifolia</i>	gorse bitter pea		
<i>Dendrobium teretifolium</i>	a rat's tail orchid		Associated with <i>Casuarina glauca</i>
<i>Desmodium gunnii</i>	southern tick-trefoil		
<i>Desmodium rhytidophyllum</i>	-		
<i>Desmodium varians</i>	slender tick-trefoil		
<i>Dianella caerulea</i>	blue flax lily		
<i>Dianella longifolia</i>	flax lily	Pokulbi	<p>The fruit could be eaten raw</p> <p>The rhizome was cleaned, then pounded and roasted before being eaten.</p> <p>This plant has mythological values</p>
<i>Dianella revoluta</i>	blueberry lily	Pokulbi	The leaves were twisted, then split and woven into string.
<i>Dichelachne crinita</i>	long-hair plume grass		
<i>Dichelachne micrantha</i>	short-haired plume grass		The stems and leaves were used as bedding in damp places, or as thatching on shelters
<i>Dichondra repens</i>	kidney weed	Yilibili	The leaves were sundried, then soaked in hot water which was sweetened with honey, and the liquid taken as a refreshing drink or a tonic for invalids
<i>Digitaria parviflora</i>	small-flowered finger grass		
<i>Diuris sulphurea</i>	tiger orchid		
<i>Dodonaea viscosa</i> subsp. <i>angustifolia</i>	hop bush		The leaves were soaked in warm water, and when cooled, the liquid was used as a wash to reduce fevers
<i>Drosera peltata</i>	pale sundew		
<i>Echinopogon caespitosus</i> var. <i>caespitosus</i>	bushy hedgehog grass		
<i>Echinopogon ovatus</i>	forest hedgehog grass		
<i>Eclipta platyglossa</i>	yellow eclipta		
<i>Einadia hastata</i> syn. <i>Rhagodia hastata</i>	berry saltbush		The berries produce a dye for body decoration.
<i>Einadia trigonos</i> subsp. <i>trigonos</i>	fishweed		

<i>Entolasia marginata</i>	bordered panic		Seed eaten by Finches
<i>Entolasia stricta</i>	wiry panic		
<i>Eragrostis leptostachya</i>	paddock love grass		
<i>Eucalyptus amplifolia</i> subsp. <i>amplifolia</i>	cabbage gum	Boo'angi	The gum was soaked in wam water and applied to sores, cuts and scabies.
* <i>Eucalyptus bosistoana</i>	coast grey box	Terri'yergro	The nectar was collected by washing the flowers in water until it had become sweet to taste, it was then taken to treat colds and breathing difficulties in the very young and very old. Resprouts from epicormic buds after fire.
* <i>Eucalyptus botryoides</i>	bangalay	Terri'yergro	The bark exudate was used to relieve the pain of toothache
<i>Eucalyptus eugenioides</i>	thin-leaved stringybark	Bai'yali Dthaa dthaang	The bark from the young roots up to 4cm thick was roasted to a crisp, then pounded and eaten. The bark or wood was used for the making of implements and weapons. Resprouts from epicormic buds after fire.
* <i>Eucalyptus globoidea</i> †	white stringybark	Bai'yali	The young leaves were boiled until the water turned green. It was then allowed to cool, and carefully strained before being used as a wash for joint, chest or muscle pain
* <i>Eucalyptus longifolia</i> †	woollybutt	Terri'yergro Gnaoulie	Blossoms eaten by Grey Headed Flying Fox
<i>Eucalyptus maidenii</i>	Maiden's gum	Kai'yeroo	
<i>Eucalyptus paniculata</i> subsp. <i>paniculata</i>	grey ironbark	Mugga'go Baariimaa	The seeds were soaked in water for several hours, changing the water several times. They were then dried, ground to a paste and eaten.
<i>Eucalyptus pilularis</i>	blackbutt	Kai'yeroo	The bark was pounded, then boiled in water, allowed to cool, strained and used to bathe running sores and ulcers.
<i>Eucalyptus quadrangulata</i> †	coastal white box	Terri'yergro	The nectar was collected by washing the flowers in water until it had become sweet tasting. The liquid was then taken to treat the symptoms of colds and breathing difficulties. Resprouts from epicormic buds after fire.
<i>Eucalyptus saligna</i> x <i>botryoides</i>	Hybrid of bangalay and Sydney blue gum	Kai'yeroo	Seed eaten by Crimson Rosella Blossoms eaten by Grey Headed Flying Fox Leaves browsed by Koalas Resprouts from epicormic buds after high intensity fire
<i>Eucalyptus tereticornis</i>	forest red gum	Buringoa	The fresh gum was collected, mixed with warm water and applied to sores, burns and scabies The bark was used for the making of implements and weapons. The bark exudate was used to plug holes in aching teeth to relieve pain. The bark was burned to charcoal, which was then crushed to a powder, and packed into cuts made for ceremonial scarring. The leaves were placed on a low fire and the vapour inhaled to relieve breathing difficulties. In the springtime, the young root tips were roasted and chewed, and the fibres spat out once the flavour had gone. Blossoms eaten by Grey Headed Flying Fox Major Food Source for Koalas Habitat Tree for cockatoos

<i>Eustrephus latifolius</i>	wombat berry		
<i>Exocarpos cupressiformis</i>	cherry ballart	Goo'weregana	The fruit was eaten raw, but the seed was discarded. Fruit eaten by black faced cuckoo shrike, king parrot, crimson rosella Foodplant of butterfly larvae <i>Delius aganippe</i>
<i>Ficus macrophylla</i>	Moreton Bay fig	Tam'noon Karreuirra	The fruit was eaten raw once it had become soft and pulpy. Pollinated by Agaonidae wasps Fruit eaten by Grey Headed Flying Fox
<i>Ficus rubiginosa</i>	Port Jackson fig	Tam'noon Dthaaman	
<i>Ficus superba</i> [ <i>Ficus superba</i> var. <i>henniana</i> ]	deciduous fig	Tam'noon	
<i>Gahnia radula</i>	thatch saw-sedge		The seeds were ground to a paste, and cooked as for damper. The leaf bases were eaten raw. The leaves were used as thatching in shelters and bark huts.
<i>Geijera salicifolia</i>	-		The leaves were chewed to relieve toothache. Fruit eaten by king parrot
<i>Geitonoplesium cymosum</i>	scrambling lily		
<i>Geranium homeanum</i>	rainforest crane's bill		In autumn and winter the tubers were pounded to a paste, then cooked as for damper.
<i>Geranium solanderi</i> s.lat.	native geranium		
<i>Glochidion ferdinandi</i>	cheese tree		
<i>Glycine clandestina</i>	twining glycine		A perennial climber
<i>Glycine microphylla</i>	small-leaf glycine		
<i>Glycine tabacina</i>	glycine pea		
<i>Gonocarpus teucrioides</i>	germander raspwort		
<i>Goodenia hederacea</i> subsp. <i>hederacea</i>	forest goodenia		The leaves and twigs were sundried, then soaked in boiling water and allowed to cool. The liquid was then taken as a treatment for symptoms of diabetes
<i>Hakea sericea</i>	silky hakea		
<i>Hardenbergia violacea</i>	purple coral pea, native sarsparilla		
<i>Hibbertia aspera</i>	rough guinea flower		
<i>Hibiscus heterophyllus</i>	native rosella		
<i>Hibiscus trionum</i>	flower-of-an-hour		
<i>Hydrocotyle geraniifolia</i>	forest pennywort		The green parts of the plant were cooked and eaten.
<i>Hydrocotyle sibthorpioides</i> [ <i>Hydrocotyle peduncularis</i> ]	lawn water pennywort		
<i>Hypericum gramineum</i>	small St John's wort		
<i>Hypoxis hygrometrica</i> var. <i>hygrometrica</i>	golden weather grass		
<i>Imperata cylindrica</i> var. <i>major</i>	blady grass		
<i>Indigofera australis</i>	Australian indigo	duwabili	
<i>Jacksonia scoparia</i>	winged broom-pea		
<i>Juncus prismatocarpus</i>	branching rush		
<i>Juncus subsecundus</i>	finger rush		
<i>Juncus usitatus</i>	common rush		

<i>Kennedia rubicunda</i>	dusky coral pea		The leaves were rubbed in sand to remove the hairs, then soaked overnight in warm water. When cooled, the liquid was taken by persons recovering from illness.
<i>Lachnagrostis filiformis</i> [ <i>Agrostis avenacea</i> ]	blown grass		
<i>Lagenophora stipitata</i>	blue bottle daisy		
<i>Laxmannia gracilis</i>	slender wire-lily		
<i>Lepidosperma laterale</i>	variable sword-sedge		
<i>Leptospermum polygalifolium</i>	tantoon		
<i>Leptospermum morrisonii</i>	-		
<i>Leucopogon juniperinus</i>	prickly -beard heath		The leaves were sun dried, then later soaked in hot water, sweetened with honey and taken as a beverage The leaves were bruised, then soaked in hot water and taken as an energising beverage.
<i>Linum marginale</i>	native flax		
<i>Livistona australis</i>	cabbage palm		
<i>Lomandra filiformis</i> subsp. <i>filiformis</i>	-		Used for weaving dilly bags
<i>Lomandra longifolia</i>	spiny-headed mat rush		The leaves were dried and used for the weaving of mats and baskets. The leaf base was eaten raw or cooked. The flowers were eaten raw The leaves were used to make eel traps The leaves were split to make string for bags Camps were never set up between this plant and water
<i>Lomandra multiflora</i> subsp. <i>multiflora</i>	many-flowered mat rush		The leaves were dried and used for the weaving of mats and baskets. The leaf base was eaten raw or cooked.
<i>Luzula flaccida</i>	pale wood rush		
<i>Maclura cochinchinensis</i>	cockspur thorn		
<i>Marsdenia rostrata</i>	common milk vine		The tubers were pounded, then roasted before being eaten.
<i>Melaleuca decora</i>	paper bark	Bujor	The nectar from the flowers was gathered by washing the flowers in water until it became sweet to taste. The liquid was then given to young children as a refreshing drink
<i>Melaleuca ericifolia</i>	swamp paperbark		
<i>Melaleuca linariifolia</i>	flax leaf paperbark	Gurren'durren	The very fine inner bark layers were used to cover burns.
<i>Melaleuca styphelioides</i>	prickly leaved tea-tree	Naambarr	
<i>Melia azedarach</i>	white cedar		
<i>Microlaena stipoides</i> var. <i>stipoides</i>	weeping grass		
<i>Microtis parviflora</i>	slender mignonette orchid		
<i>Muellerina eucalyptoides</i>	creeping mistletoe		
<i>Myrsine howittiana</i>	brush muttonwood		
<i>Myrsine variabilis</i> [ <i>Rapanea variabilis</i> ] <i>Rapanea</i>	muttonwood		
<i>Notelaea venosa</i>	large mock olive		
<i>Olearia microphylla</i>	-		
<i>Olearia viscidula</i>	wallaby weed		

<i>Opercularia diphylla</i>			
<i>Opercularia hispida</i>	hairy stinkweed		
<i>Opercularia varia</i>	variable stinkweed		
<i>Oplismenus aemulus</i>	Australian basket grass		
<i>Oplismenus imbecillis</i>	creeping beard grass		
<i>Oxalis perennans</i>	-		
<i>Ozothamnus diosmifolius</i>	rice flower		
<i>Pandorea pandorana</i>	wonga wonga vine	wongawonga	Used for making spears
<i>Panicum simile</i>	hairy panic		
<i>Panicum spp.</i>	panic grass		
<i>Parsonsia straminea</i>	common silkpod		
<i>Paspalidium spp.</i>	-		
<i>Phyllanthus gunnii</i>	shruggy spurge		
<i>Pimelea curviflora</i> var. <i>curviflora</i>	-		
<i>Pittosporum multiflorum</i> syn. <i>Citriobatus pauciflorus</i>	orange thorn		
<i>Pittosporum revolutum</i>	wild yellow jasmine		
<i>Pittosporum undulatum</i>	sweet pittosporum		The seeds were crushed, the fruit pulp and the leaves bruised, soaked and used to relieve pain and cramps and colds. The seeds were ground to a paste and cooked as for damper. Fruit eaten by Grey Headed Flying Fox Currawong Crimson Rosella Silvereye
<i>Platylobium formosum</i> subsp. <i>formosum</i>	handsome flat-pea		
<i>Plectranthus parviflorus</i>	cockspur flower		
<i>Poa labillardierei</i>	tussock grass		
<i>Podolepis jaceoides</i>	showy copper-wire daisy		
<i>Polygala japonica</i>	dwarf milkwort		
<i>Polymeria calycina</i>	-		
<i>Poranthera microphylla</i>	small-leaf Poranthera		
<i>Pratia purpurascens</i>	whiteroot		
<i>Pseuderanthemum variabile</i>	love flower		
<i>Pterostylis bicolor</i>	black tip greenhood		
<i>Pterostylis curta</i>	blunt greenhood		
<i>Pterostylis gibbosa</i>	Illawarra greenhood		The second year tubers were eaten raw or cooked, once flowering had finished
<i>Pterostylis longipetala</i>	curved greenhood		
<i>Pterostylis truncata</i>	brittle greenhood		
<i>Pultenaea linophylla</i>	halo bush-pea		
<i>Pultenaea mollis</i> [ <i>Pultenaea villosa</i> ]	guinea flower bush-pea, soft bush-pea		
<i>Pultenaea retusa</i>	blunt bush-pea		
<i>Pyrrosia rupestris</i>	rock felt fern		
<i>Ranunculus inundatus</i>	river buttercup		
<i>Ranunculus spp.</i>	-		
<i>Rubus parvifolius</i>	native raspberry		The fruit was eaten raw, once it had fully ripened. The young leaves were bruised, then soaked in warm water. When cooled, the liquid was taken

			to treat upset stomachs The leaves were sun-dried, then, when needed, soaked in hot water and the liquid given to women who were experiencing difficulty in childbirth.
<i>Rumex brownii</i>	slender dock		
<i>Rytidosperma pallidum</i>	silvertop wallaby grass, redanther wallaby grass		
<i>Schelhammiera undulata</i>	lilac lily		
<i>Senecio bipinnatisectus</i>	Commonwealth weed		
<i>Senecio linearifolius</i>	fire groundsel		
<i>Solanum americanum</i>	-		
<i>Solanum pungetium</i>	eastern nightshade		
<i>Solanum celatum</i>	-		
<i>Sorghum leiocladum</i>	wild sorghum		
<i>Sporobolus creber</i>	-		
<i>Sporobolus elongatus</i>	hairy grass		
<i>Streblus pendulinus</i>	axe-handle wood		
<i>Stylidium graminifolium</i>	grass trigger plant		
<i>Syncarpia glomulifera</i>	turpentine		The resin was applied to sores and ulcers. Coolamons made from this tree were used to carry fire. Blossom eaten by Grey headed Flying Fox Pollinated by Native bees Nectar eaten by Rainbow Lorikeet Noisy Miner
<i>Syzygium smithii</i> ( <i>Acmena smithii</i> )	lilly pilly		
<i>Thelionema umbellatum</i>	clustered lily		
<i>Themeda triadra</i>	kangaroo grass		
<i>Thysanotus tuberosus</i> subsp. <i>tuberosus</i>	tuber fringe-lily		
<i>Trema tomentosa</i> var. <i>aspera</i>	peach-leaf poison-bush		An edible grub lives in the branches, trunk and roots favoured for the production of charcoal.
<i>Tricoryne elatior</i>	star lily		
<i>Tylophora barbata</i>	bearded tylophora		
<i>Typha domingensis</i>	bullrush		
<i>Typha orientalis</i>	broad-leaved cumbungi		
<i>Veronica plebeia</i>	creeping speedwell		
<i>Viola betonicifolia</i>	mountain violet		
<i>Viola banksii</i>	trailing or creeping speedwell		
<i>Wahlenbergia gracilis</i>	Australian bluebell		
<i>Wahlenbergia stricta</i> subsp. <i>stricta</i>	-		

Sources: Mills (1993); NSW Scientific Committee (1999); NPWS (2002a); Mills (2004); Sainty and Cross (2005); Wesson(2005); Midge Bushland Restoration (2010); Tozer et al, (2010); Vine (2010); Bodkin (pers.comm., 2016);Atlas of Living Australia (undated a and b); PlantNET (undated);

## APPENDIX C- LAND USE HISTORY; INDIGENOUS CULTURAL VALUES AND KNOWLEDGE OF THE ECOLOGICAL COMMUNITY

### Land use history

The earliest human occupation of the south coast of NSW occurred approximately 20 000 years ago, with Indigenous use of the land including fire management and hunting for animals such as koala, gliders and possums as well as fishing (Lunney and Leary, 1988; Mills and Jakeman, 1995; Magee, 2006). The Illawarra district was one of earliest areas targeted for non-Indigenous settlement due to the value of red cedar (*Toona ciliata*) found in the rainforest, as well as coal deposits. It was also found to be good agricultural and grazing country. In 1818 Allan Cunningham visited the district and on the plain west of Lake Illawarra found 'many head of large well-bodied cattle grazing', and commented on the fine grazing land (Mills and Jakeman, 1995: p.34). By 1857 it was reported that the land between Wollongong and Dapto was 'lightly timbered and much cleared and cultivated' (Mills and Jakeman, 1995 p.34). Further south, the Shoalhaven River area was explored in 1805, with surveying to formalise title from the 1840s. Clearing for grazing and introduction of non-native pasture grasses was accompanied by drainage of the lower-lying areas of the floodplain (Keith et al, 2007). Further south again, non-Indigenous settlement of the Moruya area began in the late 1820s with initial development of primary industries limited by poor transportation. Small scale cropping as well as grazing for meat and dairy, and also pig farming were the main industries during the next 100 years. The development of tourism along the south coast began in the 1920s, increasing interest in property and the concentration of settlement. The increase in housing across the region coincides with a decline in primary industries and change to service-based industries as the main sources of occupation (Magee, 2006).

### Cultural values and Indigenous knowledge of the ecological community

*This section will be completed following consultation on Indigenous cultural values, occurring from January to May 2016.*

The ecological community mainly occurs in country of the Tharawal/D'harawal people in the northern part of its range and the Yuin people in more southerly areas (Horton, 1996). These people have developed extensive and detailed knowledge of the ecological community and its function. Associations between plant species, and other ecosystem characteristics are of critical importance, and central to this body of knowledge. For example, *Eucalyptus tereticornis*, a central canopy species, is dependent on an association with mycorrhizal fungus in the soil. *Eucalyptus bosistoana* is important for maintaining the water table as before rain, the bark produces saponins, which assist water infiltration to the soil. *Bursaria spinosa* is an understorey plant important for eucalypt health. It attracts a flightless wasp that lays eggs in the nests of the cutleaf moth. The wasp larvae predate on the caterpillars, reducing the impact of their herbivory on the growing tips of eucalypts, and subsequent dieback (Bodkin, pers.comm., 2016).

Traditional uses of the ecological community included materials for shelter, food and medicines. For example, in the Blackbutt reserve, south of Lake Illawarra, various parts of plants were harvested for food including kangaroo grass (*Themeda* spp.) or sword sedge seeds; mat rushes (*Lomandra* spp), for leaves, fruits, flowers; native flax (*Dianella* spp) roots, while other flowers were harvested for their nectar (Hepworth et al, 2011). Some further examples of the traditional uses or other characteristics of plants in the ecological community are noted in Table 8. The seasons determine many of the interactions between Indigenous people and the ecological community, including permissible foods. This serves to protect regeneration, for example, by prohibition of hunting animals during their breeding seasons (Bodkin and Robertson, 2006) (Table 9).

**Table 9 D'harawal seasonal calendar extract**

Season	Natural signs
<i>Goray'murrai</i> Nov-Dec (approx)	<ul style="list-style-type: none"> <li>· warm and wet, do not camp near rivers</li> </ul>
<i>Gadalung Marool</i> Jan-Feb (aprox)	<ul style="list-style-type: none"> <li>· Time of the blooming of the Weetjellan (<i>Acacia implexa</i>)</li> <li>· hot and dry, eat only fruit and seeds</li> <li>· <i>Burra</i> (kangaroos) start having their babies</li> </ul>
<i>Bana'murrai'yung</i> Mar-May (approx)	<ul style="list-style-type: none"> <li>· Wet, getting cooler, time to make cloaks and start the journey to the coast</li> <li>· <i>Marra'i'gang</i>, the spotted-tail quoll seeks her mate</li> </ul>
<i>Tugarah tuli</i> Jun-Jul (approx)	<ul style="list-style-type: none"> <li>· Time of the flowering of the <i>Burringoa</i> (<i>Eucalyptus tereticornis</i>)</li> <li>· Cold, time to gather the nectar for ceremony</li> <li>· <i>Barrugin</i>, the echidna begin their gatherings</li> </ul>
<i>Tugarah gunya'marra</i> Aug (approx)	<ul style="list-style-type: none"> <li>· Time of the flowering of the Marrai'uo (<i>Acacia floribunda</i>)</li> <li>· cold and windy, build shelters facing the rising sun, time to begin the journey to the highlands along the rivers, plenty of fish</li> <li>· <i>Boo'gul</i> the marsupial mouse mates and dies</li> </ul>
<i>Murrai'yunggoray</i> Sep-Oct (approx)	<ul style="list-style-type: none"> <li>· Cool, getting warmer, time for major ceremony</li> <li>· Gathering of the <i>Ngoonuni</i>, flying foxes</li> </ul>

Source: Extracted from Bodkin and Andrews cited in Kingsley(2003). Modified with permission.



*Kennedia rubicunda*, Guerrilla Bay



## APPENDIX D- ADDITIONAL INFORMATION ON LANDSCAPE, ECOLOGY AND BIOLOGY

### Geology

Some of the main geological groups underlying the ecological community, progressing from the south to the north along the NSW coast are the Adaminaby, Shoalhaven and Narrabeen groups. Generally the better drained expression of the ecological community is more closely associated with sedimentary rocks and volcanic outcrops towards the north of the range. The expression of the ecological community with poorer drainage also primarily occurs on sedimentary rock substrates, but tends more towards alluvial substrates, as well as the higher granite substrates found to the south of the ecological community's range.

The specific relationships between the ecological community and the outcropping geology are not clear. While there are some local patterns of apparent preference correlating with geology, these appear to be less important than topography. Around Milton, there is a strong association between areas of Illawarra and south coast lowland grassy woodland and Milton Monzonite (an igneous intrusive) substrate. It is likely that the ecological community does not extend into the surrounding areas underlain by Shoalhaven group rocks. However, west of Lake Illawarra, there are large patches of the ecological community that occur on this substrate. Similarly, to the north of Lake Illawarra, the ecological community occurs over Gerringong Volcanics at lower density than on other nearby substrates, however, southwest of the lake, there are extensive patches of the ecological community on this substrate. While the ecological community seems less likely to occur on recent alluvial sediments, this pattern may also be related to altitude and drainage (Tozer et al, 2010; Geoscience Australia, undated; NICTA undated).

The ecological community provides important habitat for many fauna, including vertebrates and invertebrates. Invertebrates have crucial roles in ecosystem function, including nutrient cycling, pollination, seed dispersal, predation and herbivory, as well as providing an important food source for many other animals. However, little specific information on the habitat use and ecological roles of invertebrates is available, so the examples presented here are of the vertebrate groups: mammals, reptiles, amphibians and birds.

### Mammals

The importance of *Eucalyptus tereticornis* forest in providing high quality habitat for various arboreal mammal species has been noted by Mills (2004). In general, the mammals of the region have suffered the severe declines identified for medium sized mammals across temperate Australia (Burbidge et al, 2008). Population changes for many species are likely to be related to complex interactions between changes to hunting and predation and the loss and degradation of vegetation and other habitat features, both in this ecological community and across the broader landscape.

Lunney and Leary (1988) reviewed the historical records of mammals for the Bega district, identifying 'spectacular changes' since 1830. While that study area is to the south of the geographical range of the Illawarra and south coast lowland grassy woodlands, the analysis indicates a high level of historical exploitation and targeting of native species, often related to legislation or official incentives, across the broader coastal region. This includes bounties on *Macropus giganteus* (eastern grey kangaroo), wallabies (including *Wallabia bicolor* and *Macropus rufogriseus*), *Macropus robustus* (wallaroo) and pademelon (likely to have been *Macropus parma* (parma wallaby) and *Thylogale thetis* (red-necked pademelon)). The latter two species probably no longer occur in the region (Lunney and Leary, 1988; Ellis et al, 2008; McKenzie et al, 2008; Office of Environment and Heritage, undated). These grazing and browsing herbivores affect structure and floristics of the ground and shrub layers.

Other marsupials dependent on and affecting canopy vegetation include *Phascolarctos cinereus* (koala), previously subject to hunting for the fur trade but likely to be still present in small numbers. They are particularly associated with *Eucalyptus tereticornis* but may also browse on other tree species including *E. botryoides*, *E. globoidea* and *E. pilularis* (Benson and McDougall, 1998). Populations in eastern Australia have been affected negatively by urbanisation (Rhodes et al, 2006), and it has been suggested that with the loss of *E. tereticornis* trees and reliance on less preferred species, koalas have been more vulnerable to disease (Lunney and Leary, 1988).

Some more adaptable arboreal species likely to be present in the ecological community include *Trichosurus vulpecula* (brush-tail possum) and *Pseudocheirus peregrinus* (ringtail possum) as well as *Petaurus breviceps* (sugar glider) (Salas et al., 2008), also previously trapped for fur (Lunney and Leary, 1988). Populations of some arboreal mammal species may have increased temporarily following decline of predatory birds such as owls and reduction of hunting pressure by Aboriginal communities (Lunney and Leary, 1988). They eat a range of foods, including invertebrates, but sap from eucalypts as well as other species such as *Acacia mearnsii* (black wattle), commonly found in the ecological community, may be especially important during winter. Connections between vegetation patches across the landscape, even where these are fairly narrow linear roadside strips, are also important to allow movement between patches (Suckling, 1984). In the Shellharbour area it has been identified that movement of sugar gliders between patches is currently limited by fragmentation, as well as rarity of tree hollows (Department of Environment, Climate Change, and Water, 2011). The gliders inhabit large hollows in trees including *Eucalyptus pilularis* aged more than 200 years (Benson and McDougall, 1998 citing Mackowski, 1984). This dependence on hollows in mature trees may make gliders and possums particularly vulnerable to vegetation loss and disturbance (although ringtail possums may also use hollows in smaller trees and are able to build dreys) (Lindenmayer et al, 2008). *Cercartetus nanus* (eastern pygmy possum) may also occur in the ecological community, sometimes making use of tree hollows or abandoned bird nests and feeding on insects or nectar (Office of Environment and Heritage, 2014a). This species, and some others, including sugar glider and the small dasyurid *Antechinus stuartii* (brown antechinus) may contribute to pollination (Goldingay et al, 1991; Burnett and Dickman, 2008a). Other dasyurids possibly in Illawarra and south coast lowland grassy woodland include the small insectivorous *A. swainsonii* (dusky antechinus) and *Sminthopsis leucopus* (white-footed dunnart), likely to be in small numbers (Lunney et al, 2008). *Perameles nasuta* (long nosed bandicoot) and *Isoodon obesulus* (southern brown bandicoot) may also be present but with greatly reduced populations (Friend et al, 2008; Lunney et al, 2008b). Where present in sufficient numbers, their foraging habits may contribute to the cycling of nutrients and maintenance of soil structure. *Vombatus ursinus* (common wombat) similarly plays a role as a soil engineer and is dependent on and affects ground layer vegetation respectively. Of the mammalian soil engineers likely to have been present, the *Tachyglossus aculeatus* (echidna) is the only one that has not suffered great reduction in total range, having effective anti-predator strategies. This suggests that many of the functions supplied by these digging and soil foraging animals, such as increase in soil water infiltration, distribution of fungi and seeds, promotion of soil fertility and moderation of fuel loads, are likely to be impaired, compromising the health of the ecological community (Fleming et al, 2014).

Rodents that may be present in the ecological community include *Rattus fuscipes* (bush rat) and *Rattus lutreolus* (swamp rat) (Burnett et al, 2008; Menkhorst et al, 2008). *Dasyurus viverrinus* and *D. maculatus* (eastern and spotted-tail quoll respectively) are likely to have been part of the ecological community, playing a regulatory role at the top of the food chain, but eastern quoll is now extinct on the mainland and spotted-tail quoll has declined and may no longer be present within the ecological community (Lunney and Leary, 1988; Burnett and Dickman, 2008b; McKnight, 2008). Similarly, the ecological role of *Canis lupus dingo* (dingo) includes predation both on native and introduced animals, as well as regulation of predation by other predators such as cats, foxes and quolls. It is also likely to

still be present in low numbers, but previously subject to bounties and still largely excluded due to their perceived incompatibility with grazing (Lunny and Leary, 1988).

Bats are amongst the taxa that in 2002 were recognised to have persisted with notably high diversity, even in small, degraded and isolated remnants of coastal grassy forest, perhaps not being so dependent on intact understorey and also being relatively mobile between patches (NPWS, 2002b). Since this time ongoing losses of large old trees and associated tree hollows may have led to some decline in bat populations. The species are variously insectivores, frugivores and nectarivores, with the latter contributing to pollination. Many species, including *Falsistrellus tasmaniensis* (eastern false pipistrelle), listed as 'vulnerable' in NSW, benefit from small tree hollows often found in mature vegetation with large trees (Office of Environment and Heritage, 2014b). In surveys of the Illawarra Plain, the distinctive bat assemblage included *Nyctophilus geoffroyi*, (the lesser long-eared bat), *N. gouldii* (Gould's long-eared bat) and *Vespadelus vulturnus* (little forest bat) (NPWS, 2002b). Study for the Shellharbour urban fringe Local Environment Plan area also identified *Miniopterus shreibersii* (common bentwing bat), although for roosting, these are likely to also be dependent on caves, more likely to be present on the escarpment than in the ecological community (Mills, 2004). The ecological community also includes the fruit, nectar and blossom-eating *Pteropus poliocephalus* (grey-headed flying fox), which travels widely across the landscape and performs an ecological role as a pollinator and distributor of seeds (Benson and McDougall, 1998; NSW Scientific Committee, 2001). It is particularly associated with *E. tereticornis* (Lunney and Leary 1988) but also eats blossoms of *Angophora floribunda*, *C. maculata*, *E. longifolia*, *E. paniculata* ssp. *paniculata* and *E. pilularis* (Benson and McDougall, 1998). Seasonal food shortages due to habitat loss threaten their populations and also result in encroachment on agricultural crops such as fruit trees (Eby, 1991; Law et al, 2002).

### **Reptiles**

The ecological community includes reptiles from a range of groups. Skinks are well represented throughout the range, including *Eulamprus quoyii* (eastern water skink) and *Tiliqua scincoides* (Eastern blue-tongue). *Intellagama lesueurii lesueurii* (eastern water dragon) and especially *Amphibolurus muricatus* (jacky lizard) are amongst the typical dragon species that make use of habitat features such as fallen logs. *Varanus varius* (lace monitor) is a semi-arboreal carnivore, feeding on insects, reptiles, mammals, birds and eggs. *Ramphotyphlops nigrescens* (blackish blind snake) is a small, nocturnal snake that burrows to search for invertebrates. *Morelia spilota spilota* (diamond python) preys on a range of fauna, while elapid snakes are represented by species including *Pseudechis porphyriacus* (red-bellied black snake) and *Pseudonaja textilis* (eastern brown snake), which mainly prey on lizards and small mammals. In general, the transformation of the landscape for grazing and agriculture, for example, through underscrubbing, or for urban use, reduces habitat complexity for reptiles. For some species such as tiny *Lampropholis delicata* and *L. guichenoti* (dark-flecked and pale-flecked garden sunskinks), alternative habitats may become available (Atlas of Living Australia undated)(NPWS, 2002b).

### **Amphibians**

The ecological community provides terrestrial habitat for a range of amphibian species, including refuges in fallen timber, rocks and standing vegetation. Any wetter areas encompassed within patches of the ecological community may also provide suitable breeding habitat for species requiring free water for this. Species that may be present include the highly adaptable *Crinia signifera* (common eastern froglet) and *Limnodynastes peronii* (striped marsh frog), as well as *Litoria peronii* (Peron's tree frog), which is found in tree canopies outside of the breeding season (Hero et al, 2004a; Hero et al, 2004b; Hero et al, 2004c), as well as *Pseudophryne bibronii* (Bibron's toadlet), which is found in a variety of habitats (Atlas of Living Australia, undated b).. Less common species that may be present include *Litoria verreauxii* (Verreaux's frog) and the EPBC listed *L. aurea* (green and

golden bell frog), which is declining for unknown reasons, but possibly including habitat loss, chytrid fungus infection and predation by invasive species (Atlas of Living Australia, undated a; Hero et al, 2004d; Threatened Species Scientific Committee, 2014).

### **Birds**

Several owl species inhabit the ecological community and are important nocturnal predators. These include *Ninox connivens* (barking owl), *Tyto tenebricosa*, (sooty owl) *Tyto novaehollandiae* (masked owl) and *Ninox strenua* (powerful owl). Threats to these species include loss of hollow trees, as well as removal of wood for firewood, which reduces nesting sites and habitat for prey species. Competition with cats and foxes for prey, and bees for hollows, as well as predation by cats and foxes are also associated with declines (Birdlife, undated; Office of Environment and Heritage, 2014c, undated a). *Falco peregrinus* (peregrine falcon) is amongst the diurnal raptors that may be found in the ecological community (Mills, 2004). Other bird species typical of the ecological community include small canopy gleaners such as *Pardalotus punctatus* (spotted pardalote), *Gerygone olivacea* (white-throated gerygone) and *Zosterops lateralis* (silveryeye) as well as the larger *Pachycephala rufiventris* (rufous whistler). The winter flowering of *Eucalyptus tereticornis* may help support the partially migratory *Lichenostomus chrysops* (yellow-faced honeyeater), as well as the resident *Platycercus eximius* (eastern rosella) (Birdlife, undated; NPWS, 2002b). *Dicaeum hirundinaceum* (mistletoe bird) may also be nomadic, feeding on the fruits of mistletoe and effectively distributing their seeds. Many other bird species, including insectivorous species are likely to benefit from the presence of mistletoes in the ecological community. Sallying and pouncing insectivores that are typical of woodlands and present in this ecological community include *Rhipidura albiscapa* (grey fantail) and *Eopsaltria australis* (eastern yellow robin) (Birdlife, undated; NPWS, 2002b).

*Anthochaera phrygia* (regent honeyeater), nationally listed as critically endangered, may travel long distances to find suitable resources, including nectar of *Corymbia maculata* and *Angophora floribunda*, (although these are not the primary nectar sources for this species). It also forages for fruit and nectar on mistletoe plants, as well as lerp, honeydew and insects.

Predatory birds in the ecological community include *Cracticus torquatus* (grey butcherbird) and *Coracina novaehollandiae* (black-faced cuckoo-shrike), which pounce on prey from perches. *Acanthiza nana* (yellow thornbills) and *A. pusilla* (brown thornbills) use the ground and lower shrubby layers, so are vulnerable the removal of these strata, as well as possible predation by cats (Birdlife, undated; NPWS, 2002b).

### **Landscape context, patch distribution and the role of connectivity in the landscape.**

Ecological communities exist within the context of their surrounding landscape. As for the Illawarra and south coast lowland grassy woodland, much of the other woody vegetation in the area between the eastern escarpment and the coast has been heavily cleared for timber extraction, agriculture and grazing, and more recently for residential and commercial development and infrastructure. Some much larger patches exist, particularly in areas of higher elevation less suitable for development.

Within Illawarra, Jervis, Ettrema and Bateman subregions the median patch size of woody native vegetation is 0.69 ha, indicating that the great majority of vegetation patches in the area are now small fragments (analysis of data from Department of the Environment, 2014). The role of connectivity for ecological processes and the specific thresholds that apply for this ecological community are not understood in detail. Nevertheless, the current expectation is that in general, elements of structural connectivity contribute to the function of woody ecological communities in Australia (Doerr et al, 2010).

For long term health of faunal populations, the effective population size is an important consideration, which is limited by patch size and landscape connectivity, with species richness often declining for some time after habitat fragmentation. Small or linear patches have a large edge to area ratio. This is likely to allow the introduction of weeds and incursions by feral animals, and alter microclimates, making the ecological community more vulnerable to damage during droughts. The associated loss in physical and ecological connectivity is likely to limit regeneration if there are no nearby sources of seeds and may also affect animals that require connected links to disperse, or have a large home range. Seed dispersal for *Eucalyptus tereticornis* and the other canopy species dominating the vegetation structure of the Illawarra and south coast lowland grassy woodland is by wind and gravity, estimated to be to a distance of approximately 20 m (up to 30 m for *Corymbia maculata*) (Benson and McDougall, 1998). Many of these canopy species store seed in the canopy but have no stored seed bank in the soil (Florence, 1996), so regenerative capacity is limited where there are large gaps between remnants. Where there are large gaps in the canopy, seedlings may also be more prone to drying in hot conditions, which is a major cause of their loss (Florence, 1996).

Many animals are reluctant to travel between patches of their preferred habitat, particularly if this involves crossing open areas. For example, sugar gliders are primarily limited to patches with trees. A large number of patches of the ecological community are separated by gaps well beyond the dispersal distance of the canopy eucalypt seeds and greater than the expected gap-crossing threshold for many fauna. . The mean gap between patches of the ecological community is 150m (analysis of data from Department of the Environment, 2014). In a review of Australian studies of connectivity, mostly in wooded habitats, the mean threshold for fauna (mainly birds and mammals) to cross gaps was 106 m (Doerr et al, 2010). The separation of habitat patches imposes energy costs on fauna attempting to travel between patches, and can also introduce acute dangers. For example, vehicle collision and dog attack are amongst the major causes of koala death in eastern Australia (McAlpine et al, 2015). While high quality core feeding habitat is a primary determinant of koala populations, retention of corridors for dispersal (which may be of lower quality) is also important (McAlpine et al, 2006).

Many fauna are not restricted to Illawarra and south coast lowland grassy woodland and may use habitat features in other adjoining ecological communities. There is insufficient information available on the pre-1750 distribution of ecological communities to know how contiguous the various patches were. However, as described, the current distribution of all woody native vegetation is highly fragmented across the subregions where the ecological community occurs. Some patches of the ecological community, such as around Yalwal remain surrounded by native woody vegetation, supporting their ecological function. At the western edge of the current extent of the ecological community in the Illawarra area and around Milton, many of the remnants adjoin other woody vegetation on at least one side. These remnants are likely to be on hill slopes. A similar pattern exists north of Moruya. This is likely to support some of the ecological functions of the ecological community. However, on the other side of these remnants, facing the settled areas, much of the vegetation has been cleared, exposing the patches to edge effects. In the lower lying areas, particularly in the Illawarra, where a substantial proportion of the ecological community occurs, the effects of fragmentation may be most severe as many of the remnants are small isolates in a largely cleared landscape (Figure 1).

The Illawarra Regional Strategy 2006-2031, (Department of Planning, 2006) and the draft Illawarra Biodiversity Strategy (Illawarra Councils, 2010) identify regional biodiversity corridors including the 'Escarpment moist forest corridor' and 'Yallah corridor'. These corridors encompass many of the remnants of the ecological community within the Illawarra. The Regional Strategy states that local environmental plans, which define zoning are to "maximise protection of 'Significant Native Vegetation', 'Indicative DEC Regional Habitat Corridors' and other 'Indicative Habitat Corridors'" (Department of Planning, 2006, p.30).

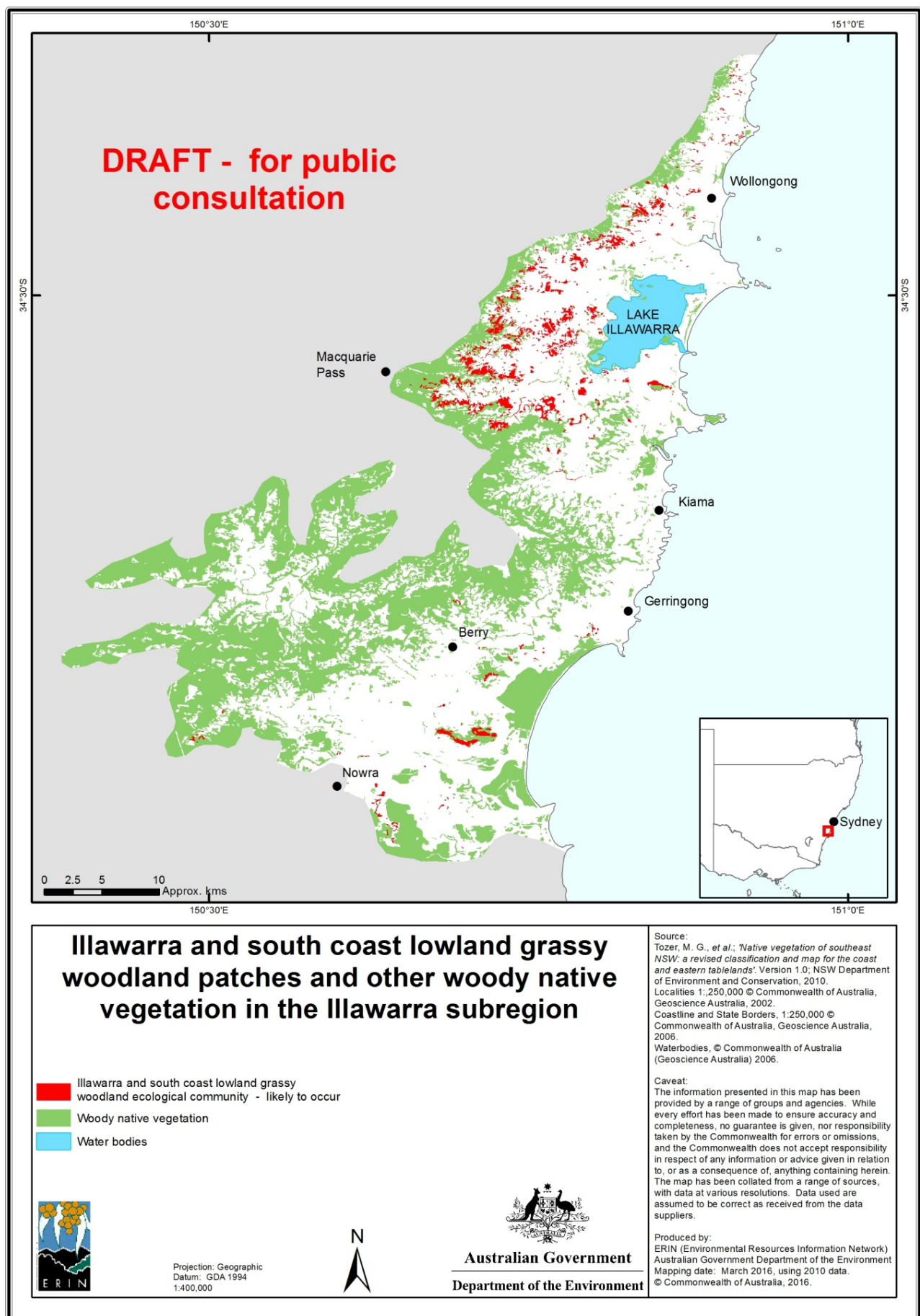


Figure 1 Map of patches of Illawarra and south coast lowland grassy woodland ecological community patches and all native woody vegetation in the Illawarra subregion.

## APPENDIX E – DESCRIPTION OF THREATS

The ecological community has suffered considerable damage, primarily through vegetation clearing and fragmentation and associated impacts of changing landuse, for example, the introduction of invasive species. The effects of many of these past changes also constitute ongoing threats. In addition, clearing for agriculture and grazing is being supplemented or replaced by clearing and fragmentation for urban development and associated infrastructure.

Many of the threats described here are likely to interact, rather than acting independently, increasing the complexity of ecological responses and management considerations. For example, the occurrence or absence of fire is likely to change the susceptibility of a patch to weed invasion and affect the hunting behaviour of predatory animals.

### Clearing and fragmentation of vegetation and associated changes to hydrology

Along the NSW coast the initial clearing has been for agricultural development, grazing and timber extraction (described in). In the 20th century urban populations increased markedly, resulting in the clearing of substantial areas of vegetation in accessible areas. This trend is continuing, albeit with more consolidated planning. For example, the population of the Illawarra is projected to increase by 65 050 (to 450 300) between 2014 and 2031 (Department of Planning and Environment, 2014). The NSW government expects that this additional population will require 45 000 new houses in the region, some in existing urban areas and others in ‘greenfield’ sites. The new release areas will include West Dapto, Calderwood and Tallawarra, in the West Lake Illawarra area. Approximately 27 000 dwellings are planned to be built there over the next 30-40 years, as well as at sites at Nowra-Bomaderry, Bulli, Shell Cove and West Culburra (Department of Planning and Environment, 2014). Similarly, residential developments are occurring further south, within the range of the ecological community, including in the Eurobodalla Shire.

Many of the remnants of the ecological community occur in the vicinity of the new developments in the Illawarra. Some will be cleared while the development of the surrounding areas will mean that other areas of the ecological community will exist in a greatly modified landscape, with reduced connectivity. For example, in a draft plan for part of the West Dapto area it was proposed that approximately 30% of the NSW listed Illawarra lowlands grassy woodland in the Sydney Basin Bioregion would be cleared and approximately 70% retained in a reserve (Wollongong City Council 2013, 2016). This reserve will be surrounded by residential areas and may be used for some recreation, which is likely to create additional pressures on the ecological community. The proximity of new urban areas to remnants of the ecological community makes it likely these developments will cause a range of associated types of ongoing damage. Dumping rubbish and inappropriate recreational activities such as creation of bike tracks are common problems. Gardens can be a source of weeds and domestic animals prey on, disturb or compete with native fauna (NSW Scientific Committee, 1999). Changes to hydrology and water quality can also occur.

Some remaining areas are likely to be too small to sustain populations of certain species of plants and animals. Koala is one species that has dramatically declined in proximity to some urban areas in eastern Australia, with total loss of habitat and other associated threats such as road deaths and dog attacks (McAlpine, 2015). Grey-headed flying foxes are threatened primarily due to habitat loss (including winter and spring flowering *Eucalyptus tereticornis*), but populations are also vulnerable to additional losses associated with urbanisation, including lead toxicity, electrocution on powerlines and disturbance, particularly during pregnancy (Eby, 1991). In a study of the impact on urbanisation of arboreal marsupials on the south coast of NSW, Villasen et al, (2014) found that responses to the boundary between urban and forested areas were complex. Some species were able to persist within low density urban areas, but high density urban areas had an overall negative affect on arboreal marsupial populations. For species, such as *Petaurus australis* (yellow-bellied glider) there is a negative spill-over effect from urban areas into nearby forest.



Port development in Wollongong is also encouraging the development of industrial infrastructure such as greatly increased storage for imported cars at Kembla Grange, near where the ecological community occurs. This would be likely to also require additional road development (Humphries, 2014).

### *Road construction*

In association with the increase in populations in the areas where the ecological community occurs there is the development of infrastructure, including roads. The Princes Highway upgrade is a major project occurring over several stages, with potential impacts on the ecological community in various locations during construction and through the longer term use of the road. As the upgrade is staged, environmental impact assessments are being made for each section. In addition to direct losses through clearing of Illawarra and south coast lowland grassy woodland, there are possible indirect impacts through changes to the regional landscape. Roadside vegetation is often narrow and subject to impacts such as weed invasion, but it can also provide important connections between larger patches of vegetation, allowing dispersal of plant material and fauna. Roadside vegetation has been identified as useful for sugar gliders, maintaining otherwise unviable populations in small remnants (Suckling, 1984). Removal and fragmentation of any native vegetation through road construction may therefore impact on the viability of remnants of Illawarra and south coast lowland grassy woodland.

Other impacts may occur due to changes in hydrology. For example, the Albion Park bypass is being planned to avoid clearing a high quality patch of the ecological community located in the Croome Reserve, with re-location of sporting facilities occurring to allow this (NSW Transport, Roads and Maritime Services, 2015), yet the road's likely proximity to the patch and location up-slope may mean that there are other impacts on the patch such as runoff from the new road.

### *Quarrying*

Rock extraction is a well established activity in the region. As particular rock types, such as basalt are targeted, it may disproportionately affect some ecological communities. In the Shellharbour area, Illawarra and south coast lowland grassy woodland is one of the identified ecological communities that are affected by clearing and fragmentation for quarries. Changes to regional surface and groundwater hydrology can also manifest at a regional scale, for example, disturbance of upland groundwater recharge areas may affect spring discharge in more low-lying areas (Department of Environment, Climate Change, and Water, 2011).

### **Weeds**

The high rainfall and fertile soils where the ecological community occurs makes these areas prone to weed invasion. Where clearing and fragmentation has decreased the density of the canopy the risk is increased (NPWS, 2002a). Along the NSW coast there are many sources of weeds, such as farms and urban gardens (NSW Scientific Committee, 1999). Many of these have been long-established, with some weeds identified in the Illawarra from as early as 1815 (Illawarra Councils, 2010). One of the most severe threats is *Lantana camara*, which forms a dense shubby layer, and is particularly aggressive where clearing and fragmentation have led to an open canopy (NPWS, 2002a). However, removal of this weed should be planned carefully as it can provide valuable shelter for both flora and fauna, including threatened species (Mills, 2004 and 2006). Other weeds likely to damage the Illawarra and south coast lowland grassy woodland include:

African boxthorn *Lycium ferocissimum*

African lovegrass (*Eragrostis curvula*)

African olive (*Oleus europaea* ssp.cuspidata)

Asparagus (*Asparagus asparagoides*, *A.densiflorus* (syn. *aethiopicus*), *A. scandens*, *A. plumosus*)



Bitou bush (*Chrysanthemoides monilifera* subsp. *rotundata*)

Blackberry (*Rubus fruticosus*)

Carpet grass (*Axonopus fissifolius*)

Fireweed (*Senecio madagascarensis*)

Gorse *Ulex europaeus*

Kikuyu (*Pennisetum clandestinum*)

Privet (*Ligustrum lucidum*, *L. sinense*)

Additionally, there are many other weeds identified within the areas where the ecological community occurs (Table 10). The NSW Noxious Weeds Act 1993 establishes weed control classes including notifiable weeds (Department of Environment, Climate Change and Water, 2011).

**Table 10 Declared weeds in Local Control Authority areas for Illawarra District Weeds Authority and Eurobodalla Local Government Area (additional weeds)**

Source: NSW Department of Primary Industries, undated

African turnip weed - eastern <i>Sisymbrium thellungii</i>	African feather grass <i>Pennisetum macrourum</i>
Alligator weed <i>Alternanthera philoxeroides</i>	African turnip weed - western <i>Sisymbrium runcinatum</i>
Annual ragweed <i>Ambrosia artemisiifolia</i>	Anchored water hyacinth <i>Eichhornia azurea</i>
Artichoke thistle <i>Cynara cardunculus</i>	Arrowhead <i>Sagittaria montevidensis</i>
Asparagus - ground asparagus <i>Asparagus aethiopicus</i>	Asparagus - climbing asparagus fern <i>Asparagus plumosus</i>
Athel pine <i>Tamarix aphylla</i>	Asparagus weeds <i>Asparagus</i> spp.
Black knapweed <i>Centaurea nigra</i>	Bear-skin fescue <i>Festuca gautieri</i>
Blue hound's tongue <i>Cynoglossum creticum</i>	Black willow <i>Salix nigra</i>
Bridal creeper <i>Asparagus asparagoides</i>	Boneseed <i>Chrysanthemoides monilifera</i> subsp. <i>monilifera</i>
Broomrapes <i>Orobanche species</i>	Bridal veil creeper <i>Asparagus declinatus</i>
Burr - Californian burr <i>Xanthium orientale</i>	Burr - Bathurst burr <i>Xanthium spinosum</i>
Burr - Noogoora burr <i>Xanthium occidentale</i>	Burr - Italian cocklebur <i>Xanthium italicum</i>
Burr ragweed <i>Ambrosia confertiflora</i>	Burr - South American burr <i>Xanthium cavanillesii</i>
Cane needle grass <i>Nassella hyalina</i>	Cabomba <i>Cabomba caroliniana</i>
Cat's claw creeper <i>Dolichandra unguis-cati</i>	Cape broom <i>Genista monspessulana</i>
Chilean needle grass <i>Nassella neesiana</i>	Cayenne snakeweed <i>Stachytarpheta cayennensis</i>
Clockweed <i>Gaura parviflora</i>	Chinese violet <i>Asystasia gangetica</i> subsp. <i>micrantha</i>
Corn sowthistle <i>Sonchus arvensis</i>	Coolatai grass <i>Hyparrhenia hirta</i>
Crofton weed <i>Ageratina adenophora</i>	Creeping lantana <i>Lantana montevidensis</i>
Espartillo - broad kernel <i>Amelichloa caudata</i>	Dodder <i>Cuscuta</i> species
Eurasian water milfoil <i>Myriophyllum spicatum</i>	Espartillo - narrow kernel <i>Amelichloa brachychaeta</i>
Flax-leaf broom <i>Genista linifolia</i>	Fine-bristled burr grass <i>Cenchrus brownii</i>

Frogbit <i>Limnobium laevigatum</i>	Fountain grass <i>Cenchrus setaceus</i>
Gamba grass <i>Andropogon gayanus</i>	Gallon's curse <i>Cenchrus biflorus</i>
Giant reed <i>Arundo donax</i>	Giant Parramatta grass <i>Sporobolus fertilis</i>
Golden thistle <i>Scolymus hispanicus</i>	Glaucous starthistle <i>Carthamus leucocaulos</i>
Green cestrum <i>Cestrum parqui</i>	Grey sallow <i>Salix cinerea</i>
Groundsel bush <i>Baccharis halimifolia</i>	Harrisia cactus <i>Harrisia</i> spp.
Hawkweeds <i>Hieracium</i> spp.	Horsetails <i>Equisetum</i> spp.
Hydrocotyl <i>Hydrocotyl ranunculoides</i>	Hymenachne <i>Hymenachne amplexicaulis</i> and hybrids
Karoo thorn <i>Acacia karroo</i>	Kidney-leaf mud plantain <i>Heteranthera reniformis</i>
Kochia <i>Bassia scoparia</i>	Koster's curse <i>Clidemia hirta</i>
Kudzu <i>Pueraria lobata</i>	Lagarosiphon <i>Lagarosiphon major</i>
Lantana <i>Lantana camara</i>	Leafy elodea <i>Egeria densa</i>
Lippia <i>Phyla canescens</i>	Long-leaf willow primrose <i>Ludwigia longifolia</i>
Madeira vine <i>Anredera cordifolia</i>	Mexican feather grass <i>Nassella tenuissima</i>
Mexican poppy <i>Argemone mexicana</i>	Miconia <i>Miconia</i> spp.
Mikania vine <i>Mikania micrantha</i>	Mimosa <i>Mimosa pigra</i>
Mossman River grass <i>Cenchrus echinatus</i>	Mysore thorn <i>Caesalpinia decapetala</i>
Nodding thistle <i>Carduus nutans</i>	Pampas grass <i>Cortaderia</i> spp.
Parthenium weed <i>Parthenium hysterophorus</i>	Pond apple <i>Annona glabra</i>
Prickly acacia <i>Acacia nilotica</i>	Prickly pear - common pear <i>Opuntia stricta</i>
Prickly pear - Hudson pear <i>Cylindropuntia rosea</i>	Prickly pear - smooth tree pear <i>Opuntia monacantha</i>
Prickly pear - tiger pear <i>Opuntia aurantiaca</i>	Prickly pear - velvety tree pear <i>Opuntia tomentosa</i>
Red rice <i>Oryza rufipogon</i>	Rhus tree <i>Toxicodendron succedaneum</i>
Rubber vine <i>Cryptostegia grandiflora</i>	Sagittaria <i>Sagittaria platyphylla</i>
Salvinia <i>Salvinia molesta</i>	Scotch broom <i>Cytisus scoparius</i>
Senegal tea plant <i>Gymnocoronis spilanthoides</i>	Serrated tussock <i>Nassella trichotoma</i>
Siam weed <i>Chromolaena odorata</i>	Silverleaf nightshade <i>Solanum elaeagnifolium</i>
Smooth-stemmed turnip <i>Brassica barrelieri</i> subsp. <i>Oxyrrhina</i>	Soldier thistle <i>Picnomon acarna</i>
Spanish broom <i>Spartium junceum</i>	Spongeplant <i>Limnobium spongia</i>
Spotted knapweed <i>Centaurea stoebe</i> subsp. <i>Micranthos</i>	St. John's wort <i>Hypericum perforatum</i>
Texas blueweed <i>Helianthus ciliaris</i>	Tropical soda apple <i>Solanum viarum</i>
Water caltrop <i>Trapa</i> spp.	Water hyacinth <i>Eichhornia crassipes</i>
Water lettuce <i>Pistia stratiotes</i>	Water soldier <i>Stratiotes aloides</i>
Willows <i>Salix</i> spp.	Witchweeds <i>Striga</i> spp.
Yellow burrhead <i>Limncharis flava</i>	Yellow nutgrass <i>Cyperus esculentus</i>

## Feral animals

The ecological community is subject to impacts by a suite of feral and domestic animals common along the NSW coast. The damage caused includes predation on and competition with native animals, damage to flora through excessive grazing, trampling and spread of weed seeds. Deer, including fallow deer (*Dama dama*) are in high densities in some locations. Their browsing removes and modifies understorey, preventing recruitment and re-generation of all layers of vegetation. Rabbits (*Oryctolagus cuniculus*) also are grazers with potential to limit regeneration in the ecological community.

As across the continent, cats (*Felis catus*), whether feral, stray or domestic, predate on a range of small and medium sized fauna, both native and introduced, and may have contributed to the functional or complete loss of some species in the ecological community including eastern quoll, spotted tail quoll, southern brown bandicoot, long-nosed potoroo, Parma wallaby, and green and golden bell frog; although it is noted that these species have also suffered from other threats such as predation by foxes, habitat clearing and fragmentation and inappropriate fire regimes (Department of the Environment, 2015a). Cats may also compete with native predators such as the spotted tail quoll. Likewise, foxes (*Vulpes vulpes*) have been associated with loss of a range of small fauna, including all of the species described previously as adversely affected by cats (Mills, 2006b; Department of the Environment 2015 b,c). Lunney and Leary (1988) noted that the peak of fox abundance around Bega, in the early 20<sup>th</sup> century coincided with the extinction of many small native vertebrates. Both cats and foxes also compete with dingoes, and suppression of dingoes may have allowed these introduced predators to have greater impacts on their prey species (Department of the Environment, 2015c). Presence of cats and foxes is likely to limit the possibility of re-establishing populations of many terrestrial native mammals. Some of these native prey species are also soil engineers, so their loss may have a substantial long term impact on the health of the ecological community (Fleming et al, 2014).

## Fire

Fire is one of the primary shapers of ecological communities within the range of the Illawarra and south coast lowland grassy woodlands, with fire regime characteristics such as frequency, burn size and intensity influencing floristics, structure and other habitat features, as well as directly affecting fauna. It also interacts with other disturbances or threats to the community, including climate change, feral animal behaviour and weed invasion.

Fire frequency and intensity, and the interaction with fuel, weather and topography is particularly important in defining the transition to rainforest dominated vegetation (Mills, 1993; Mills and Jakeman, 1995). Absence of fire in the ecological community can lead to the increase in the density of the shrub layer, with mesic species such as *Pittosporum undulatum* and weeds such as *Lantana camara* becoming more common. The regeneration of some species, for instance *Acacia mearnsii*, may be restricted where fires are now infrequent and of low intensity (Suckling, 1984). Infrequent fire can also threaten species such as the threatened Illawarra greenhood orchid if it allows vigorous understorey growth, crowding out the orchid, which is only seasonally present. Fire occurring in winter or spring will destroy the above ground parts of the plant and prevent setting of seed. Where fire is very frequent in the ecological community, species tolerant of burning, such as *Imperata cylindrica* (blady grass) may become dominant. (NPWS, 2002c).

Fires have both immediate effects on fauna, depending partly on their mobility, as well as long term effects on population dependent on habitat availability and suitability of conditions for re-colonisation. At Nagee Nature Reserve, in eucalypt forests on the south coast of NSW, the effects on small terrestrial mammals of intense, large fire and smaller patchy fires were compared. *Antechinus agilis* (agile antechinus), dusky antechinus, bush rat, swamp rat as well as the introduced house mouse (*Mus musculus*) disappeared for approximately 2 years following an intense fire, and re-colonised from surrounding areas. Following a smaller, patchy fire, recovery was much faster, occurring from the

remaining resident population. This highlights the importance of landscape context for ecological response to disturbances such as fire, with unburnt areas providing refuge and source populations for recovery (Recher et al, 2009). Faunal populations in isolated patches (common in Illawarra and south coast lowland grassy woodland) may be vulnerable to permanent extinction following severe disturbance, although fragmentation may also protect some patches from burning.

Gellie (2005) summarised the long-term trends for disturbance in dry grass/shrub forests of the NSW southern forests area. Previous to European style settlement, which occurred in the 1820s, fire regimes were characterised by infrequent moderate-high intensity fires at 12-30 year intervals. During the European style settlement period, from the 1820s to 1950s there were typically frequent low to moderate intensity fires at five to ten year intervals. A 1920s reference suggests that in the 19th century, clearing in the Illawarra was followed by burning six months later (Mills and Jakeman, 1995). This may have reduced the capacity of cleared vegetation in the ecological community to re-generate.

The current regime from the 1950s to the present includes infrequent moderate to high intensity fires at intervals of more than 20 years, with more frequent burns occurring as part of prescribed burning programmes from the 1950s to 1970s (Gellie, 2005). This interpretation of current fire regimes suggests that in some ways they may have returned to a pattern similar to pre-European regimes, although there may also be underlying differences and likely to be variation between patches. Amongst the many inferred effects of the decline of digging fauna is the potential for fire intensity to increase, due to the higher above ground fuel loads (previously incorporated into the soil) (Fleming et al, 2014). Other possible differences include patch size and distribution, which may be designed to prioritise protection of built assets. Arson is another source of fire near urban areas, for example, in Croome Reserve (NPWS, 2002c). The considerable change in landcover, with the clearing and fragmentation of this ecological community and other vegetation across the landscape changes the ecological responses to fire. For example, there are now more limited short and long term refuges for fauna and source populations for recovery, while there is now greater potential for competition from weeds and feral animals.

### **Agriculture and grazing**

According to Gellie (2005), throughout NSW southern forests, grazing levels were low prior to European-style settlement from the 1820s. Following non-Indigenous settlement, clearing for agriculture and grazing were primary causes of damage to the ecological community. While clearing for these purposes has slowed, the impacts are ongoing.

Cropping directly replaces the ecological community, altering soil structure and chemical properties and destroying the seedbank. It can also indirectly affect the ecological community at nearby sites, by fragmentation, and as a source of weed seeds, spray drift and runoff.

Grazing by stock including cows, sheep and horses resulted in extensive clearing of south coast forests from the 1920s, after which the level of grazing has been described as 'moderate' (Gellie, 2005). Ongoing damage through grazing occurs through the removal of sub-canopy and understorey, trampling and browsing of understorey, erosion and other changes to the soil, such as increased nutrient loads, which can severely limit regenerative capacity (NSW Scientific Committee, 1999; NPWS, 2002a). Differences in palatability of plant species may result in changed species composition, with regeneration of some species such as *Acacia mearnsii* potentially prevented by prolonged grazing (Suckling, 1984). Some introduced pasture grasses have also become environmental weeds. Intermittent grazing may allow some understorey species to prevent the dominance of larger shrubs and grasses, but timing is critical to allow seeding.

### **Logging and timber removal**

Timber extraction occurred in the Wollongong area from the beginning of non-Indigenous occupation, although the primary target species was *Toona ciliata* (red cedar), which is a rainforest tree. Gellie (2005) identifies timber harvesting as a characteristic feature throughout the southern forests area from the 1820s

to the 1950s. Ironbarks such as *Eucalyptus paniculata* ssp. *paniculata* was also extracted early for uses such as fence posts, wharfs and railway sleepers (Bodkin, pers.comm., 2016). More recently, between 1988 and 2010, within the subregions occupied by the ecological community, logging was a source of disturbance mainly in the Bateman subregion, where it was the responsible for almost half of the disturbance identified for woody vegetation (Office of Environment and Heritage, 1988-2010). Selective logging was identified by the NSW Scientific Committee (1999) as a threat within the range of the NSW listed ecological community. Small scale selective logging targets individual trees for fence posts and firewood. The removal of dead timber also changes habitat structure within the ecological community.

### **Climate change**

There is little specific information on the likely impact of climate change on this ecological community, but as for most communities, it seems likely to compound other threats. Allowing for uncertainty and variation between models, it has been projected with very high confidence that along the east coast of Australia, the annual and seasonal mean, maximum and minimum surface temperatures will increase in coming decades. It is possible that this will affect the survival rate of some organisms in the community. There is also very high confidence in projections of substantial increases in temperature of the hottest days, which may lead to direct heat stress. For the south coast there is a projection, with medium confidence, of reduced winter rainfall, while there may be increased summer rainfall. The intensity of heavy rainfall events is also expected to increase (Dowdy et al, 2015).

Reduced winter rainfall may change plant establishment and survival, also more general resource availability, as dry conditions have been linked to sharp declines in populations of bird species across various guilds in Victoria (MacNally et al, 2009). It has also been suggested that declines of regent honeyeater, swift parrot and little lorikeet may be linked to 'dry flowering' of eucalypts, with insufficient nectar available to support these species, whose populations move between resource rich patches (Watson, 2011). All of these species may occur in the Illawarra and south coast lowland grassy woodlands, using winter flowering species such as *Eucalyptus tereticornis* for nectar and lerps (Saunders and Heinsohn, 2008; Office of Environment and Heritage, 2014d, e, 2015a). Other changes in habitat suitability may be subtle, for example, the increase in atmospheric carbon dioxide concentrations may decrease nutritional value of foliage (McAlpine et al, 2015). Hunter (2015) suggests that in northern NSW, where summer rainfall is prevalent, seasonality is a strong predictor of hollow development, with summer moisture availability being the greatest contributor. With a change in seasonal distribution of rainfall, development of hollows may also be affected.

Land cover also affects local temperatures, with trees playing a role both through transpiration and canopies blocking radiation. The conversion of woody vegetation to urban areas can result in increases in air temperatures, creating an 'urban heat island' (Brown et al., 2013).

## APPENDIX F – ELIGIBILITY FOR LISTING AGAINST EPBC ACT CRITERIA

### Criterion 1. Decline in geographic distribution

Illawarra and south coast lowland grassy woodland originally existed on suitable loamy soils on the flat and gently sloping land below the eastern escarpment and above the immediate coastal strip, from the north side of Wollongong to the south of Moruya. However, this area was also highly attractive for primary industries such as logging, grazing and agriculture and was rapidly cleared following non-Indigenous settlement. For this reason, the original extent of this ecological community is not known in detail. Two units described by Tozer et al (2010): GW p3 'South coast lowland swamp woodland' and 'GW p34' South coast grassy woodland' are considered to be approximately equivalent to the ecological community. These are estimated to have occupied between 17 667 ha and 42 667 ha before 1750 (Table 11). Of this approximately 4 200 ha remains<sup>4</sup>. This represents a decline of approximately 76-90% in area of occupancy.

**Table 11 Estimated original and current extent of the ecological community**

Tozer et al 2010	Estimated current extent (ha)	Estimated original extent (ha)	Estimated extent remaining/lost
South coast lowland swamp woodland GW p3	1100	7 333-22 000	5-15% / 85-95%
South coast grassy woodland GW p34	3100	10 333- 20 667	15-30% / 70-85%
Total	4200	17 667-42 667	10-24% / 76-90%

It is likely that since the information used in Tozer et al (2010) was collected, there have been further losses, additionally, this information does not consider the likely condition of the remnants, so the figure suggests a 'best case' for the current extent of the ecological community.

#### Conclusion

Based on estimates in Table 11, the ecological community is considered to have undergone a severe decline (at least 70%) in its geographic extent and is therefore eligible for listing as **endangered** under this criterion.

<sup>4</sup> Tozer et al, 2010 identifies 4200 ha. If remnants <0.1ha are excluded due to likelihood of errors in spatial interpretation the remaining area is 4032 ha. This figure is used for patch size analysis (section 1.6.7 and Criterion 2).

## **Criterion 2. Small geographic distribution coupled with demonstrable threat**

The purpose of this criterion is to recognise that an ecological community with a distribution that is limited, either naturally or that has become so through modification has an intrinsically higher risk of extinction if it continues to be subjected to a threatening process.

Thresholds to identify terrestrial vegetation communities with limited distributions are typically based on three indicative measures:

- 1) extent of occurrence- an estimate of the total geographic range over which the ecological community occurs;
- 2) area of occupancy- an estimate of the area actually occupied by the ecological community (which generally equates with its present extent); and
- 3) patch size distribution- an indicator of the degree of fragmentation of the ecological community and vulnerability of small patches to particular threats.

The highest category met (i.e. indicating the most restricted distribution), against any one of these measures, is applied in the assessment of the criterion to determine the conservation status of the ecological community.

### **Extent of occurrence**

The area over which the ecological community occurs is approximately 93 000 ha (analysis of data from Tozer et al, 2010).

### **Area of occupancy**

The total area of occupancy of the ecological community is estimated to be up to 4200 ha (Tozer et al, 2010) which is indicative of a **restricted** distribution.

### **Patch size distribution**

The total area of occupancy comprises approximately 906 patches of individual size  $>0.1$  ha<sup>5</sup>. Approximately 67% of these patches are  $\geq 0.5$  ha, which is the minimum size required to meet the condition classes in Section 1.5.3.

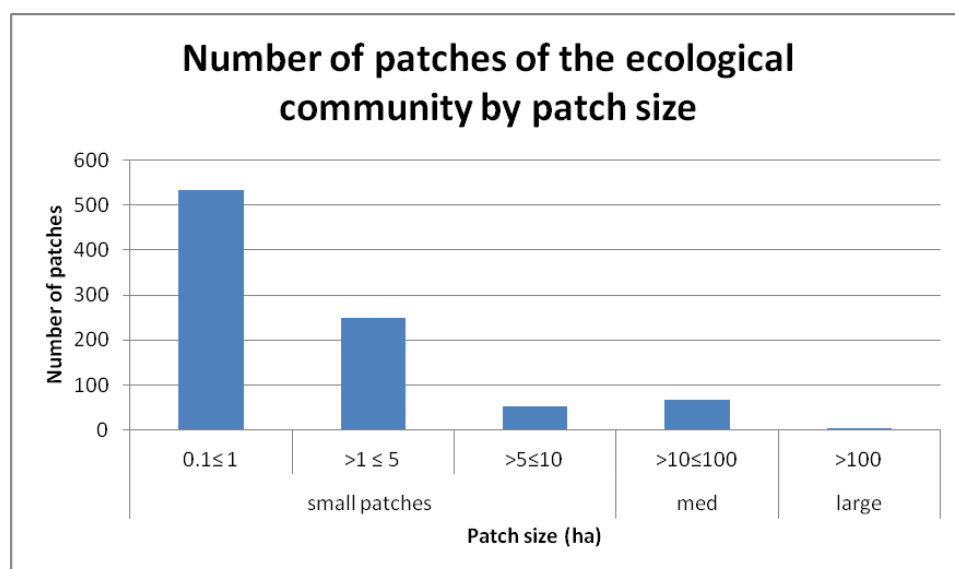
The vast majority of remnants are small, with 92% of all patches being smaller than 10 ha each (Figure 2a). The mean patch size for the ecological community is 4.45 ha and the median size is 0.75 ha. This is indicative of a '**very restricted**' distribution (analysis of data from Tozer et al, 2010).

When considered by the area covered by patches of various sizes, only five patches are bigger than 100 ha (18% of the total area) (Figure 1b). The majority of the area is comprised of medium sized patches ( $>10$  -  $\leq 100$  ha) (53% of the total area), and small patches ( $\leq 10$  ha) (29% of the total area).

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<sup>5</sup> Analysis of data from Tozer et al, 2010, patches are buffered by 25m.

**Figure 2 Patch size in the ecological community**



**Table 12 Area of the ecological community by patch size<sup>6</sup>**

Size of patch	Area of patches (ha)	Percentage of area
<b>Combined small combined (0.1 - ≤10 ha)</b>	1175	29
<b>Medium (&gt;10 - ≤100 ha)</b>	2154	53
<b>Large ( &gt;100 ha)</b>	704	18

Source: Analysis of data from Tozer et al, 2010.

### Threatening processes affecting the ecological community

Limited information is available to project future losses to the extent and function of the ecological community. Currently only 275 ha (7% of the current extent or 1-1.5% of the original extent) is formally protected, but there is little information on the condition or long term viability of these areas. While much of the northern area is part of the NSW listed ‘Illawarra lowlands grassy woodland in the Sydney Basin Bioregion’, attrition continues in this area. Across the range of the ecological community most of the existing remnants are very small. This fragmentation is likely to compromise their survival with increasing intensity and extent of development, in addition to the long-standing damage associated with past and present land uses such as agriculture and grazing. Many of the impacts of future development may be indirect, for example, the further reduction of landscape connectivity, changes to regional hydrology and fire regimes, as well as introduction of new feral animals and weeds.

All of the area, including that formally protected in reserves is subject to ongoing impacts of weeds, feral animals, changes to hydrology, fire regime and climate, in addition to both direct and indirect impacts of urbanisation (see Appendix E – Description of threats). In addition, natural processes of

<sup>6</sup> Total area is approximately 4032 following removal of patches <0.1 ha, as some of these are likely to be artefacts of spatial processing errors.



attrition over time may not be balanced by regeneration of gaps where sources and vectors of seed and pollen are not present or soil condition has been compromised. A loss of 33 ha per year of the area likely to meet condition thresholds would completely extirpate the ecological community during the ‘immediate future’, taken to be 60 years<sup>7</sup>. Given past rates of loss of area and condition and the likelihood that some threats will intensify, this rate of loss is plausible.

### Conclusion

The ecological community is considered to have a very restricted distribution with a very small median patch size (0.75ha). Most (92%) of patches are smaller than 10ha, so are very vulnerable to ongoing threats such as invasion by weeds and feral animals, as well as direct losses through clearing (as identified in Appendix E – Description of threats). These threatening processes could cause it to be lost in the immediate future (considered here as three generations (up to 60 years) of a key canopy species). Therefore the ecological community is eligible for listing as **critically endangered** under this criterion.

### **Criterion 3. Loss or decline of functionally important species**

The loss of small to medium sized ground-dwelling mammals from much of temperate Australia is reflected in the ecological community. Amongst the species lost or now substantially absent include the diggers, such as potoroos and bandicoots. Wombats and echidnas are likely to still be present, however, the total populations of digging fauna are likely to have declined. The ecological functions that may have been compromised by the loss of these fauna include nutrient cycling, dispersal of fungi, seed burial and water infiltration (Fleming et al, 2014). Other functions performed by fauna including pollination and seed dispersal are likely to be compromised with declines of other populations of fauna including flying foxes and nectivorous birds.

The particular loss of large old individuals of canopy species affects many fauna in the ecological community. The loss of hollows associated with these trees will have long-lasting effects on the species identified in Appendix B.

Loss of these functions would compromise the condition and resilience of the ecological community, but **insufficient information** is available to determine eligibility against any category for this criterion.

### **Criterion 4. Reduction in community integrity**

Tozer et al. (2010) demonstrates that there have been substantial losses in total extent of the ecological community. However, the analysis does not consider the likely current condition of the remnants nor spatial integrity, which is likely to influence their long term state. There is little specific information available on condition across the range of the ecological community, yet it is likely that much of the remaining area is compromised by the threats acting across the landscape, associated with past and current land uses. Long established land uses, such as grazing within the range of the ecological community, have a range of lasting effects including soil compaction, change in nutrient

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<sup>7</sup> 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” (Threatened Species Scientific Committee, 2013b, p.14). In Illawarra and south coast lowland grassy woodland, *Eucalyptus tereticornis* is always present in the canopy and is often dominant. The generation time of this species is used here to define the ‘immediate future’ for the ecological community. As the average age of the trees producing viable seed germinating as seedlings is likely to be greater than 20 years, the maximum allowable time for three generations of this species (60 years) is applied.

profile, loss of understorey and weed infestation, as well as changes to the fire regime. These all compromise the quality of the ecological community, even where the canopy remains relatively intact. These impacts continue, for example patches of the ecological community identified by Department of Environment, Climate Change and Water (2011) were used by stock for summer shade. In recent decades, a wide range of threats, generally associated with urban encroachment have added to the long-term damage associated with agriculture and grazing: rubbish dumping, bike tracks, arson, invasion by weeds and feral and roaming domestic animals, altered hydrology, contaminated runoff (NSW Scientific Committee, 1999).

In 2002, NPWS interpreted aerial photos to assess the condition of vegetation in the Illawarra region. The study included coastal grassy redgum forest (MU23) and lowland woollybutt-Melaleuca forest on the Illawarra coastal plain (MU24). These are described as equivalent to the NSW listed ecological community (Illawarra lowlands grassy woodland in the Sydney Basin Bioregion). At the time of the NPWS study 5% of the area surveyed in these vegetation types was classified as having 'light' disturbance and 31% 'moderate'. 'Heavy' disturbance was observed in 22% of the area and 43% was 'scattered trees'. When extrapolated across the estimated pre 1750 extent of the ecological community, 3-8% of this area would have been classified as having good condition ('light' - 'moderate' disturbance) at the time of the survey. If these categories 'light' and 'moderate' disturbance are considered as an indicator of the 'moderate' condition threshold required for national protection, it is expected that less than 40% (1 479 ha) of the current extent would meet the condition threshold for protection. While the figures are approximate, they suggest that there has been high loss in the integrity of the ecological community and high likelihood of ongoing decline.

One factor underlying ongoing loss in condition is fragmentation. Of the remaining patches, 92% are <10 ha. As described in Appendix D, the distance between patches is also likely to limit dispersal of key eucalypt forming the canopy and may be greater than the expected gap-crossing threshold for many fauna. 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 movement of some fauna, such as sugar gliders may compromise the ecological community by removing services such as pollination.

Active efforts to improve the condition of the ecological community could include actions such as weeding, control of feral animals, and planting canopy and understorey species. However, there are factors associated with the existing damage that reduce the likelihood of complete restoration. Amongst the fundamental changes would be altered soil structure, function and nutrient status. Grazing is commonly associated with physical soil compaction, as well as elevated nutrients, especially with phosphorus based fertilisation. Phosphorus levels have been linked to low native plant species richness in grazing landscapes of southern Australia (Dorrough et al, 2006). Amelioration of elevated nutrient status is difficult. Another primary long term change affecting soil has been the loss of much of the original fauna of this ecological community, as well as more broadly across the landscape. Current knowledge is only sufficient for qualitative analysis of the long term implications of this loss for function of the ecological community. Loss of digging fauna, such as potoroos and bandicoots is likely to have compromised a range of soil functions, including nutrient cycling, seed capture, fungal growth (with possible implications for associated plants such as orchids) and water infiltration (see Appendix D- Additional information on landscape, ecology and biology). These soil functions are all fundamental for establishment and resilience of vegetation and fauna both below and above the ground (Fleming et al, 2014). Re-establishment of these fauna is unlikely in the immediate future due to the continuation of the threats that have caused their population declines or loss. While some habitat restoration may be feasible, predation by cats and foxes is likely to increase with urbanisation. Successful re-introduction of small and medium sized native mammals is highly dependent on intensive predator control, most completely achieved by

protective fencing, for example, at the Arid Recovery project in South Australia, Mulligans Flat in the ACT and Scotia Sanctuary in western NSW (Moseby et al, 2011; Mulligans Flat Woodland Sanctuary, 2012; Fleming et al, 2014). 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. Control of foxes is not considered a priority in the 2011 Strategy for the Conservation and Management of Biodiversity in the Dunmore – Shellharbour Hills Area, where the ecological community occurs as “it is very unlikely that foxes could be completely eradicated, and native species known to be at risk from foxes are already largely absent from the study area” (Department of Environment, Climate Change and Water, 2011:p.33). Further, fox control needs to be coordinated with management of other feral species such as rabbits and cats.

Other ecological functions that may be performed by native fauna in the ecological community include pollination and seed dispersal (see Appendix D- Additional information on landscape, ecology and biology). These functions are likely to be compromised with population declines, for example, grey-headed flying fox. The movement of this species is not limited by fragmentation but 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 *Eucalyptus tereticornis* blossom, to support breeding, has limited populations. (Martin and McIlwee, 2002; Department of the Environment, 2015d). 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 and McIlwee, 2002).

Many of the fauna likely to be associated with the ecological community use hollows in mature trees. Some of these species are identified in Appendix B – Species lists. Birds may use hollows seasonally, for example to house nestlings, but some may also use them regularly as roost sites, for example the masked owl and sooty owl. Amphibians may 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, but additionally to seek prey, for example, the lace monitor preys on bats and other taxa such as gliders nesting in hollows. A large proportion of the bat species within the Illawarra and south coast lowland grassy woodland may use hollows, which can assist with thermoregulation as well as some relying on roosting sites in caves found in the escarpment above where the ecological community occurs. Other mammal species likely to use hollows include sugar glider, brown and dusky antechinus (Gibbons and Lindenmayer, 2002). Benefits of the 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. The high value of hollows as habitat features is recognised in the condition thresholds for the ecological community (section 1.5.3) (Category D) both directly, and indirectly (by identifying large trees). However, a past practice of preferentially removing senescent trees and ongoing clearing and development of areas with mature and hollow trees has reduced the number of hollow trees available. Development of new hollows requires suitable environmental conditions, and sufficiently large trees for them to persist once decayed. It is estimated that it takes between 120 years and 220 years for hollows to develop in most eucalypts. This means that the restoration of this integral habitat feature is unlikely across the ecological community in the foreseeable future (Gibbons and Lindenmayer, 2002).

One of the problems associated with the fragmentation of native vegetation across the range of the ecological community is its vulnerability to invasion by weeds. For example, the patches of the ecological community identified in the Dunmore-Shellharbour area by Department of Environment, Climate Change and Water (2011) were largely re-growth areas or scattered trees with an understorey dominated by *Lantana camara*. While this is identified as one of the main current weeds, others such as African olive are thought likely to be a future problem for the ecological

community. Across the areas containing the ecological community there are many weeds present (see Appendix E – Description of threats, including those likely to be from agricultural sources (such as grasses) as well as some more likely to be urban escapees (such as privet). Dumping of garden waste is frequently a problem in natural areas near urban sites and a source of weeds. The development of sites such as West Dapto will bring houses into very close proximity of remnants of the ecological community (for example, see the West Dapto Darkes Road South West Precinct Planning Proposal (Wollongong City Council 2016). This continues the pattern of other recent housing developments adjacent to remnants of the ecological community, for example, adjacent to Purrungully Road reserve, making them vulnerable to both weeds and impacts by domestic animals such as cats. Such changes of land use locally, and across the coastal plain are likely to be permanent, with restoration to natural areas very unlikely in the foreseeable future.

Climate change is an overarching threat affecting the ecological community, as well as surrounding areas. Temperatures are increasing, which is likely to affect survival rates for some organisms. The winter- flowering *Eucalyptus tereticornis*, characteristic of the ecological community is considered to be a key food resource, reliably producing nectar at a time when little else is available. This flowering and nectar production is dependent on the seasonal availability of water, so the likely change in rainfall patterns across the region may compromise this ecological function. There are moderately confident forecasts of reduced winter rainfall for south-eastern Australia by 2090 (Dowdy, et al, 2015), suggesting that these threats are unlikely to be abated within the near future.

### Conclusion

The integrity of the ecological community has been substantially compromised through various types of local damage and broad scale landscape change. Much of the damage is intractable and many of the underlying threats continue. While active interventions may make some valuable contributions to conservation, complete restoration of the ecological functions underpinning the ecological community is unlikely in the near future. Therefore the ecological community is eligible for listing as **critically endangered** under this criterion.

### **Criterion 5. Rate of continuing detrimental change**

Historically, the primary change affecting the ecological community has been clearing for agriculture and grazing, which was concentrated in the fertile floodplains and foothills below the escarpment. In recent decades, the primary cause of clearing has been urbanisation, which has also favoured the coastal strip where the ecological community occurs. Listing of the 'Illawarra lowland grassy woodland of the Sydney Basin Bioregion' as endangered in NSW has afforded some protection, and potentially slowed the rate of loss, but clearing of the ecological community does continue. In the southern extent of the ecological community, the broad pattern of landscape change indicates that clearing and fragmentation is likely to continue. Even in the absence of direct clearing of the ecological community there are a range of ongoing activities associated with urbanisation that are likely to have detrimental impacts. Hydrological change, (for example, caused by runoff from roads), mortality of fauna crossing between patches (for example, koalas and wombats crossing roads), and incursion of weeds and feral animals from local houses and gardens are amongst the common impacts. While detrimental change is likely to continue, there is **insufficient information** available on the rates of loss in the recent past, or planned for the immediate future to determine eligibility against any category for this criterion.

### **Criterion 6. Quantitative analysis showing probability of extinction**

No quantitative analysis has been undertaken showing likelihood of extinction for this ecological community. Therefore there is **insufficient information** available to determine eligibility against any category for this criterion.

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