

Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) (s266B)
Approved Conservation Advice (including listing advice) for
Cooks River/Castlereagh Ironbark Forest of the Sydney Basin Bioregion

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 provided its advice on the *Cooks River/Castlereagh Ironbark Forest of the Sydney Basin Bioregion* ecological community to the Minister as a draft of this approved conservation advice. In 2015, the Minister accepted the Committee's advice, adopting this document as the approved conservation advice.
3. The Minister amended the list of threatened ecological communities under section 184 of the EPBC Act to include the *Cooks River/Castlereagh Ironbark Forest of the Sydney Basin Bioregion* ecological community in the **critically endangered** category. The equivalent ecological community *Cooks River/Castlereagh Ironbark Forest in the Sydney Basin Bioregion* is listed under the New South Wales *Threatened Species Conservation Act 1995*.
4. A draft conservation advice and the likely conservation status for this ecological community were made available for expert and public comment for a minimum of 30 business days. The Committee and Minister had regard to all public and expert comment that was relevant to the consideration of the ecological community.
5. This approved conservation advice has been developed based on the best available information at the time it was approved; this includes scientific literature, advice from consultations, existing plans, records or management prescriptions for this ecological community.

Table of Contents

1. Description of the ecological community	4
1.1 Name of the ecological community	4
1.2 Location and physical environment	4
1.2.1 Geology	4
1.2.1 Altitude and climate	4
1.3 Vegetation	4
1.4 Fauna	5
1.5 Key diagnostic characteristics and condition thresholds.....	6
1.5.1 Key diagnostic characteristics	6
1.5.2 Condition thresholds.....	7
1.5.3 Further information to assist in determining the presence of the ecological community and significant impacts.....	8
1.6 Geographic extent	11
1.7 National context and other protection	12
2 Summary of threats	13
3 Summary of eligibility for listing against EPBC Act criteria	14
4. Priority conservation actions	16
4.1 Conservation objective	16
4.2 Research, management, recovery and other conservation measures	16
4.3 Recovery plan recommendation	18
Appendix A – Species lists.....	19
Table A1: Typical plant species	19
Table A2: Threatened fauna species	22
Table A3: Weed species	23
Appendix B - Detailed description of national context.....	24
Distribution.....	24
Relationships to other vegetation classifications	24
Similar or intergrading ecological communities	25
Level of protection in reserves	26
Appendix C - Description of threats	27
Clearing and fragmentation	27
Altered fire regimes.....	28
Invasion by weeds	28
Climate change	29
Other threats related to increased urbanisation	29
Other threats	30
Appendix D - Key Threatening Processes	31
Appendix E - Eligibility for listing against the EPBC Act criteria	32

Criterion 1 - Decline in geographic distribution	32
Criterion 2 - Limited geographic distribution coupled with demonstrable threat.....	32
Criterion 3 - Loss or decline of functionally important species	33
Criterion 4 - Reduction in community integrity.....	34
Criterion 5 - Rate of continuing detrimental change.....	37
Criterion 6 - Quantitative analysis showing probability of extinction.....	37
Appendix F - Existing plans/management prescriptions.....	38
Bibliography.....	40

1. DESCRIPTION OF THE ECOLOGICAL COMMUNITY

The Cooks River/Castlereagh Ironbark Forest of the Sydney Basin Bioregion is a dry sclerophyll open-forest to low woodland which occurs predominantly in the Cumberland Subregion between Castlereagh and Holsworthy, as well as around the headwaters of the Cooks River.

1.1 Name of the ecological community

The name of the ecological community is Cooks River/Castlereagh Ironbark Forest of the Sydney Basin Bioregion. This reflects its structure and location and is the same name as it is listed under the *Threatened Species Conservation Act 1995* in New South Wales. Information regarding the NSW ecological community can be found at:

<http://www.environment.nsw.gov.au/determinations/CooksRiverCastlereaghIronbarkForestSydneyEndComListing.htm>

1.2 Location and physical environment

Cooks River/Castlereagh Ironbark Forest of the Sydney Basin ecological community is endemic to NSW, within the Cumberland subregion of the Sydney Basin Bioregion as defined by version 7 of the Interim Biogeographic Regionalisation of Australia (IBRA v 7, 2012).

The majority of the community is found in the north-west section of the Cumberland Subregion in the Castlereagh area between Penrith and Richmond. Other significant patches occur in the Kemps Creek and Holsworthy areas. Smaller remnants occur in the eastern section of the Cumberland Subregion (e.g. upper Cooks River Valley).

1.2.1 Geology

The community occurs on clay-rich soils derived from predominantly Tertiary alluvium and on Wianamatta Shale derived soils found next to Tertiary alluvium (NSW NPWS, 2002; Tozer, 2003; NSW Scientific Committee, 2011). Tertiary Alluvium deposits produce less fertile gravelly clay loam soils than the surrounding shales (Tozer et al., 2010). To a lesser extent, the ecological community also occurs on Holocene Alluvium (NSW NPWS, 2002). The ecological community grades into other communities where clay soils are very poorly drained, and may show variation within the community where there are subtle grades in the substrate sourced from Tertiary sand, sandstone bedrock, shale and ironstone (Tozer et al., 2010; NSW OEH, 2013a). In south-eastern areas of the ecological community's distribution, a sandstone influence is evident (NSW OEH, 2013a; James, pers. comm., 2014).

1.2.1 Altitude and climate

Cooks River/Castlereagh Ironbark Forest occurs below 100 m above sea level with mean annual rainfall of 800-1000 mm (Tozer et al., 2010). The average January maximum temperature for the relevant areas of the Cumberland Plain¹ is 29.3°C and the average July minimum temperature for those areas is 4.5°C.

1.3 Vegetation

Cooks River/Castlereagh Ironbark Forest is an open-forest to low woodland, usually dominated by *Eucalyptus fibrosa* (broad-leaved ironbark) and *Melaleuca decora* (paperbark) (NSW NPWS 2002; Tozer; 2003; Tozer et al., 2010; NSW Scientific Committee, 2011). *E. longifolia* (Woollybutt) is also often present (NSW NPWS, 2002; Tozer, 2003; NSW Scientific Committee, 2011; NSW OEH, 2013a). Other over-storey species that may be present include: *E. racemosa* (syn. *E. sclerophylla*, narrow-leaved scribbly gum), *Angophora costata* (smooth-barked apple) and *Angophora bakeri* (narrow-leaved apple) at sandier sites, *E. longifolia* close to creeks, *E. parramattensis* subsp. *parramattensis* in less well drained soils, and *E. moluccana*

¹ Mean average maximum (January) and minimum (July) temperatures from Bankstown, Holsworthy, Badgerys Creek AWS, Badgerys Creek McMasters, Penrith Lakes and Richmond RAAF.

and *E. eugenioides* on less gravelly clay (NSW OEH, 2013a; James pers. comm., 2014). Hybrids of these canopy species may be present.

The understorey shrub stratum is variable, but often dense and dominated by *Melaleuca nodosa* (prickly-leaved paperbark) and *Lissanthe strigosa* (peach heath), and to a lesser extent *M. decora* (NSW NPWS, 2002), possibly at times as a result of historical factors at the site (NSW OEH, 2013a). It also includes a range of ‘pea’ flower shrubs, including *Dillwynia tenuifolia*, *Pultenaea villosa* (hairy bush-pea) and *Daviesia ulicifolia* (gorse bitter pea) (Tozer, 2003; NSW Scientific Committee, 2011). *Dillwynia parvifolia*, *Cassinia arcuata* and *Hibbertia serpyllifolia* are common species in eastern sites and less commonly found in the west (James, pers. comm., 2014). Other common species include *Ozothamnus diosmifolius*, *Bursaria spinosa* and *Acacia falcata* (James, pers. comm., 2014).

The ground layer is relatively sparse (more so in areas of dense shrub cover) and commonly includes *Entolasia stricta* (wiry panic), *Lepidosperma laterale*, *Opercularia diphylla*, *Dianella revoluta* subsp. *revoluta* (blue flax-lily), *Themeda triandra* (kangaroo grass), *Microlaena stipoides* var. *stipoides* and *Lobelia purpurascens* (whiteroot) (NSW NPWS, 2002; Tozer, 2003).

Nationally threatened plants that have been recorded in the ecological community include: *Acacia pubescens* (downy wattle); *Persoonia nutans* (nodding geebung); *Micromyrtus minutiflora* and *Allocasuarina glareicola*. NSW threatened plants recorded in the community include *Wahlenbergia multicaulis* (Tadgell’s bluebell), *Grevillea juniperina* subsp. *juniperina* and *Dillwynia tenuifolia* (NSW DECC, 2008; NSW Scientific Committee, 2011; NSW OEH, 2013a).

See **Appendix A, Table A1** for a list of characteristic plant species.

1.4 Fauna

The diversity and abundance of fauna species across the Cumberland Subregion (where the ecological community occurs) has declined. Prior to European settlement, the Cooks River/Castlereagh Ironbark Forest ecological community likely supported a range of animal species, including small mammals (particularly micro-bats), insectivorous and seed-foraging birds, birds of prey, skinks, snakes, frogs and a large range of invertebrates. The vegetation structure and species composition of the ecological community provides shelter, food and nesting material for these animals, which in turn play important roles in the ongoing function of the ecosystem. Many fauna species present (e.g. woodland birds) may not necessarily be restricted to this ecological community but may also occur in adjacent vegetation communities in the Cumberland Subregion. These species are likely to rely on the presence of other native vegetation adjacent to patches of the ecological community for their continued persistence.

No studies have specifically examined the fauna across the entire range of the ecological community. However, a number of sources provide useful information on the fauna that have been observed at certain sites and in the Cumberland Subregion more generally, including BioNet.

Reptiles and amphibians likely to occur in the ecological community includes: *Limnodynastes dumerilii* (banjo frog); *Crinia signifera* (common eastern froglet); *Anilius nigrescens* (blackish blind snake); *Tiliqua scincoides* (eastern blue-tongue); *Diplodactylus vittatus* (eastern stone gecko) (DoE, 2014a). The nationally listed vulnerable *Litoria aurea* (green and golden bell frog) has also been recorded in Cooks River/Castlereagh Ironbark Forest at Coxs Creek Bushland Reserve (NSW NPWS, 2004; NSW DECC, 2008).

Bird species observed in the ecological community include: *Gerygone mouki* (brown gerygone); *G. olivacea* (white throated gerygone); *Myiagra rubecula* (leaden flycatcher); *Myzomela sanguinolenta* (scarlet honeyeater); *Neochmia temporalis* (red-browed finch);

Nesoptilotis leucotis (white-eared honeyeater); *Oriolus sagittatus* (olive-backed oriole); *Pachycephala rufiventris* (rufous whistler); *Pachycephala pectoralis* (golden whistler); *Pardalotus striatus* (striated pardalote); *Pardalotus punctatus* (spotted pardalote); *Aegotheles cristatus* (Australian owlet-nightjar); *Podargus strigoides* (tawny frogmouth); *Todiramphus sanctus* (sacred kingfisher); *Dacelo novaeguineae* (laughing kookaburra); and *Daphoenositta chrysoptera* (varied sittella) (DoE, 2014a).

Micro-bat species observed in the ecological community include: *Nyctophilus geoffroyi* (lesser long-eared bat); *Chalinolobus morio* (chocolate wattled bat); *Vespadelus vulturnus* (little forest bat); *Austronomus australis* (white-striped freetail-bat) (DoE, 2014a).

Marsupial species observed in the ecological community include: *Wallabia bicolor* (swamp wallaby); *Petaurus australis* (yellow-bellied glider); and *Petaurus breviceps* (sugar glider) (DoE, 2014a).

Meridolum corneovirens (Cumberland land snail), listed as endangered in NSW, has been observed in the ecological community (DoE, 2014a).

See **Appendix A, Table A2** for a list of national and NSW listed threatened fauna species that either may occur or are known to occur in the area occupied by the ecological community.

1.5 Key diagnostic characteristics and condition thresholds

National listing focuses legal protection on remaining patches of the ecological community that are most functional, relatively natural (as described by the ‘Description’) and in relatively good condition. Key diagnostic characteristics and condition thresholds assist in identifying a patch of the threatened ecological community, determine when the EPBC Act is likely to apply to the ecological community and to distinguish between patches of different quality. The ecological community may exhibit various degrees of disturbance and degradation. This degree of degradation, and natural variation, has been taken into account in developing the condition thresholds.

1.5.1 Key diagnostic characteristics

The presence of dry sclerophyll forests (which include the Cooks River/Castlereagh Ironbark Forest) in the Cumberland Subregion is intimately linked to the presence of Tertiary alluvial gravels, sands and clays within the broader shale lithology of the central Sydney Basin (Keith, 2004). Rainfall is also a key determining factor, which has a most noticeable impact on the tree layer composition (Keith, 2004).

Key diagnostic characteristics for the ecological community are:

- confined to the Sydney Basin Bioregion;
- primarily occurs in elevations below 100 m above sea level;
- occurs in the Cumberland Subregion with clay soils derived from predominantly Tertiary alluvium and on Wianamatta Shale derived soils found next to Tertiary alluvium (in eastern areas of the ecological community’s distribution, a sandstone influence is evident);
- is a dry sclerophyll open-forest to low woodland typically dominated by an overstorey of *Eucalyptus fibrosa* and *Melaleuca decora*, with *Eucalyptus longifolia* also often present;
- usually includes a moderate to dense mid/shrub stratum, commonly including *Melaleuca nodosa* and *Lissanthe strigosa*, and to a lesser extent *Melaleuca decora*;
- the ground layer is variable and generally sparse with a mix of grasses and other graminoids, forbs, and low shrubs;
- patches typically contain many of the plant species presented at Table A1 (Appendix A) and may contain fauna species presented in Section 1.4.

1.5.2 Condition thresholds

Condition categories, classes and thresholds provide guidance for when a patch of a threatened ecological community retains sufficient conservation values to be considered as a Matter of National Environmental Significance, as defined under the EPBC Act. This means that the referral, assessment and compliance provisions of the EPBC Act are focussed on the most valuable elements of the ecological community. Very degraded patches that do not meet the minimum condition thresholds are excluded from full national protection.

Although very degraded/modified patches are not protected as the ecological community listed under the EPBC Act, it is recognised that 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 some of these patches to the point that they may be regarded as part of the ecological community fully protected under the EPBC Act. Management actions should, where feasible, also aim to restore patches to meet the high quality condition thresholds outlined below.

For Cooks River/Castlereagh Ironbark Forest in the Sydney Basin Bioregion, categories A and B are considered a moderate quality condition class and the minimum thresholds for a patch of the ecological community to be subject to the referral, assessment and compliance provisions of the EPBC Act. Categories C and D are considered the thresholds for a patch of Cooks River/Castlereagh Ironbark Forest in the Sydney Basin Bioregion to be regarded as an example of high quality condition and provide a benchmark for the recovery of lower quality patches.

Note that patches in Categories A and B that occur in the eastern most range of the ecological community (defined as those patches east of Riverstone (150° 51' 38"E)) have lower patch size thresholds as this would otherwise exclude the few remnants at the eastern edge of the range.

Category and Rationale	Thresholds
<p>A. Moderate condition class</p> <p>Represented by medium to large-size patch as part of a larger native vegetation remnant and/or with mature trees</p>	<p>Patch size ≥ 0.5 ha (Patch size ≥ 0.1 ha in areas east of Riverstone (150° 51' 38"E))</p> <p>And</p> <p>$\geq 30\%$ of the perennial understorey vegetation cover is made up of native species.</p> <p>And</p> <p>The patch is contiguous with a native vegetation remnant (any native vegetation where cover in each layer present is dominated by native species) ≥ 1ha in area.</p> <p>Or</p> <p>The patch has at least one tree with hollows or at least one large locally indigenous tree (>80 cm dbh).</p>
<p>B. Moderate condition class</p> <p>Represented by medium to large size patch with high quality native understorey</p>	<p>Patch size ≥ 0.5 ha (Patch size ≥ 0.1 ha in areas east of Riverstone (150° 51' 38"E))</p> <p>And</p> <p>$\geq 50\%$ of the perennial understorey vegetation cover is made up of native species.</p>
<p>C. High condition class</p> <p>Represented by medium to large size patch with very high quality native understorey</p>	<p>Patch size ≥ 0.5 ha</p> <p>And</p> <p>$\geq 70\%$ of the perennial understorey vegetation cover is made up of native species.</p>
<p>D. High condition class</p> <p>Represented by large size patch with high quality native understorey</p>	<p>Patch size ≥ 2 ha</p> <p>And</p> <p>$\geq 50\%$ of the perennial understorey vegetation cover is made up of native species.</p>
<p><i>Perennial understorey vegetation cover</i> includes vascular plant species of the ground and mid/shrub layers with a lifecycle of more than two growing seasons. Measurements of perennial understorey vegetation cover exclude annuals, cryptogams, plant litter or exposed soil but include plants that are subject to dieback.</p> <p><i>Contiguous</i> means the patch of the ecological community is continuous with, or in close proximity (within 100 m), of another patch of vegetation (of the same or a different type) that is dominated by native species in each vegetation layer present.</p>	

1.5.3 Further information to assist in determining the presence of the ecological community and significant impacts

Land use history will influence the state in which a patch of the ecological community is currently found. The structural form of the ecological community will influence its species richness and diversity. The following information should also be taken into consideration when evaluating the key diagnostic characteristics and condition thresholds (to assess a site that may include the ecological community and determine the potential impacts on a patch).

Defining a patch

A **patch**² is defined as a discrete and mostly continuous area of the ecological community. Patches can be spatially variable and often there are one or more areas within a patch that do not meet the condition threshold criteria that are surrounded by areas of higher quality that meet the condition thresholds. Therefore a patch may include small-scale disturbances, such as

² Note that NSW vegetation assessment tools define 'patch' as an area of native vegetation (of one or more different communities that occur together, separated by a gap of no greater than a set distance (usually 100m)). However, the Threatened Species Scientific Committee uses the term 'patch' to describe any discrete remnant/area of the ecological community in question.

tracks or breaks (including exposed soil, leaf and other plant litter, cryptogams), watercourses/drainage lines or small-scale (up to 0.1 ha) variations in vegetation that do not significantly alter its overall functionality³.

Where derived native grassland/shrubland connects discrete patches of the ecological community that are in close proximity (up to 100 m apart), this should be considered a single patch of the ecological community rather than individual patches.

Sampling protocols

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 and features that appear within a given patch. As a general principle, sampling should address the following:

- the area(s) with the highest apparent number of different native plant species to determine estimates of native species richness in each patch;
- any significant variation in the vegetation, landscape qualities and management history (where possible) across the patch, for instance localised weed cover, drainage lines, grazed areas, saline zones; and
- the appropriate size and number of plots or transects to provide a representative sample across the full extent of the patch.

The recommended sampling protocol involves developing a simple map of the vegetation, landscape qualities and management history (where possible) of the site. The site should then be thoroughly and representatively sampled for vegetation cover and species richness. This should include the areas with the highest level of structural and species richness of native species. The number of plots required will depend on the size of the patch: the plots should provide a good representation of the species present across the whole patch. The survey plot dimensions may also vary with the patch size, shape and variability but plots of 0.04ha (quadrats of 20m x 20m) are suggested as likely to be suitable (after Tozer, 2003; Tozer et al., 2010). Search effort should be recorded, identifying the number of person hours spent per plot and across the entire patch.

Seasonal variation/Timing of surveys

Timing of surveys is an important consideration because the ecological community can be variable in its appearance through the year, and between years, depending on drought-rain cycles. Assessment should occur in spring and summer to early autumn (i.e. when the greatest number of species is likely to be detectable and identifiable). Ideally, surveys should be undertaken during more than one season to maximise the chance of detecting all species present. In years of low rainfall, assessment 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. Presence and detectability of some species may also be affected by the time since disturbance, such as fire or grazing, so surveys should be planned to occur after an adequate time for some recovery (for example, at least 18 months post fire).

Buffer zone

A buffer zone is a contiguous area adjacent to a patch that is important for protecting the integrity of the ecological community. The purpose of the buffer zone is to help protect and manage the national ecological community. As the risk of damage to an ecological community is usually greater for actions close to a patch, the purpose of the buffer zone is to minimise this risk by guiding land managers to be aware when the ecological community is nearby and take extra

³ Functionality refers to processes such as the movement of wildlife and pollinators, the dispersal of plant propagules, activities of seed and plant predators and many others.

care around the edge of patches. The edges of a patch are considered particularly susceptible to disturbance and the presence of a buffer zone is intended to act as a barrier to further direct disturbance. For instance, a buffer zone will help protect the ecological community, including 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 and other damage.

As the buffer zone lies to the outside, around the community, it is not part of the ecological community – it is strongly recommended but 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. Where the buffer is subject to existing land uses, such as cropping, grazing or fire breaks, these can continue. However, practical application of a buffer zone is strongly recommended to avoid adverse impacts to the patch. It may also be a focus of revegetation initiatives, where practical.

The recommended minimum buffer zone is 30 m from the outer edge of the patch. A larger buffer zone should be applied, where practical, to protect patches that are of very high conservation value, or if patches are down slope of drainage lines or a source of eutrophication.

Area critical to the survival of the ecological community

Given reduced extent of the already limited distribution of the Cooks River/Castlereagh Ironbark Forest, areas that meet the minimum (moderate class) condition thresholds 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 in the surrounding environment and landscape context as outlined in the other considerations below.

Other considerations related to significance

Actions that may have ‘significant impacts’ on any patches of Cooks River/Castlereagh Ironbark Forest meeting the condition thresholds require approval under the EPBC Act. The ecological importance of a patch is also influenced by its surrounding landscape, for example, if connected or nearby to other native vegetation it may contribute substantially to landscape connectivity and function. Similarly, actions beyond the boundary of any patch of Cooks River/Castlereagh Ironbark Forest may have a significant impact on the patch. For this reason, when considering actions likely to have impacts on this ecological community, it is important to also consider the environment that surrounds any patches 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 link them with other native vegetation.

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

The following indicators of the ecological context provided by the areas surrounding patches of Cooks River/Castlereagh Ironbark Forest 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 (disturbances such as weed invasion and other anthropogenic impacts). However, diverse smaller patches or isolated 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 have importance due to their rarity, genetic significance, connectivity 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 as saplings through to large hollow-bearing trees.
- Good faunal habitat as indicated by diversity of landscape, for example patches containing mature trees (particularly those with hollows), logs, watercourses, natural rock outcrops or diversity of plant species.
- 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.
- 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. a variant of the 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).
- Areas with minimal weeds and feral animals, or where these threats can be efficiently managed.
- Presence of cryptogams, soil crust and leaf litter on the soil surface indicating low recent disturbance and potential for good functional attributes such as nutrient cycling.
- Derived native grasslands and shrublands that were formally the woodlands, particularly those adjacent or near to forest/woodland remnants. These can be important to the survival of the ecological community in a fragmented, modified landscape.
- Connectivity to other native vegetation remnants or restoration works (e.g. native plantings) in particular, 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.

1.6 Geographic extent

Cooks River/Castlereagh Ironbark Forest has a naturally restricted distribution, and is often found as part of a complex intergrading with Castlereagh Scribbly Gum Woodland and other communities such as Castlereagh Swamp Woodland and Shale Gravel Transition Forest. Since European settlement, the Cooks River/Castlereagh Ironbark Forest has undergone a significant reduction in extent (Table 1) having been cleared or substantially modified by urban and rural/residential development (NSW NPWS, 2002; Tozer, 2010; NSW OEH, 2013a).

Table 1. Estimates of decline and extent of the Cooks River/Castlereagh Ironbark Forest based on information in NSW NPWS (2002), excluding units recorded with tree cover only and no understorey as condition thresholds would exclude these patches.

Pre 1750 ha (modelled)	Current ha	% remaining
12 185	1011	8%

Tozer et al. (2006, 2010) estimates the remaining extent to be 5–20 per cent of the pre-1750 extent.

1.7 National context and other protection

The Cooks River/Castlereagh Ironbark Forest ecological community is endemic to New South Wales, being generally restricted to the Cumberland Subregion of the Sydney Basin Bioregion (IBRA 7.1). The Sydney Basin Bioregion is on the central east coast of NSW and occupies approximately 3 624 008 ha, or 4.5 per cent of NSW (NSW OEH, 2011). The Interim Biogeographic Regionalisation of Australia (IBRA) divides the Australian continent into bioregions and subregions. IBRA is endorsed by all levels of government as a key tool for identifying land for conservation. More information regarding IBRA, including maps are available at: <http://www.environment.gov.au/topics/land/nrs/science-maps-and-data/australias-bioregions-ibra>.

Cooks River/Castlereagh Ironbark Forest is included within the vegetation class: Cumberland Dry Sclerophyll Forests (Keith, 2004).

Further information about the national context, including information on differences to similar or intergrading ecological communities as well as corresponding map units is available at **Appendix B**.

Existing protection

Cooks River/Castlereagh Ironbark Forest is listed under the NSW *Threatened Species Conservation Act 1995* as an endangered ecological community.

Tozer et al. (2010) estimated that approximately 26% (around 290 ha) of the current extent of the ecological community is protected in reserves.

2 SUMMARY OF THREATS

Vegetation clearance was, and continues to be, a major contributor to the decline of native vegetation across the Cumberland Plain. The reduction in geographic distribution of the Cooks River/Castlereagh Ironbark Forest was initially due to tree-felling for timber and clearing for crops and pasture (Benson & Howell, 1990). Clearance continues due to the increasing urbanisation of western Sydney and the ecological community is highly fragmented as a result.

In addition to clearance and fragmentation of native vegetation, key threats to the ecological community occurring as a result of increasing urbanisation are:

- Inappropriate fire regimes, most significantly increased fire frequency due to arson, although some patches have been impacted by a lack of burns.
- Weed invasion from escaped garden plants, agriculture and increased run-off due to urbanisation. Weeds include mid-storey species such as green cestrum (*Cestrum parqui*) and Mickey Mouse bush (*Ochna serrulata*); ground covers such as ground asparagus (*Asparagus aethiopicus*); grasses, including kikuyu (*Cenchrus clandestinus*), common couch (*Cynodon dactylon*) and panic veldt grass (*Ehrharta erecta*) (NSW DECC, 2008). Introduced vines such as moth vine (*Araujia sericifera*) and bridal creeper (*Asparagus asparagoides*) are widespread, as is blackberry (*Rubus* spp.).
- Hydrological changes and increased nutrient loads from urban run-off, rubbish and garden waste dumping and domestic pet excrement.
- Predation and displacement of native fauna by domestic pets and other species adapted to an urban setting.

Other ongoing threats include:

- Climate change.
- Dryland salinity as a result of historical clearance of the Cumberland Plain.
- Uncontrolled grazing.
- Potential impacts to the seedbank due to inappropriate mowing regimes.
- Diseases, such as *Phytophthora cinnamomi* and myrtle rust (*Puccinia psidii* s.l.).

Further details about the threats to the ecological community can be found at [Appendix C](#) and a list of Key Threatening Processes relevant to the ecological community is at [Appendix D](#).

3 SUMMARY OF ELIGIBILITY FOR LISTING AGAINST EPBC ACT CRITERIA

Criterion 1 - Decline in geographic distribution

The Cooks River/Castlereagh Ironbark Forest ecological community is estimated to have undergone a decline in area of occupancy from 12 211 ha of its estimated pre-clearing extent to 1100 ha (NSW NPWS, 2002). Tozer 2010 estimates that 5-20 per cent of the ecological community remains. This represents a severe to very severe decline in the order of 80-95 percent.

Based on these estimates, it is considered that the ecological community is **eligible** for listing as **critically endangered** under this criterion.

Criterion 2 - Limited geographic distribution coupled with demonstrable threat

Available data indicate the present geographic distribution of the ecological community is 'restricted' with the total area of occupancy < 10 000 ha, however it is very close to the definition of 'very restricted' (defined as <1000 ha) at around 1100 ha. The total extent of occurrence is 90 250 ha, indicating that it is 'restricted' (defined as <100 000 ha) (Tozer, 2010).

The ecological community is also highly fragmented with a mean patch size of approximately 6.8 ha and median size of 2.7 ha, also considered as 'very restricted' (analysis of data from Tozer et al., 2006). Almost all patches (83%) have a size of less than 10 ha (analysis of data from Tozer et al., 2006).

The ecological community is subject to a range of ongoing threats including clearing, fragmentation and other damage associated with urbanisation; inappropriate fire regimes, weed invasion, nutrient loading and changes to hydrology (NSW DECCW, 2010). These threats are expected to increase (NSW DECCW, 2010). Climate change is likely to increase the severity of many existing threats.

It is considered that the ecological community has a very restricted geographic distribution, based on the fragmentation of remnants into very small patch sizes across an already restricted area, coupled with demonstrable ongoing threats that could cause it to be lost in the immediate future. Therefore, the ecological community is **eligible** for listing under Criterion 2 as **critically endangered**.

Criterion 3 - Loss or decline of functionally important species

There has been an extensive decline in the diversity of the terrestrial mammalian fauna across the Sydney Basin bioregion. Of the 67 species identified as present in the bioregion, 27 species (or 40% of the total number) have experienced a decline of at least 50% of their former range (Burbidge et al., 2008). The ecological community also supports a number of threatened plant species (NSW DECC, 2008; NSW Scientific Committee, 2011).

Tozer (2003) recorded a high proportion of rare flora species in field survey plots on the Cumberland Plain and noted that this suggested that any further clearing of native vegetation in the area would carry a high probability of loss of rare species, leading to a loss of floristic diversity more generally. He noted that this loss of diversity was most likely in those ecological communities with limited distribution, including Cooks River/Castlereagh Ironbark Forest (Tozer, 2003).

It is not known if any of the flora or fauna species lost from the Cooks River/Castlereagh Ironbark Forest played a functionally important role within the ecological community.

There are insufficient data available to determine the loss or decline of functionally important species within the ecological community or about the restorability of their functions. Therefore, the ecological community is **not eligible** for listing in any category under this criterion.

Criterion 4 - Reduction in community integrity

The ecological community has undergone a very severe reduction in its ecological integrity through: fragmentation; structural alteration to the mid and ground layers as a result of altered fire regimes and to the canopy as a result of clearance, urbanisation, weed invasion, inappropriate fire and grazing regimes; and decline in faunal components. The ongoing diminution of the diversity and function of the ecological community is likely to continue in the light of ongoing threats and continuation of existing land use patterns, in particular, the increasing urbanisation of the region. The ecological community is substantially fragmented, which has the capacity to exacerbate the impacts from other disturbance. The ability of the ecological community to regenerate and recover in the near future from these impacts is limited by the length of time taken to recover key structural elements and by the regional patterns of loss of native species. The continuation of damaging land use is also likely to limit recovery. 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 a considerable rate of continuing detrimental change in the past, which has continued to the present time. Further declines in geographic distribution and integrity are projected to occur in at least part of the range over the next 10 years, particularly associated with planned urban development. Although there has been continuing detrimental change to the ecological community, data are insufficient to determine an overall rate, as such, there is **insufficient information to determine the eligibility** of the ecological community for listing under any category of Criterion 5.

Criterion 6 - Quantitative analysis showing probability of extinction

There are no quantitative data available to assess this ecological community under this criterion. As such, there is **insufficient information to determine the eligibility** of the ecological community for listing under any category of Criterion 6.

Further details about the eligibility for listing against EPBC Act criteria can be found at **Appendix E**

4. PRIORITY CONSERVATION ACTIONS

4.1 Conservation objective

To mitigate the risk of extinction of the Cooks River/Castlereagh Ironbark Forest, and help recover its biodiversity and function, through the protections provided under the *Environment Protection and Biodiversity Conservation Act 1999* and through the implementation of the following priority conservation actions.

4.2 Research, management, recovery and other conservation measures

Management and research priorities for Cooks River/Castlereagh Ironbark Forest, that would inform future regional and local priority actions include:

High priorities:

- Protect and conserve patches of this ecological community to avoid further clearance and fragmentation of remnants that meet the condition thresholds. Identify high conservation value sites for conservation management (formal reserve and off-reserve protection), on private and public lands. These may include the ‘priority conservation lands’ identified in the New South Wales Cumberland Plain Recovery Plan (DECCW, 2010), as well as other remnants of Cooks River/Castlereagh Ironbark Forest that meet the high quality condition thresholds⁴.
- Promote formal conservation arrangements, management agreements and covenants on private land. For crown and private land, promote inclusion in reserve tenure.

The following high priority measures should be undertaken consistent with the Best Practice Guidelines: Cooks River/Castlereagh Ironbark Forest (NSW DECC, 2008) and Recovering Bushland on the Cumberland Plain: best practice guidelines on the management and restoration of bushland (NSW DEC, 2005a):

- Avoid disturbances to native vegetation (e.g. under-scrubbing, slashing, mowing, grazing or burning), particularly during peak flowering and fruiting seasons of the ecological community.
- Protect the soil seedbank and support the regeneration of the ecological community through:
 - The appropriate use of fire and weed removal;
 - The use of ‘trigger’ practices such as smoke water, brush matting and soil disturbance; and
 - Plantings from seedlings grown from seeds collected in the area, if the seedbank is gone and regeneration is not possible.
- Undertake weed control and restoration activities consistent with the three phases of weed control outlined in the Best Practice Guidelines: Cooks River/Castlereagh Ironbark Forest. In addition:
 - Broad-scale, non-selective herbicide use should be minimised, with particular attention paid to avoiding areas that include *Allocasuarina glareicola*, nodding geebung, downy wattle or Tadgell’s bluebell, as well as waterways (NSW DECC, 2008);
 - Sediment fences can be utilised to prevent some weeds from invading a remnant.

⁴ It should be noted that a Strategic Assessment under the *Environment Protection and Biodiversity Conservation Act 1999* has been undertaken for the Sydney Growth Centres. As the Cooks River/Castlereagh Ironbark Forest was not nominated at the time the assessment was undertaken, the ecological community has not been considered in the assessment.

- Avoid planting potential weeds in roadworks, landscaping and other development near the ecological community (plant local species). Implement appropriate measures to prevent introduction and dispersal of weeds (e.g. during mowing, roadworks, adjacent development).
- Control introduced pest animals, including limiting access by domestic pets and feral animals, to allow natural regeneration and to manage other impacts (e.g. to threatened species).
- Undertake appropriate fire management practices that vary in frequency, intensity and seasonality, in order to maximise biodiversity outcomes. The Best Practice Guidelines: Cooks River/Castlereagh Ironbark Forest contains further information on appropriate and inappropriate fire regimes, recommended frequency, site preparation and post fire maintenance and monitoring.
- Control storm-water and other urban run-off to prevent:
 - The further alteration of hydrological regimes in the ecological community;
 - The infiltration of litter;
 - The dispersal of weeds; and
 - The introduction of unnaturally high nutrient levels to the ecological community
- Stream-bank restoration and other actions to mitigate stream-bank erosion should also be undertaken within remnants of the ecological community (NSW DECC, 2008).
- Buffer zones with native species should be utilised to minimise ‘edge effects’ such as increased run-off, weed invasion, rubbish dumping and other disturbances. Buffers should be as large as possible, at a minimum 30 metres from the outer edge of the patch. Further information on appropriate buffering for the ecological community is available in the Best Practice Guidelines: Cooks River/Castlereagh Ironbark Forest.
- Manage tree dieback, including preventing the spread of *Phytophthora cinnamomi*, a plant pathogen that can survive for long periods in soil. Further information on avoiding further spread of the disease is in the national Threat Abatement Plan, available here: <http://www.environment.gov.au/biodiversity/invasive-species/diseases-fungi-and-parasites/phytophthora-cinnamomi-disease>.
- Avoid disturbances (e.g. slashing, mowing, grazing or burning) during peak flowering and fruiting seasons of the ecological community.
- Ensure that all management and regeneration activities are undertaken in a manner that ensures the retention of a functional habitat for native fauna, including those outlined in the Best Practice Guidelines: Cooks River/Castlereagh Ironbark Forest (NSW DECC, 2008).

Other priorities:

- Investigate and implement options for enhancing condition of remnants or establishing linkages, through enhanced management, or replanting of key ground layer and canopy species, in areas that do not currently meet condition thresholds for the ecological community. Ensure appropriate seed collection and propagation methods, and appropriate species, are used.
- Ensure outcomes and feedback from previous management and research are adapted into future planning and management.
- Develop and promote educational materials for the community, organisations and agencies, which raise their understanding and appreciation of the ecological community.

- Liaise with individuals, organisations and agencies to ensure conservation of the ecological community is taken into account in activities such as infrastructure development and maintenance, and regional planning.
- Support and encourage land managers to implement monitoring of management actions.
- Support opportunities for Traditional Owners to manage the ecological community.

See **Appendix F** for existing plans/management prescriptions.

4.3 Recovery plan recommendation

The Threatened Species Scientific Committee recommends that a recovery plan is developed for the Cooks River/Castlereagh Ironbark Forest ecological community. This is because the actions required to conserve and promote recovery of the ecological community include short and long term activities that need to be co-ordinated at a landscape level and involve a range of stakeholder groups. A recovery plan would provide further guidance to land managers and raise public awareness of conservation actions.

It is suggested that the recovery plan for the Cooks River/Castlereagh Ironbark Forest ecological community could be part of a regional recovery plan for all relevant nationally threatened ecological communities that occur on or near the Cumberland Plain. This is because these communities tend to have similar threats acting upon them and a coordinated, strategic and regional approach is likely to have improved overall conservation outcomes.

APPENDIX A – SPECIES LISTS

Table A1 lists vascular plant species characteristic of Cooks River/Castlereagh Ironbark Forest. It is an indicative rather than comprehensive list of plant species present in the ecological community. Patches may not include all species on the list, or may include other species not listed. At any one time, above-ground individuals of some species may be absent, but the species may be represented below ground in soil seed banks or as dormant structures such as bulbs, corms, rhizomes, rootstocks or lignotubers.

Species designated as characteristic by the NSW OEH (2013a) are bolded.

Table A1: Typical plant species (NSW Scientific Committee, 2011; NSW OEH, 2013a; Royal Botanic Gardens and Domain Trust, 2014; James, pers. comm., 2014). This is a list of characteristic plant species, with scientific names as at August 2014, rather than comprehensive list of all plants present in the ecological community. Some local Indigenous names have also been provided.

Plant form	Species name	Common name
Tree or shrub	<i>Acacia binervia</i>	coast myall, coastal myall, coastal wattle, kai'arrewan (D'harawal)
Tree to 15 m high	<i>Angophora bakeri</i>	narrow-leaved apple
	<i>Acacia decurrens</i>	
	<i>Acacia elongata</i>	
Erect or spreading tree/ shrub	<i>Acacia falcata</i>	
	<i>Acacia pubescens</i>	
	<i>Allocasuarina littoralis</i> [^]	
Tree to 30 m high	<i>Angophora floribunda</i>	apple, rough-barked apple
Tussocky perennial, inflorescence to 1.2m high	<i>Aristida ramosa</i>	purple wiregrass
Erect tufted or rhizomatous perennial, inflorescence to 0.8 m high	<i>Aristida vagans</i>	threeawn speargrass
Mat-forming shrub with branches ascending to 15 cm high with a spread of up to 1m	<i>Astroloma humifusum</i>	native cranberry
Caespitose perennial, basal foliage tussocky, inflorescence to 1.5m high	<i>Austrostipa pubescens</i>	downy wattle
Caespitose perennial, basal foliage tussocky, inflorescence to 1.2m high	<i>Austrostipa rudis</i>	
Twining perennial herb or slender vine to 3m high in groundcover and midstorey	<i>Billardiera scandens</i>	hairy apple berry
Shrub, 0.08–0.6 m high	<i>Boronia polygalifolia</i>	dwarf boronia
	<i>Bossiaea prostrata</i>	
	<i>Brunoniella australis</i>	
Shrub or small to medium tree, typically to 3m, rarely to 10 m high	<i>Bursaria spinosa</i>	blackthorn, boxthorn, sweet bursaria, kurwan (D'harawal)
Perennial, erect or prostrate herb to 60 cm high	<i>Calotis cuneifolia</i>	purple burr-daisy
Shrub to 2 m high	<i>Cassinia arcuata</i> *	sifton bush, chinese shrub
Glabrous twiner with stems c. 0.5 mm thick	<i>Cassytha glabella</i>	
Ground covering, creeping fern with erect fronds to 30cm	<i>Cheilanthes sieberi subsp. sieberi</i>	poison rock fern, mulga fern

Annual to perennial 0.2–1 m high	<i>Cyanthillium cinereum</i>	
	<i>Daviesia ulicifolia</i>	Gorse bitter pea
	<i>Dianella longifolia</i>	
Perennial herb, basal foliage in a clump, inflorescence to 1 m high	<i>Dianella revoluta</i>	blueberry lily, blue flax-lily
Tufted perennial grass, inflorescence to 1.2 m high	<i>Dichelachne micrantha</i>	shorthair plumegrass
	<i>Dichondra repens</i>	
Spreading to erect shrub 0.3–1 m high	<i>Dillwynia parvifolia</i> *	
Erect shrub 0.5–2.5 m high	<i>Dillwynia sieberi</i>	
Erect shrub to 1 m	<i>Dillwynia tenuifolia</i>	
	<i>Dodonaea falcata</i> ^	
	<i>Echinopogon caespitosus</i>	
	<i>Echinopogon ovatus</i>	
Perennial plant, persistent rootstock with prostrate or twining herbaceous or softly-woody stems	<i>Einadia nutans</i>	climbing saltbush
Perennial plant, persistent rootstock with prostrate or twining herbaceous or softly-woody stems	<i>Einadia trigonos</i>	fishweed
Stragglng or somewhat shrubby, wiry, rhizomatous perennial grass usually to 0.8 m high	<i>Entolasia stricta</i>	wiry panic
Tufted perennial grass, basal foliage with inflorescence to c. 0.6 m high	<i>Eragrostis brownii</i>	brown's lovegrass
Tree to 20 m high	<i>Eucalyptus capitellata</i> *	brown stringybark
	<i>Eucalyptus eugenioides</i>	
Tree to 35 m high	<i>Eucalyptus fibrosa</i>	red ironbark
	<i>Eucalyptus globoidea</i>	
Tree to 35 m high	<i>Eucalyptus longifolia</i>	woollybutt
Tree to 25 m high	<i>Eucalyptus moluccana</i>	grey box, terriyergro (D'harawal)
Tree to 45 m high	<i>Eucalyptus resinifera</i>	red mahogany
Leafless shrub or small tree to 8 m high	<i>Exocarpos cupressiformis</i>	cherry ballart, native cherry
Twiner, perennial with stems non-stoloniferous	<i>Glycine clandestina</i>	slender glycine
	<i>Glycine microphylla</i>	
	<i>Glycine tabacina</i>	
Erect or ascending perennial herb 15–30 cm high	<i>Gonocarpus tetragynus</i>	
Erect herbs to 60 cm high	<i>Goodenia bellidifolia</i>	
Groundcover or decumbent herb to 10cm high	<i>Goodenia hederacea</i> subsp. <i>hederacea</i>	ivy goodenia, forest goodenia
Short-lived herb to 50 cm high	<i>Goodenia paniculata</i>	branched goodenia
Spreading bushy shrub 1–3 m high	<i>Hakea sericea</i>	needlebush
	<i>Hibbertia aspera</i>	
Decumbent to spreading shrub to 30 cm high and 60-100cm	<i>Hibbertia empetrifolia</i>	

across		
Decumbent or prostrate shrub with branches to 30 cm long	<i>Hibbertia serpyllifolia</i> *	hairy guinea flower
	<i>Hypericum gramineum</i>	
Shrub to 3.5 m high	<i>Kunzea ambigua</i>	tick bush
Erect branching herb to c. 40 cm high	<i>Laxmannia gracilis</i>	slender wire lily
Tufted perennial with erect, leaf-like culms to 1m	<i>Lepidosperma laterale</i>	
Shrub or small tree, 2–5 m high	<i>Leptospermum trinervium</i>	flaky-barked tea-tree, slender tea-tree
Erect, densely branched shrub to 1 m high	<i>Leucopogon juniperinus</i>	prickly beard-heath
Shrub, 15–70 cm high	<i>Lissanthe strigosa</i>	peach heath
Glabrous, decumbent herb	<i>Lobelia purpurascens</i>	whiteroot
	<i>Lomandra filiformis</i>	
Tufted, sometimes robust, perennial herb.	<i>Lomandra longifolia</i>	spiny-headed mat-rush, honey reed
Tufted perennial herb, slender to robust	<i>Lomandra multiflora</i> subsp. <i>multiflora</i>	many-flowered mat-rush
Tall shrub or tree to 10 m high	<i>Melaleuca decora</i>	
Shrub usually 1–4 m high	<i>Melaleuca nodosa</i>	prickly-leaved paperbark
Slender, often tufted perennial grass with rambling stems and inflorescences to 0.7 m high	<i>Microlaena stipoides</i> var. <i>stipoides</i>	weeping grass
Shrub or tree to c. 9 m high	<i>Notelaea longifolia</i> *	large mock-olive, large-leaved olive
	<i>Olearia microphylla</i>	
Small weak or procumbent herb	<i>Opercularia diphylla</i>	
	<i>Oxalis perennans</i>	
Much-branched, erect shrub to 5 m high	<i>Ozothamnus diosmifolius</i>	rice flower, white dogwood, pill flower, sago bush
Tufted to tussocky perennial grass with inflorescences to 0.7 m high	<i>Panicum simile</i>	two-colour panic
Tufted perennial grass with inflorescences to 0.7 m high	<i>Paspalidium distans</i>	
Erect to spreading shrub up to 2m tall but usually less.	<i>Persoonia nutans</i>	nodding geebung
	<i>Pimelea linifolia</i> subsp. <i>linifolia</i>	
	<i>Poa labillardierei</i> var. <i>labillardierei</i>	
Erect shrub to 3 m high	<i>Podolobium ilicifolium</i>	prickly shaggy pea
Erect to spreading herb or subshrub to 40 cm high	<i>Pomax umbellata</i>	
Decumbent to ± erect, slender, annual herb, 8–15 cm high	<i>Poranthera microphylla</i>	
	<i>Prostanthera scutellarioides</i> ^	
Prostrate to erect shrub	<i>Pultenaea villosa</i>	hairy bush-pea
Dwarf shrub or woody herb, rarely more than 20cm tall	<i>Rhytidosporum procumbens</i>	
Erect, densely caespitose perennials to c. 70 cm tall	<i>Rytidosperma setaceum</i>	smallflower wallaby grass
Erect, caespitose perennial to 1.2 m high	<i>Rytidosperma tenuius</i>	
Perennial herb, inflorescences to 70 cm high	<i>Stackhousia viminea</i>	slender stackhousia
Tall tree	<i>Syncarpia glomulifera</i>	turpentine

Terrestrial, tuberous, ephemeral herb with a solitary leaf	<i>Thelymitra pauciflora</i>	slender sun orchid
Densely caespitose, leafy perennials	<i>Themeda triandra</i> (syn. <i>T australis</i>)	kangaroo grass, durawi (D'harawal)
	<i>Veronica plebeia</i>	
Perennial tufted herb, 5–80 cm high	<i>Wahlenbergia gracilis</i>	sprawling bluebell, australian bluebell
Tufted, arborescent herb	<i>Xanthorrhoea media</i>	grass tree, gulgadya (Cadigal)

* These species are more likely to be present in eastern examples of the ecological community (James, pers. comm., 2014).

^These species are restricted to the western examples of the ecological community (James, pers. comm., 2014).

Nationally threatened plants that have been recorded in the ecological community include: downy wattle (*Acacia pubescens*); nodding geebung (*Persoonia nutans*); *Micromyrtus minutiflora*; *Pultenaea parviflora*; and *Allocasuarina glareicola* (James, pers. comm., 2014; NSW DECC, 2008; NSW Scientific Committee, 2011; DoE, 2014c). New South Wales threatened plants recorded in the community include Tadgell's bluebell (*Wahlenbergia multicaulis*), *Grevillea juniperina* subsp. *juniperina* and *Dillwynia tenuifolia* (James, pers. comm., 2014; NSW DECC, 2008; NSW Scientific Committee, 2011, NSW OEH, 2013b).

Table A2: Threatened fauna species that either may occur, are known to occur, or have been observed in the area occupied by the ecological community as at August 2014 (DoE, 2014a; DoE 2014b)

Species name	Common name	TSC Act*	EPBC Act*
<i>Xanthomyza phrygia</i>	regent honeyeater	CE	E
<i>Botaurus poiciloptilus</i>	Australasian bittern		E
<i>Lathamus discolor</i>	swift parrot	E	E
<i>Litoria aurea</i>	green and golden bell frog		V
<i>Rostratula australis</i>	Australian painted snipe		E
<i>Turnix varius varius</i>	painted button-quail		V
<i>Falcunculus frontatus</i>	crested shrike-tit		V
<i>Heleioporus australiacus</i>	giant burrowing frog		V
<i>Chalinolobus dwyeri</i>	large-eared pied bat, large pied bat		V
<i>Pteropus poliocephalus</i>	grey-headed flying-fox	V	V
<i>Dasyurus maculatus</i>	spot-tailed quoll, spotted-tail quoll, tiger quoll (southeastern mainland population)		E
<i>Phascolarctos cinereus</i>	koala (combined populations of Queensland, New South Wales and the Australian Capital Territory)	V	V
<i>Potorous tridactylus tridactylus</i>	long-nosed potoroo (SE mainland)		V
<i>Pseudomys novaehollandiae</i>	New Holland mouse, pookila		V
<i>Hoplocephalus bungaroides</i>	broad-headed snake		V

* V – Vulnerable, E – Endangered, CE – Critically Endangered

Table A3: Weed species observed in Cooks River/Castlereagh Ironbark Forest. Scientific names are as at August 2014.

Species	Common name
<i>Araujia sericifera</i>	moth vine
<i>Asparagus aethiopicus</i>	ground asparagus
<i>Asparagus asparagoides</i>	bridal creeper
<i>Cenchrus clandestinus</i>	kikuyu
<i>Cestrum parqui</i>	Green cestrum
<i>Cynodon dactylon</i>	common couch
<i>Ehrharta erecta</i>	panic veldt grass
<i>Juncus</i>	rushes
<i>Ochna serrulata</i>	Mickey Mouse bush
non-native <i>Rubus</i> spp.	blackberry and related plants
<i>Typha</i>	cattail

APPENDIX B - DETAILED DESCRIPTION OF NATIONAL CONTEXT

Distribution

The Cooks River/Castlereagh Ironbark Forest ecological community is endemic to New South Wales, being generally restricted to the Cumberland Subregion of the Sydney Basin Bioregion (IBRA 7.1). The Sydney Basin Bioregion is on the central east coast of NSW and occupies approximately 3,624,008 ha, or 4.5 per cent of NSW (NSW OEH, 2011). The Interim Biogeographic Regionalisation of Australia (IBRA) divides the Australian continent into bioregions and subregions. IBRA is endorsed by all levels of government as a key tool for identifying land for conservation. More information regarding IBRA, including maps are available at: <http://www.environment.gov.au/topics/land/nrs/science-maps-and-data/australias-bioregions-ibra>.

The majority of the community is found on the Cumberland Subregion north and west of Botany Bay towards Richmond. The largest patches occur in the Castlereagh, Kemps Creek, and Holsworthy areas. Smaller remnants occur in the eastern section of the Cumberland Subregion (e.g. upper Cooks River Valley).

Cooks River/Castlereagh Ironbark Forest occurs in the Local Land Service region of Greater Sydney and in the following local government areas: Campbelltown, Strathfield, Auburn, Liverpool, Parramatta, Blacktown Fairfield, Hawkesbury, Holroyd, Penrith, Bankstown. It may occur elsewhere in the Sydney Basin Bioregion.

Relationships to other vegetation classifications

The ecological community corresponds to the Cooks River/Castlereagh Ironbark Forest in the Sydney Basin Bioregion listed under the New South Wales *Threatened Species Conservation Act 1995* (TSC Act) as ‘endangered’.

The ecological community corresponds, entirely or in part, to the vegetation classifications outlined in Table B1.

Table B1: Equivalent map units in key references (based on information in NSW NPWS 2002, Tozer 2006 and Tozer 2010).

Tozer et al., 2010	Tozer et al., 2006	Tindall et al., 2004	Tozer, 2003	NSW NPWS, 2002	Benson 1992, 1994	NPWS, 1997
DSF P1 Castlereagh Ironbark Forest	DSF P1 Castlereagh Ironbark Forest	DSF 1	Map Unit 3 Castlereagh Ironbark Forest	Community ID 3 Cooks River/ Castlereagh Ironbark Forest	Shale/Gravel Transition Forest (9d)	Eastern Shale/ Sandstone Transition Forest
					Castlereagh Ironbark Forest (9e)	

Cooks River/Castlereagh Ironbark Forest is included within the vegetation class: Cumberland Dry Sclerophyll Forests (Keith, 2004).

The ecological community is included within the following National Vegetation Information System (NVIS) classifications:

- Major Vegetation Group (MVG)

MVG 4 - Eucalypt Woodlands

- Major Vegetation Subgroup (MVS)

MVS 9 - *Eucalyptus* woodlands with a tussock grass understorey.

Similar or intergrading ecological communities

Cooks River/Castlereagh Ironbark Forest generally as part of a complex intergrading with Castlereagh Scribbly Gum Woodland (DSF p7). That community is often present on free-draining, sandier soils, but also clay loam or sandier clay soils and sometimes lateritised soils, especially in the eastern parts of its range. Where drainage is poor, the community transitions to Castlereagh Swamp Woodland (DSF p4). While the community is present on shale-derived soils next to Tertiary alluvium, as the depth of the alluvium decreases, Cooks River/Castlereagh Ironbark Forest grades into Shale-Gravel Transition Forest (DSF p502) (Tozer et al., 2006).

Shale Gravel Transition Forest of the Sydney Basin Bioregion (TSC Act) as part of the Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest (EPBC Act) is described by Tozer et al. (2010) as a eucalypt woodland with an open layer of sclerophyll shrubs and grassy groundcover. Shale Gravel Transition Forest has a number of species in common with Cooks River/Castlereagh Ironbark Forest, including dominant canopy species *Eucalyptus fibrosa* (broad-leaved ironbark) and mid-story species *Melaleuca decora* (paperbark). Unlike Shale Gravel Transition Forest, *Eucalyptus longifolia* is often present in Cooks River/Castlereagh Ironbark Forest. *Eucalyptus haemastoma*, *Eucalyptus oblonga* and *Eucalyptus parramattensis* subsp. *parramattensis* occur occasionally in Cooks River/Castlereagh Ironbark Forest and have not been recorded in Shale Gravel Transition Forest (Tozer et al., 2010). *E. tereticornis* (forest red gum) and *Eucalyptus moluccana* (grey box) are less common in Cooks River/Castlereagh Ironbark Forest but are not definitive (NSW OEH, 2013a).

Shale Gravel Transition Forest has a sparse shrub stratum, whereas Cooks River/Castlereagh Ironbark Forest typically has a rather dense shrub layer, although recent fire history can confound this distinction. The understory of Shale Gravel Transition Forest is grassier than that of Cooks River/Castlereagh Ironbark Forest although both include grasses such as *Themeda triandra* (kangaroo grass) and *Microlaena stipoides* (weeping meadow grass).

Shale Gravel Transition Forest is listed under the New South Wales *Threatened Species Conservation Act 1995* (TSC Act) as ‘endangered’ and is listed nationally under the EPBC Act as part of the Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest.

Castlereagh Scribbly Gum Woodland occurs on free-draining soils with a sandier texture with patches of Cooks River/Castlereagh Ironbark Forest occurring within it where the soil is more clay-based and less well drained. The over storey of Castlereagh Scribbly Gum Woodland is dominated by *Angophora bakeri*, *Eucalyptus parramattensis* subsp. *parramattensis* and *E. racemosa* and commonly includes *Melaleuca decora* (paperbark) and *Eucalyptus fibrosa* (broad-leaved ironbark). Unlike Cooks River/Castlereagh Ironbark Forest, the mid-layer of Castlereagh Scribbly Gum Woodland includes the shrubs *Banksia spinulosa* with *Banksia oblongifolia*.

Castlereagh Scribbly Gum Woodland is a low eucalypt woodland with an understory of sclerophyll shrubs, grasses and sedges.

Castlereagh Scribbly Gum Woodland is listed under the New South Wales *Threatened Species Conservation Act 1995* (TSC Act) as ‘vulnerable’ and is concurrently under assessment for national listing as part of the Castlereagh Scribbly Gum and Agnes Banks Woodlands of the Sydney Basin Bioregion.

Castlereagh Swamp Woodland is dominated by *Melaleuca decora*, *Eucalyptus parramattensis*, and *M. linariifolia*. The ecological community intergrades with Cooks River/Castlereagh Ironbark Forest where the Tertiary alluvium substrate is poorly drained. Small billabongs and/or wetlands may occur with the Castlereagh Swamp Woodland. *Angophora bakeri* and *Eucalyptus longifolia* are diagnostic over storey species in Cooks River/Castlereagh Ironbark Forest that are not present in Castlereagh Swamp Woodland.

Castlereagh Swamp Woodland is listed under the New South Wales *Threatened Species Conservation Act 1995* (TSC Act) as ‘endangered’.

Shale Sandstone Transition Forest of the Sydney Basin Bioregion generally occurs on soils that are primarily derived from shale substrates and thus tend to have a clay texture, but also have some influence from weathered sandstone substrates. These most commonly occur primarily where the Wianamatta Group shale underlying the Cumberland Plain grades into sandstone. Dominant overstorey species include *Eucalyptus crebra*, *Eucalyptus fibrosa*, *Allocasuarina littoralis*, and *Eucalyptus punctata*. Sites that are near to sandstone outcrops may have a more shrubby understorey, while those with less sandstone influence may have more herbs and grasses in the understorey (Tozer et al., 2010).

Level of protection in reserves

Tozer et al. (2010) estimated that approximately 26% (around 290 ha) of the current extent of the ecological community is protected in reserves. It has been reported from Agnes Banks Nature Reserve, Castlereagh Nature Reserve, and Windsor Downs Nature Reserve, as well as Coxs Creek Nature Reserve (NSW Scientific Committee, 2011; NSW DECC, 2008).

APPENDIX C - DESCRIPTION OF THREATS

The ecological community has suffered substantial damage in the past, largely associated with the direct loss and degradation of vegetation. The main threats are: vegetation clearance due to agriculture and, more recently, urban and industrial expansion; inappropriate fire regimes; and weed invasion. A number of these threats are ongoing, and are likely to interact in complex ways to reduce the integrity, function and resilience of the Cooks River/Castlereagh Ironbark Forest ecological community.

Clearing and fragmentation

Cooks River/Castlereagh Ironbark Forest has a naturally restricted distribution (Tozer et al., 2006, 2010). In addition to this, the ecological community has been extensively cleared (NSW NPWS, 2002; Tozer 2003; Tozer et al. 2006, 2010; Keith 2004; NSW OEH, 2013a). It is estimated that only around eight per cent of the estimated pre-1750 extent remains and much of this is fragmented (NSW NPWS, 2002).

Vegetation clearance was, and continues to be, a major contributor to the decline of native vegetation across the Cumberland Plain, including the ecological community. The reduction in geographic distribution of the ecological community was initially due to tree-felling for timber and clearing for crops and pastures (Benson & Howell, 1990).

Despite being listed as endangered under the NSW *Threatened Species Conservation Act 1995* (NSW TSC Act) in 2002, the ecological community, like many threatened communities on the Cumberland Plain, is under ongoing pressure due to the effects of past disturbance and new land-use pressures (NSW DECCW, 2010; Tozer et al., 2010). Now it is primarily under pressure from urban and commercial development.

The Sydney Growth Centres are the largest coordinated land release in the history of New South Wales and cover around 27 000 ha (approximately 10 000 ha in the North West Growth Centre and around 17 000 ha in the South West Growth Centre) (NSW P&E, 2013). The growth centres plan to provide more than 180 000 homes for around 500 000 people (NSW P&E, 2013).

Of a total of around 220 ha of Cooks River/Castlereagh Ironbark Forest present within the Sydney Growth Centres, approximately 150 ha have been identified as ‘priority conservation lands’. Priority conservation lands are areas to be prioritised for voluntary acquisition for reservation, or for the establishment of conservation agreements with landholders in order to offset the impact of the growth areas on the ecological community. This leaves around 70 ha within the growth centres that have not been earmarked for some kind of protection (based on analysis of Tozer et al., 2006; NSW OEH, 2010).

In order to mitigate the impact of the development, the New South Wales Cumberland Plain Recovery Plan (2010) identified 708 ha of the remaining approximately 1 100 ha (~70%) to be included in ‘priority conservation lands’. Because the priority conservation lands are earmarked for voluntary acquisition, protection of the ecological community in these areas cannot be assured. Some priority areas have already been impacted by development since the NSW recovery plan was released. Some other areas are Commonwealth land dedicated for Defence purposes. In addition, some areas marked as priority conservation lands are already held in national parks so these areas will not constitute an additional conservation gain.

In addition to future impacts to the ecological community from the land release for the North West and South West growth centres, the Draft Metropolitan Strategy for Sydney proposes the investigation of a potential south west expansion (the ‘Western Sydney Employment Area’), which would develop up to 10 000 ha to support employment through the release of land for industries such as freight, logistics, agribusiness and food production (NSW P&E, 2013). Mapping data indicates that approximately 17 ha of Cooks River/Castlereagh Ironbark Forest that is likely to meet condition thresholds is present within the Western Sydney Employment

Area (Eco Logical Australia, 2013). There is a very small overlap of the Western Sydney Employment Area with the South West Growth Centre.

The ecological community is also highly fragmented due to extensive clearing (NSW Scientific Committee, 2011). Using Tozer et al. (2006) SCIVI spatial model data⁵, excluding patches under 0.5 ha⁶, the mean patch size is 6.8 ha and the largest patch is 154.6 ha. 123 (83 per cent) patches are under 10 ha, 24 (16 per cent) are 10-99 ha and one is over 100 ha.

Cooks River/Castlereagh Ironbark Forest typically occurs within Castlereagh Scribbly Gum Woodland (Tozer et al., 2010). Small, isolated fragments, such as for most patches of this ecological community are a natural feature as well as a consequence of land clearance. The further fragmentation is a threat itself as patches are less buffered against disturbances, such as invasion by weeds (Tozer, 2003; Cuneo et al., 2009), or other impacts from surrounding agricultural and urban activities such as spray drift. Loss of connectivity through increased fragmentation is also likely to result in a decrease in biological and genetic diversity and increased predator pressure on native fauna (Anderson & Burgin, 2002).

Altered fire regimes

The vegetation composition of Cooks River/Castlereagh Ironbark Forest is influenced by its recent disturbance history, as well as the patch size (NSW Scientific Committee, 2011). Because the Cooks River/Castlereagh Ironbark Forest occurs in and near urban and peri-urban areas, frequent fire from arson is a major threat to the ecological community (NSW DECCW, 2010).

‘High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition’ is a Key Threatening Process under the NSW *Threatened Species Conservation Act 1995* (NSW OEH, 2014a).

Burning the Cooks River/Castlereagh Ironbark Forest too often may result in the loss of species diversity if native species do not have enough time to mature and set seed. The New South Wales listed endangered nodding geebung, downy wattle and *Allocasuarina glareicola* are all present in the ecological community and are particularly sensitive to frequent burns (NSW DECC, 2008).

Conversely, the exclusion of fire for greater than 30 years is likely to have a detrimental impact on the ecological community, particularly through the loss of understorey plant diversity (DECC, 2005). This can be exacerbated by measures to avoid large fires in some patches as more residential areas are being built near the ecological community.

Further information about fire management is included in the *Priority Conservation Actions* section.

Invasion by weeds

Alteration of the natural fire regime (fewer fires) leads to the accumulation of leaf litter. In combination with nutrient-rich urban runoff, this creates the high nutrient conditions that support the growth of soft-leaved, moisture and nutrient adapted weeds that have escaped from nearby farms and gardens (NSW DECC, 2008).

Weed incursion in the Cumberland Plain is associated with grazing and agricultural land uses as well as urbanisation. Weeds are known to occur on the ecological community in densities that displace native plants and lead to a decline in native species diversity and regenerative capacity (NSW DECC, 2008).

⁵ Note the majority of SCIVI is model data and ground truthing is variable across the landscape.

⁶ Many of the smallest patches of vegetation shown on the mapped output were identified as artefacts of the spatial intersection process.

Weeds that occur in Cooks River/Castlereagh Ironbark Forest include: mid-storey species such as green cestrum (*Cestrum parqui*) and Mickey Mouse bush (*Ochna serrulata*); ground covers such as ground asparagus (*Asparagus aethiopicus*); grasses, including kikuyu (*Cenchrus clandestinus*), common couch (*Cynodon dactylon*) and panic veldt grass (*Ehrharta erecta*) (NSW DECC, 2008). Introduced vines such as moth vine (*Araujia sericifera*) and bridal creeper (*Asparagus asparagoides*) are widespread and difficult to manage over the long-term, as is blackberry (in the genus *Rubus*) in the creek banks and drainage swales (NSW DECC, 2008). Native weeds in creek and drainage lines within the ecological community include *Typha* and *Juncus* species (NSW DECC, 2008).

Climate change

Climate change poses a serious long-term threat to terrestrial and aquatic ecosystems and to have the potential to change the ecology of these environments, through changed species composition and function (Dunlop et al., 2012). The very fragmented nature of the remnants of Cooks River/Castlereagh Ironbark Forest greatly increases their vulnerability to the effects of rapidly changing climates, as the resilience of the ecological community is already compromised. It could also influence the future distribution and extent of the ecological community. Not only does climate change directly threaten species that cannot adapt, it is also likely to exacerbate existing threats, including loss of habitat, altered hydrological regimes, altered fire regimes and invasive species.

Eco Logical Australia (2010) investigated the vulnerability of various natural and cultural assets in the Hawkesbury-Nepean catchment to climate change. That report did not include the Cooks River/Castlereagh Ironbark Forest ecological community. However, many of the findings reported for that community can be sensibly extrapolated to this ecological community. In summary, these include:

- Continued clearing, degradation, and fragmentation will limit the ability of the ecological community to adapt and/or migrate in response to climate change;
- Invasion by non-native plant species is likely to increase in intensity, spread, and diversity, with some such species taking advantage of climate change-induced effects such as periodic depletion of ground cover due to drought and over-grazing;
- Remnants containing riparian vegetation may suffer erosion due to intensification of rainfall events, and this increased disturbance may facilitate or worsen weed invasion;
- Altered native flora and fauna species mix; and
- Altered fire regimes due to changed climate and weather, and due to changed vegetation structure and composition.

Vegetation such as this ecological community is also important in the landscape as a means of mitigating extreme temperatures in the local area through evaporative and cooling influences, mitigating the 'urban heat island effect' operating in western Sydney (Beshara, 2008).

Other threats related to increased urbanisation

Urbanisation of the landscapes that adjoin the ecological community may have significant hydrological effects. The 'hardening' of surfaces through development such as road building surrounding the ecological community results in increased runoff. This can change stream flow patterns, causing erosion and often penetrates adjacent bushland and carries high nutrient and sediment loads, which can encourage weed invasion (DEC, 2005; DECCW, 2010). Increased levels of phosphorus are a particular threat, originating from fertiliser use, excrement from domestic pets, dumped refuse and garden waste, stormwater and sewer discharges. Increased nutrients in the soil is virtually impossible to reverse.

The presence of domestic animals such as cats and dogs as well as pest animals such as foxes, rats, house mice and rabbits may be related to agricultural land use, but intensified with urban development. These introduced species have impacts through predation and damage to

vegetation and soils and can also compete for resources. For example, the Indian myna competes with native birds for nesting hollows while foxes can occupy wombat burrows (Upper Parramatta River Catchment Trust, 1999).

Especially in rural-residential areas, remnants of the ecological community are often mowed, slashed or scrubbed for bushfire fuel reduction, grazing and perceived aesthetics. These activities can deplete the soil seed bank (James, 1994) and contribute to the spread of weeds.

Clearing, mowing and under-scrubbing have also created suitable habitat for a number of large and aggressive native animal species, including *Cacatua galerita* (sulphur-crested cockatoo), *Cracticus tibicen* (Australian magpie) and *Manorina melanocephala* (noisy miner). These species have all increased throughout the extensively cleared landscapes of the Cumberland Plain and now out-compete smaller woodland bird species in areas of fragmented vegetation, contributing to further decline in biodiversity (NSW OEH, 2013c).

Other threats

Within the range of Cooks River/Castlereagh Ironbark Forest, dryland salinity is a threat (DEC, 2005) that results from the widespread and intensive removal of deep-rooted perennial vegetation from the naturally salty Wianamatta Shale that dominates the Cumberland Plain and surrounding shale caps. The removal of this vegetation can result in the upward movement of groundwater bearing salts that can retard and ultimately kill most vegetation.

Uncontrolled grazing can have a significant impact on endangered ecological communities through suppression of the regrowth of the community, which will ultimately impact on regeneration. On the Cumberland Plain, the introduction of domestic stock has had a significant effect on the vegetation, including the loss of some grasses and shrubs that are selectively grazed, such as kangaroo grass (*Themeda triandra* syn. *T. australis*) (Benson & Howell, 1990).

Transmission of plant pathogens occurs through various vectors such as humans and kangaroos, and on larger scales, through contaminated vehicles and machinery. Effective hygiene practices can help to manage human and mechanical transmission. Phytophthora is a known threat to the ecological community with at least one outbreak at Kemps Creek (NSW Scientific Committee 2010). 'Dieback caused by the root-rot fungus (*Phytophthora cinnamomi*)' is a nationally listed Key Threatening Process under the EPBC Act, and is also listed in NSW as a Key Threatening Process under the TSC Act.

The ecological community is also at risk of infection by myrtle rust (*Puccinia psidii* s.l.), a serious fungal pathogen which affect plants belonging to the family Myrtaceae. Myrtle rust is now widely distributed in coastal areas across New South Wales, including the Sydney region (NSW Department of Primary Industries, 2012).

Dieback (in this case caused by *Cardiaspina* psyllid insects) has recently caused substantial impacts (including tree mortality) to vegetation in the Cumberland sub-region, notably to grey box (*Eucalyptus moluccana*) (Steenbeeke, pers. comm., 2014).

APPENDIX D - KEY THREATENING PROCESSES

Key Threatening Processes identified under the NSW TSC Act and EPBC Act that are affecting Cooks River/Castlereagh Ironbark Forest (or are likely to affect the community in the future) are:

- Land clearance (EPBC Act); Clearing of native vegetation (NSW TSC Act)
- Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants (NSW TSC Act/EPBC Act); Invasion of native plant communities by exotic perennial grasses (NSW TSC Act); Invasion and establishment of exotic vines and scramblers (NSW TSC Act)
- Infection of native plants by *Phytophthora cinnamomi* (NSW TSC Act); Dieback caused by the root-rot fungus (*Phytophthora cinnamomi*) (EPBC Act)
- Introduction and establishment of Exotic Rust Fungi of the order Pucciniales pathogenic on plants of the family Myrtaceae (NSW TSC Act)
- Loss of hollow-bearing trees (NSW TSC Act)
- Removal of dead wood and dead trees (NSW TSC Act)
- Competition from feral honeybees (NSW TSC Act)
- Aggressive exclusion of birds from woodland and forest habitat by abundant Noisy Miners *Manorina melanocephala* (NSW TSC Act)
- Predation by European red fox (EPBC Act); Predation by the European red fox (*Vulpes vulpes*) (NSW TSC Act)
- Predation by feral cats (EPBC Act); Predation by the feral cat (*Felis catus*) (NSW TSC Act)
- Loss of terrestrial climatic habitat caused by anthropogenic emissions of greenhouse gases (EPBC Act); Anthropogenic climate change (NSW TSC Act)
- High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition (NSW TSC Act)

APPENDIX E - ELIGIBILITY FOR LISTING AGAINST THE EPBC ACT CRITERIA

Criterion 1 - Decline in geographic distribution

The Cooks River/Castlereagh Ironbark Forest ecological community is estimated to have undergone a decline in area of occupancy from 12 211 ha of its estimated pre-clearing extent to 1100 ha (Table F1 below). This represents a severe to very severe decline in the order of 80-95%.

Table F1. Estimates of pre-European and current extent for the Cooks River/Castlereagh Ironbark Forest.

Estimated area pre-clearing (ha)	Estimated area extant (ha)	% original extent remaining	Estimated area reserved (ha)	% of current extent reserved
12 211*	1100	8.3* (5-20)	290	26

Figures in this table are taken from Tozer et al. (2010) unless marked with a *, in which case they are from NSW NPWS (2002). Data are merged from polygon classification codes A, B, C and SA as defined in NSW NPWS, (2002).

It is considered that the ecological community has undergone a very severe decline in geographic distribution. Therefore, the ecological community has been demonstrated to have met the relevant elements of Criterion 1 to make it **eligible** for listing as **critically endangered**.

Criterion 2 - Limited geographic distribution coupled with demonstrable threat

The purpose of this criterion is to recognise that an ecological community with a distribution that is currently limited has an inherently higher risk of extinction if it is subject to a threatening process. Thresholds to identify terrestrial vegetation communities with limited distributions are typically based on three indicative measures; area of occupancy, total extent of occurrence and patch size (indicative of fragmentation). If any of the three measures is demonstrated to apply to the ecological community it is considered to have a limited geographic distribution.

Data from Tozer et al. (2010) indicate that the present geographic distribution of the ecological community is ‘restricted’ with the total area of occupancy < 10 000 ha, however it is very close to the definition of ‘very restricted’ (defined as <1 000 ha) at around 1 100 ha. The total extent of occurrence is approximately 90 250 ha, indicating that it is ‘restricted’ (defined as <100 000 ha).

The ecological community is also highly fragmented with a mean patch size of approximately 6.8 ha and median size of 2.7 ha, also considered as ‘very restricted’ (analysis of data from Tozer et al., 2006). Almost all patches (83%) have an area of less than 10 ha (Table F2)⁷.

Table F2. Patch size distribution (based on Tozer et al., 2006)

Thresholds		Size range (ha)	No. patches	% patches	Cumulative %	
Restricted	Very Restricted	0.5 – 10	123	83	83	99
		> 10-100	24	16		
		> 100	1	1		
		Total	148	100		

⁷ Note the patch size data excludes patches less than 0.5 ha in area as these have been identified as artefacts of the spatial intersection process (Tozer et al. 2006).

As detailed in *Description of Threats*, the Cooks River/Castlereagh Ironbark Forest ecological community is subject to a range of ongoing demonstrable threats, several of which interact. Key threats include the impacts associated with clearance and fragmentation of remnants as well as weed invasion and change in fire regimes. The naturally restricted distribution of the ecological community, combined with loss due to clearance, poor condition and the presence of ongoing threats has a compounding impact that puts this community at high risk of extinction.

In addition to direct loss through clearance of vegetation, threats associated with urbanisation including weed invasion, inappropriate fire regimes, changes to hydrology, dumping and predation by domestic pets are expected to increase as western Sydney is further developed.

Regeneration is limited by a range of threats, combined with the slow growth and long regeneration times of some key species, for example, the dominant canopy species of broad-leaved ironbark and *Melaleuca decora*, live for more than 100 years (Benson & McDougall, 1998). Woollybutt (*E. longifolia*) is also often present and lives for more than 100 years (Benson & McDougall, 1998).

It is considered that the ecological community has a very restricted geographic distribution, based on the fragmentation of remnants into very small patch sizes, coupled with demonstrable ongoing threats that could cause it to be lost in the immediate future. Therefore, the ecological community is **eligible** for listing under Criterion 2 as **critically endangered**.

Criterion 3 - Loss or decline of functionally important species

The functional roles and general biology for many key flora and fauna species in the Cooks River/Castlereagh Ironbark Forest remain poorly understood.

Tozer (2003) recorded a high proportion of rare flora species in field survey plots on the Cumberland Plain and noted that this suggested that any further clearing of native vegetation in the area would carry a high probability of loss of rare species, leading to a loss of floristic diversity more generally. He noted that this loss of diversity was most likely in those ecological communities with limited distribution, including Cooks River/Castlereagh Ironbark Forest (Tozer, 2003).

Nationally threatened plants that have been recorded in the ecological community include: downy wattle (*Acacia pubescens*); nodding geebung (*Persoonia nutans*); and *Allocasuarina glareicola* (NSW DECC, 2008; NSW Scientific Committee, 2011). New South Wales threatened plants recorded in the community include Tadgell's bluebell (*Wahlenbergia multicaulis*) and *Dillwynia tenuifolia* (NSW DECC, 2008; NSW Scientific Committee, 2011). The plants, pollinators and seed dispersers and how their interactions might play a functional role in the ecological community are unknown.

The dominant species in each vegetation layer (see *Description*, above) provide structure to the vegetation and their relative abundance and cover may influence the dynamics of other vegetative components. For example, the density and shading of the tree and shrub layers influences the development of the understorey whilst the degree of closure of the ground layer cover affects the capacity of herbaceous plants to establish and spread. The presence of legumes, such as *Acacia* species in the lower tree layer may contribute significantly to soil nutrient dynamics, despite their typically sparse cover, through their ability to fix atmospheric nitrogen into a biologically available form (Murray et al., 2001; Broadhurst & Young, 2007).

Selective harvest of the main canopy species, the broad-leaved ironbark, was likely to have been undertaken in the nineteenth and twentieth centuries where taller, straighter trees were felled for use in building bridges, roads and fences. Ironbarks were also used as railroad sleepers and trees were often used for firewood (NSW DECC, 2008). However, the functional implications of past selective clearing are not known.

Across the Cumberland Plain survey sites the diameter of trees measured was small (mean 22cm), while fewer than 3% contained hollows or fissures, indicating limited current value in providing nesting habitat for hollow-dependent fauna, such as some bird species, bats and some other arboreal mammals (Leary, 2007). It is therefore likely that the species richness of the ecological community has been impacted as a result of this clearance which may have flow-on impacts. For example, the majority of eucalypt dieback in eastern Australia is caused by insect attack. In some locations a healthy bird community has been observed to remove 50-70% of leaf-feeding insects, thus playing an important role in maintaining the canopy of the ecological community (Ford, 1989 in Barrett, 2000).

There are insufficient data available to determine the loss or decline of functionally important species within the ecological community or about the restorability of their functions. Therefore, the ecological community is **not eligible** for listing in any category under this criterion.

Criterion 4 - Reduction in community integrity

The threats and disturbances that contribute to a reduction in the integrity of the Cooks River/Castlereagh Ironbark Forest ecological community are detailed in the *Description of Threats*, above. There are strong pressures to extend urban development across the Cumberland Plain, where the largest, most intact remnants are and there are already existing semi-rural and rural development pressures. Where the ecological community has not been outright cleared and irrecoverably lost, the integrity of existing remnants has declined over time as evidenced by the indicators, below.

Reduction in integrity through clearing and fragmentation

The Cooks River/Castlereagh Ironbark Forest ecological community is estimated to have undergone a decline in area of occupancy from 12,211 ha of its estimated pre-clearing extent to 1,100 ha.

The ecological community is also highly fragmented with a mean patch size of approximately 6.8 ha and median size of 2.7 ha (based on analysis of Tozer, 2006 data). This exacerbates the 'edge effects' which makes Cooks River/Castlereagh Ironbark Forest more susceptible to weed invasion and impacts on soil and water quality, which further compromise the integrity of the ecological community. Loss of connectivity through increased fragmentation is likely to result in a decrease in biological and genetic diversity and increased predator pressure on native fauna (Anderson & Burgin, 2002).

Reduction in integrity through weed invasion

A number of weeds pose a serious threat to the integrity of ecological community, with the likelihood of infestation increased by fragmentation. Amongst the most serious threats are:

- Mid-storey
 - Green cestrum (*Cestrum parqui*), which is dispersed by birds and water movement. While seedlings will not compete well when the competition is vigorous, the weed has been known to outcompete most other vegetation on alluvial flats (QLD DAFF, 2014).
 - Mickey mouse bush (*Ochna serrulata*), which is dispersed by birds and dumped garden waste. The weed can establish in disturbed and undisturbed bushland. It may establish large, dense infestations in disturbed areas, and may prevent native understorey plants from growing (Muyt, 2001).
- Ground-layer
 - Ground Asparagus (*Asparagus aethiopicus*), dispersed by birds and dumped garden waste. Asparagus fern forms a dense ground cover supported by

rhizomes and tubers below ground which suppresses other ground plants and uses much of the available soil nutrients and water (Parsons & Cuthbertson, 1992; Le Cussan, 2006; Vivian-Smith & Grimshaw, 2006).

- Grasses
 - Panic veldt grass (*Ehrharta erecta*), dispersed by water, animals (mainly birds), humans, contaminated soil and garden refuse dumping (Sydney Weeds Committees, 2014). An aggressive, perennial grass almost constantly in seed, *Ehrharta* spreads rapidly excluding many small native ground cover species.
 - Kikuyu (*Cenchrus clandestinus*), distributed by broken runners in garden refuse and mowing (Eurobodalla Shire Council 2014). May form mats which outcompetes native species (Eurobodalla Shire Council, 2014).
 - Common couch (*Cynodon dactylon*), escaped from pastures and lawns, spreads by rhizomes and can form a dense mat which may outcompete native species (Tropical Forages, 2014).
- Vines
 - Bridal creeper (*Asparagus asparagoides*), forms an extensive mat of underground tubers. Where the species is extensive, the tuber mat limits establishment sites for native ground layer species (Willis et al., 2003; NSW OEH, 2014b).

Effective control for many of these weed species is problematic and difficult. Consequently, weeds will continue to be a key factor contributing to the reduction in the integrity of many patches of the ecological community into the foreseeable future.

Reduction in integrity through inappropriate fire regimes

Another impact of increasing urbanisation is arson. Frequent fires change the structure of the community and particularly impact the composition of the mid- and ground layers.

The New South Wales listed endangered nodding geebung, downy wattle and *Allocasuarina glareicola* are all present in the ecological community and are particularly sensitive to frequent burns (NSW DEC 2005a, 2005b). The loss of these and other species from the community as a result of the direct impacts of overly frequent burning, as well as subsequent impacts from the disturbance, such as weed colonisation, are likely to impact on the integrity of the ecological community.

In addition, the exclusion of fire for greater than 30 years is likely to have a detrimental impact on the ecological community, particularly through the loss of understorey plant diversity (NSW DECC, 2005a). This can be exacerbated by measures to avoid large fires near some residential areas.

Reduction in integrity through urbanisation

As described above, increased urbanisation has increased impacts on the ecological community including: reduced water and soil quality; rubbish dumping; increased predation on native fauna from domestic cats and other introduced animals adapted to urban environments (NSW Scientific Committee, 2011).

Reduction in integrity through decline in faunal components

There has been an extensive decline in the diversity of the terrestrial mammalian fauna across the Sydney Basin bioregion. Of the 67 species identified as present in the bioregion, 27 species (or 40% of the total number) have experienced a decline of at least 50% of their former range (Burbidge et al., 2008). Of these, nine species have undergone a contraction of range of more than 90% and a further three species are now extinct from the Sydney Basin bioregion.

The original mammal fauna of the Cumberland Plain is estimated to have comprised approximately 60 native mammal species (NSW NPWS, 1997). Of these, 37 mammal species have been detected in recent surveys though only about 14 species remain sufficiently abundant to be considered common (Leary, 2007), mostly species of micro-bat. In particular, there has been an almost complete disappearance of the smaller ground-dwelling mammals, such as native rodents, bandicoots and dasyurids from the Cumberland Plain. As these small mammals have key functional roles in forest systems, their absence is likely to have significant impacts on these key functions.

Of the avifauna of the Cumberland Plain, more than 20 species of birds are considered to have, or are undergoing, a decline in abundance on the Cumberland Plain (Leary, 2007). Many of these species forage on or near the ground and major habitat changes, such as the loss of fallen timber and litter, modification of the understorey towards denser cover, and lower seed supply of understorey species as a food source, have had a deleterious impact on their abundance.

It is highly likely these impacts for the Cumberland Plain correspond to changes in the Cooks River/Castlereagh Ironbark Forest. Resultant changes in the integrity of the ecological community as a result of the loss of key faunal species may potentially include: eucalypt dieback as a result of the absence of insectivorous birds, changes in soil structure and composition due to the absence of small native digging mammals as well as reduced seed dispersal and other ecosystem services performed by the fauna.

Reduction in integrity through climate change

As described in *Description of Threats*, climate change is likely to compromise the integrity of the community both directly and by altering the survival rates of constituent species. It is also likely to interact with other threats, such as changed fire regimes or the invasion of weeds. The long generation time and limited dispersal ability of some key species, such as the canopy eucalypts, together with the unique position of the Cumberland Plain, is likely to limit adaptation through range shift.

Restorability of the ecological community

Cooks River/Castlereagh Ironbark Forest contains many species which can survive for a very long time in the seedbank (DECC, 2008). Therefore highly degraded examples of the ecological community may still contain species that will regrow given the correct conditions. This is most likely to occur if the soil profile is undisturbed. The correct conditions would include the removal of weeds, and the reintroduction of an appropriate fire regime. It may be appropriate in some sites to use 'triggers' such as smoke water and the gentle turning of soil. Replanting from nearby stock has also had some success (DECC, 2008).

Even with active management such as tree planting, the recovery of canopy layers is likely to take a substantial length of time, given the slow rates of growth of these species and the long delay for production of structural habitat features such as tree hollows. The loss of fauna is also region-wide, making their recovery within the ecological community unlikely. The associated loss of services provided by this fauna also compromises the regeneration of the native vegetation.

Summary

Substantial clearing, severe fragmentation, urbanisation, weed invasion, inappropriate fire regimes, and associated changes to vegetation structure and loss of faunal components have substantially reduced the integrity of the ecological community across its range. These losses are compounded by climate change, and together with a range of ecological characteristics of the community, as well as the nature of the ongoing threats severely limit the likelihood of recovery.

The change in integrity experienced by the ecological community across most of its geographic distribution is **very severe** and regeneration is unlikely in the immediate future. Therefore, the ecological community is **eligible** for listing as **critically endangered** under this criterion.

Criterion 5 - Rate of continuing detrimental change

Around 20% (220 ha) of Cooks River/Castlereagh Ironbark Forest is present in areas of western Sydney that have been earmarked for future residential development (through the North West and South West growth centres) (NSW P&E, 2013). Of that, 150 ha is slated for protection through the priority conservation lands, leaving around 70 ha for clearance (based on analysis of Tozer et al., 2006; NSW OEH, 2010).

In addition, the draft Metropolitan Strategy for Sydney proposes a new 'Western Sydney Employment Area', which would develop up to 10 000 ha to support employment through the release of land for industries such as freight, logistics, agribusiness and food production (NSW P&E, 2013). Mapping data indicate that approximately 17 ha of Cooks River/Castlereagh Ironbark Forest that is likely to meet condition thresholds is present within the Western Sydney Employment Area (Eco Logical for NSW DPI, 2013; NSW P&E, 2013).

The increasing urbanisation of western Sydney will increase the rate of detrimental change through: increased run-off and nutrient loads; further changes to fire regimes; predation by introduced species and other impacts. The rate of change from these impacts has not been quantified.

Although there has been continuing detrimental change to the ecological community, data are insufficient to determine an overall rate. As such there is **insufficient information to determine the eligibility** of the ecological community for listing under any category of Criterion 5.

Criterion 6 - Quantitative analysis showing probability of extinction

There are no quantitative data available to assess this ecological community under this criterion. As such there is **insufficient information to determine the eligibility** of the ecological community for listing under any category of Criterion 6.

APPENDIX F - EXISTING PLANS/MANAGEMENT PRESCRIPTIONS

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

Plans prepared for the management of Cooks River/Castlereagh Ironbark Forest include:

- NSW Department of Environment and Climate Change (2008). *Best Practice Guidelines: Cooks River/Castlereagh Ironbark Forest*. NSW DECC. Sydney. Accessed 14 August 2014.
<http://www.environment.nsw.gov.au/resources/threatenedspecies/08601tsdsbpgcooksriver1.pdf>
- NSW Department of Environment, Climate Change and Water (2010). *Cumberland Plain Recovery Plan*. Author: Sydney. Accessed 19 August 2014. Available on the internet at:
<http://www.environment.nsw.gov.au/resources/threatenedspecies/20100501CumberlandPlain.pdf>
- NSW Department of Environment and Conservation (2005). *Recovering Bushland on the Cumberland Plain: Best practice guidelines for the management and restoration of bushland*. Sydney. Accessed 14 August 2014.
<http://www.environment.nsw.gov.au/threatenedspecies/CumberlandPlainManagementGuidelines.htm>

Recovery plans prepared for species occurring in Cooks River/Castlereagh Ironbark Forest are as follows:

- NSW Department of Environment and Conservation (2005) Draft Recovery Plan for the Green and Golden Bell Frog (*Litoria aurea*). DEC NSW, Hurstville, NSW. Accessed 14 August 2014.
<http://www.environment.nsw.gov.au/resources/nature/recoveryplangreengoldbellfrogdraft.pdf>
- NSW Department of Environment and Conservation (2005) *Persoonia nutans*. R Br (Nodding Gebung) Recovery Plan. NSW Department of Environment and Conservation, Hurstville NSW.
- NSW Department of Environment and Climate Change (2009) Approved Recovery plan for the koala (*Phascolarctos cinereus*). DECC NSW, Hurstville, NSW. Accessed 14 August 2014. <http://www.environment.nsw.gov.au/resources/threatenedspecies/08450krp.pdf>
- NSW Department of Environment, Climate Change and Water (2009). Draft National Recovery Plan for the Grey-headed Flying-fox *Pteropus poliocephalus*. Prepared by Dr Peggy Eby. Department of Environment, Climate Change and Water NSW, Sydney. Accessed 14 August 2014.
<http://www.environment.nsw.gov.au/resources/threatenedspecies/08214dnrpflyingfox.pdf>
- NSW National Parks and Wildlife Service (2003) Downy Wattle (*Acacia pubescens*) Recovery Plan. NSW NPWS, Hurstville, NSW. ISBN: 0 7313 6504 6
- NSW National Parks and Wildlife (2002) Environmental Impact Assessment Guidelines: *Dillwynia tenuifolia*. Accessed 14 August 2014.
<http://www.environment.nsw.gov.au/resources/nature/DtenuifoliaEia0502.pdf>.
- QLD Department of Environment and Resource Management. (2011). National recovery plan for the large-eared pied bat *Chalinolobus dwyeri*. Report to the Department of Sustainability, Environment, Water, Population and Communities, Canberra. Accessed 14

August 2014. <http://www.environment.gov.au/resource/national-recovery-plan-large-eared-pied-bat-chalinolobus-dwyeri>

- Saunders, D.L. and Tzaros, C.L. (2011). *National Recovery Plan for the Swift Parrot Lathamus discolor*, Birds Australia, Melbourne. Accessed 14 August 2014. <http://www.environment.gov.au/resource/national-recovery-plan-swift-parrot-lathamus-dicolor>
- VIC Department of Natural Resources and Environment (1999) Regent Honeyeater Recovery Plan 1999-2003. Accessed 14 August 2014. <http://www.environment.gov.au/resource/regent-honeyeater-xanthomyza-phrygia-recovery-plan-1999-2003>

SPRAT Profiles prepared for species occurring in Cooks River/Castlereagh Ironbark Forest as at August 2014 are as follows:

- Commonwealth Department of the Environment (2014). *Allocasuarina glareicola* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: <http://www.environment.gov.au/sprat>. Accessed Thu, 14 Aug 2014 10:10:28 +1000.
- Commonwealth Department of the Environment (2014). *Botaurus poiciloptilus* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: <http://www.environment.gov.au/sprat>. Accessed Thu, 14 Aug 2014 10:18:22 +1000.
- Commonwealth Department of the Environment (2014). *Dasyurus maculatus maculatus (SE mainland population)* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: <http://www.environment.gov.au/sprat>. Accessed Thu, 14 Aug 2014 10:28:53 +1000.
- Commonwealth Department of the Environment (2014). *Heleioporus australiacus* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: <http://www.environment.gov.au/sprat>. Accessed Thu, 14 Aug 2014 10:25:15 +1000.
- Commonwealth Department of the Environment (2014). *Hoplocephalus bungaroides* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: <http://www.environment.gov.au/sprat>. Accessed Thu, 14 Aug 2014 10:40:29 +1000.
- Commonwealth Department of the Environment (2014). *Potorous tridactylus tridactylus* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: <http://www.environment.gov.au/sprat>. Accessed Thu, 14 Aug 2014 10:39:12 +1000.
- Commonwealth Department of the Environment (2014). *Pseudomys novaehollandiae* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: <http://www.environment.gov.au/sprat>. Accessed Thu, 14 Aug 2014 10:39:48 +1000.
- Commonwealth Department of the Environment (2014). *Rostratula australis* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: <http://www.environment.gov.au/sprat>. Accessed Thu, 14 Aug 2014 10:21:39 +1000.

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