High Value Arboreal Habitats in the Coffs Harbour Local Government Area

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Abbreviations

3D	three-dimensional
ADS40	Airborne Digital Sensor (Leica Geosystems)
API	aerial photograph interpretation
CRAFTI	Comprehensive Regional Assessment Aerial Photographic Interpretation
DBH	diameter at breast height
HV	high value (as in HV Arboreal Habitats)
LGA	Local Government Area
LiDAR	light detecting and ranging
NPWS	NSW National Parks and Wildlife Service (which now falls within Office of Environment and Heritage)
NSW	New South Wales
PNF	private native forestry

Summary

- High Value Arboreal Habitats have important conservation value where ever they occur in the Coffs Harbour Local Government Area (LGA).
- There is very little High Value Arboreal Habitat left in the Coffs Harbour LGA, especially on freehold lands.
- What remains requires the highest level of protection.
- What remains also requires supplementation by management regimes that promote the protection and recruitment of old trees including hollow-bearing trees throughout all tenures.
- There is a need to examine both the response of local forest fauna to variations in the abundance of trees with hollows and the scale and pattern of forest disturbance.
- In order to appreciate the enormous time scales involved in hollow development, dendrochronological studies, or similar, are required to determine the longevity of tree species in the Coffs Harbour LGA and length of time it takes for cavities suitable for use by wildlife to develop.

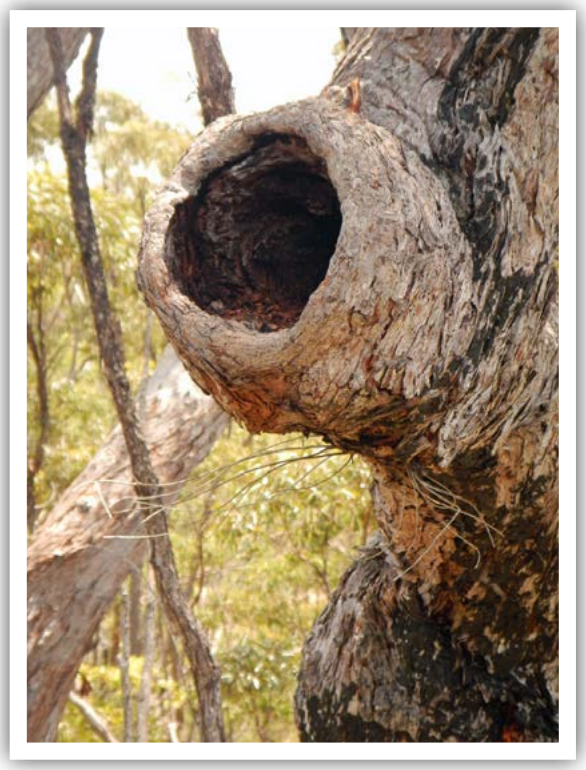
Old-growth forest is recognised as a high value habitat in conservation assessment programs (RACD 1999a) but previous mapping, undertaken at regional scales, did not map patches of old forest less than 5 hectares in area. In seeking to map high value habitats for hollow-dependent species at finer scales for the purposes of land-use assessment and planning, the Coffs Harbour City Council (Council) requires growth stage mapping at finer scales to incorporate these smaller patches. The term ‘High Value Arboreal Habitats’ (HV Arboreal Habitats) is introduced to convey the ecological importance of hollow-bearing trees as part of a wider identification and mapping of high value habitats across the LGA.

A survey and mapping project was undertaken to identify HV Arboreal Habitats in forested areas of the Coffs Harbour LGA using high resolution digital imagery.

The purpose of the project was two-fold:

1. Use air photo interpretation (API) to produce a fine-scale map, using 3D API of HV Arboreal Habitats suitable for Council’s planning and project requirements.
2. Produce a classification (definition) for HV Arboreal Habitats in the Coffs Harbour LGA, including:
    - HV Arboreal Habitat category 1 old-growth forest classification with mapping and field validation methods consistent with the *Private Native Forestry Code of Practice* (DECC 2008)

- to define and identify HV Arboreal Habitat categories 2–4 as highly significant components of forest structure and as important habitats for hollow-dependent species — an approach that could be more widely adopted by other local governments across coastal New South Wales to assist in the development of biodiversity management strategies.



The project was carried out in five stages:

1. Classify (or define) HV Arboreal Habitats in Coffs Harbour LGA.
3. Use API techniques to map areas of HV Arboreal Habitat.
4. Cross-check mapping against CRAFTI candidate old-growth forest mapping.
5. Undertake field surveys to guide API work and to validate areas mapped as HV Arboreal Habitat.
6. Refine mapped boundaries of HV Arboreal Habitats and finalise mapped determinations (coding).

The latest techniques, software and hardware were used for this mapping project. The most efficient and accurate method was used involving conventional API of high resolution digital imagery within the Stereo Analyst™ 3D viewing and mapping environment. Mapping was conducted at a scale of 1:3000.

HV Arboreal Habitats were divided into four categories

- HV Arboreal Habitat category 1 — old-growth forest
- HV Arboreal Habitat category 2 — forest areas >10 hectares with ≥ 5 senescent trees per hectare
- HV Arboreal Habitat category 3 — forest areas 5–10 hectares with ≥ 5 senescent trees per hectare
- HV Arboreal Habitat category 4 — forest areas 1–5 hectares with ≥ 5 senescent trees per hectare.

The delineation and identification of HV Arboreal Habitats reflected forest structure (i.e. the composition of late mature and over mature crowns) and disturbance regimes.

Field validation was undertaken at 149 survey sites to support the classification and mapping program. Information on structure and disturbance was collected through rapid site surveys or point-to-plant transects. Sites provided data for extrapolation and mapping purposes. To achieve maximum survey effort for all mapped areas, 85 private landowners were invited to voluntarily have surveys conducted on their land (14 landholders provided access).

API was conducted over 49,894 hectares of forested freehold lands in the Coffs Harbour LGA. A total 339 polygons were initially mapped as HV Arboreal Habitats.

The final mapping shows 1502 hectares (189 polygons) of HV Arboreal Habitats on freehold lands in the LGA. This represents less than 3% of freehold forested lands. The 1502 hectares includes 'verified' areas (i.e. those with an initial high mapping reliability and those areas that have been field validated) and 'potential' areas (i.e. those areas which still require field validation). Of the 339 polygons initially mapped as HV Arboreal Habitats within the LGA, 108 have been verified as meeting the classification for HV Arboreal Habitats. There are 81 polygons representing 835 hectares which still requiring further field validation, including 256 hectares (12 polygons) mapped as category 1 old-growth. For the first time, all old-growth forest and other HV Arboreal Habitats on freehold land have been consistently mapped across the LGA. This provides Council with a valuable conservation assessment and planning tool. The mapped information allows Council to identify old-growth forest and other HV Arboreal Habitats and to make comparisons of its distribution and extent to determine appropriate management actions.

The new HV Arboreal Habitats map will underpin a range of environmental planning and strategic management programs, for example the 'Biodiversity Action Strategy 2012–2030', *Coffs Harbour Local Environment Plan 2013* and *Coffs Harbour Development Control Plan 2013*. The development of the HV Arboreal Habitats map has been an initiative supported by Council and the Office of Environment and Heritage (OEH). It is anticipated that the HV Arboreal Habitats mapping products will be adopted by a range of end-users and natural resource managers.

1. Introduction

1.1 Aim of the study

The aim of this study is to produce a contiguous map of High Value Arboreal Habitats (HV Arboreal Habitats) on freehold forested lands in the Coffs Harbour Local Government Area (LGA) at a scale of 1:3000.

This study identifies senescent forest characteristics according to attributes which can be identified from the forest canopy, predominantly through remote sensing techniques. This is consistent with the Commonwealth and states' agreed JANIS[1] definition of old-growth forest which places an emphasis on the use of over-storey attributes to identify old-growth forest:

> 'Old-growth forest is ecologically mature forest where the effects of disturbances are now negligible' (JANIS 1997).

The study is also consistent with current *Private Native Forestry Code of Practice for Northern NSW* (DECC 2008) and supporting *Protocol for Re-evaluating Old-growth Forest on Private Property – Private Native Forestry Code of Practice Guideline No. 2* (DECC 2007) with respect to mapping and field validation procedures for old-growth forest.

1.2 Study area

The eucalypt forests of the North Coast of New South Wales have been recognised as some of the most diverse and species rich communities in the world (Cerese 2012). These forests include high levels of both endemic eucalypt diversity and overall eucalypt diversity (Cerese 2012).

In the Coffs Harbour LGA, wet sclerophyll and rainforest formations dominate the landscape, covering over 60% (54,750 hectares), and this is mainly due to the rich, fertile landscapes and high annual rainfall. Dry sclerophyll forests cover 20% (17,442 hectares), while the coastal forest covers only 6% (5214 hectares) of the LGA (OEH 2012).

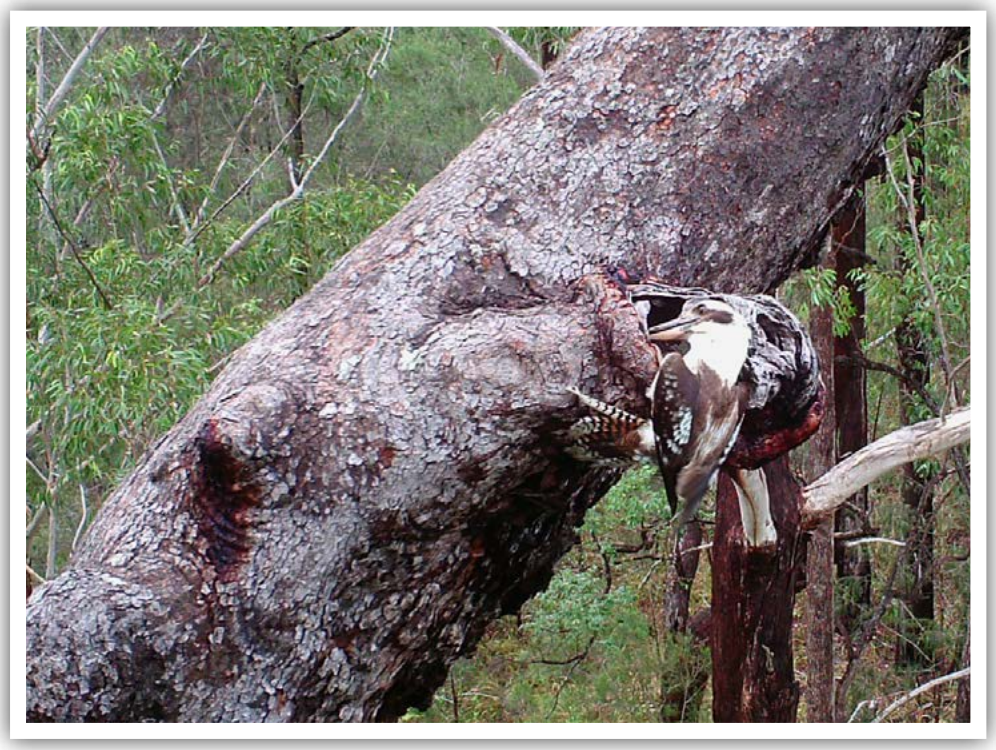
1 'JANIS' refers to the Joint ANZECC/MCFFA National Forest Policy Statement Implementation Sub-committee report of 1997. ANZECC is the Australian New Zealand Environment and Conservation Council; and MCFFA is the Ministerial Council on Forestry, Fisheries and Aquaculture.

The Coffs Harbour LGA covers 117,300 hectares and is one of the few areas of coastal New South Wales where the high elevation landscapes of the Great Dividing Range are within close proximity to the coast. The diversity and extremes in landforms across the study area combined with past land-use practices have resulted in the majority of remaining forests supporting older trees being limited to the least accessible and least fertile areas in the LGA. These areas are typically escarpments and slopes greater than 30 degrees, and low fertility sites often on sandstone. In these areas past and present forest management activities have had less impact on the structural diversity of eucalypt forests.

The study area can be seen as consisting of three predominant topographical landscapes: coastal plains, midland hills and escarpment ranges (See Figure 1 and Table 1).

Table 1. Landscapes of the Coffs Harbour LGA

Landscape	Area (ha)	Area (%)
Coastal plains	32,150	27
Midland hills	47,500	41
Escarpment ranges	37,650	32
Total	117,300	100



Laughing Kookaburra (*Dacelo novaeguineae*) at hollow entrance, Corindi cemetery

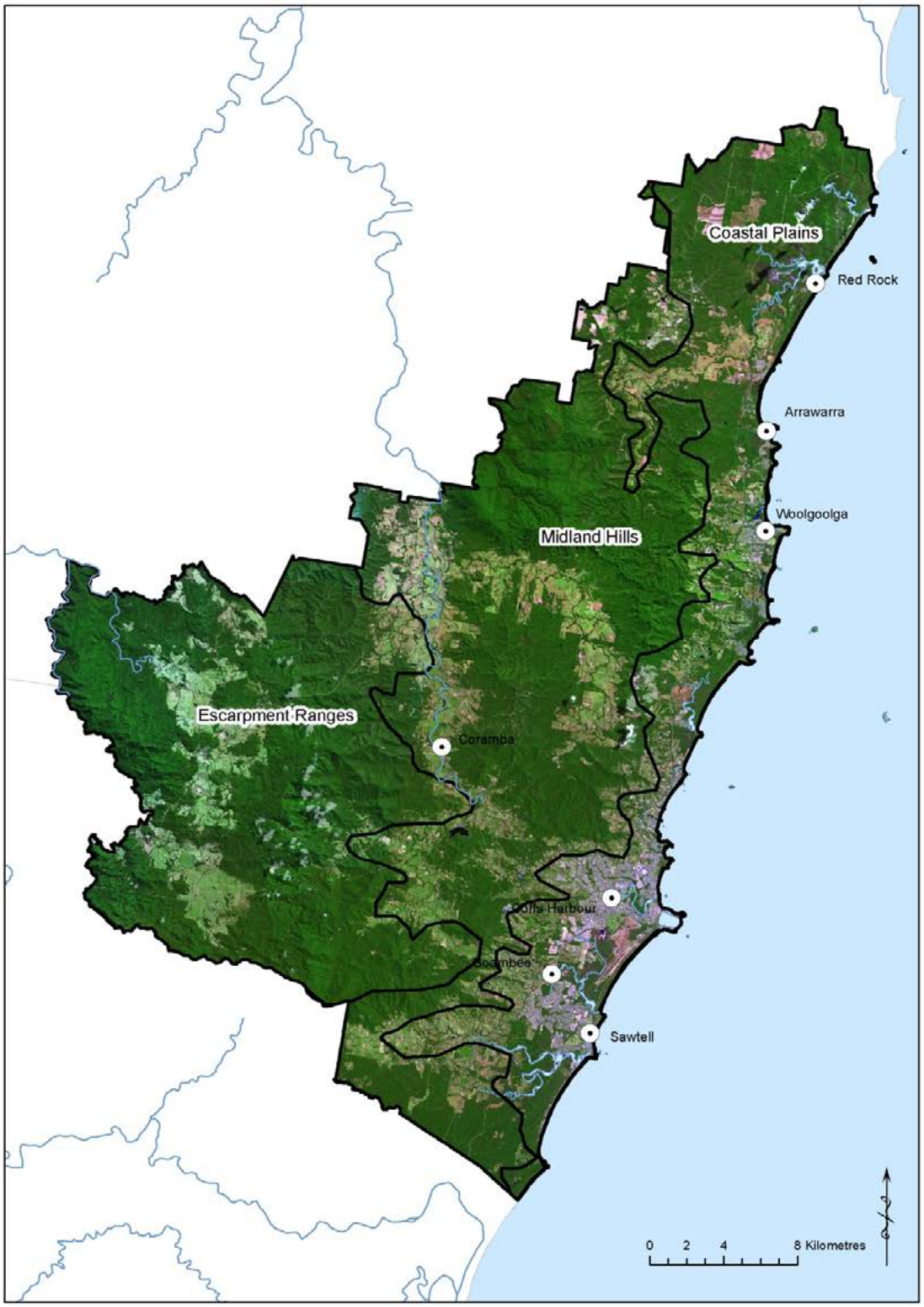


Figure 1. The study area and landscapes of Coffs Harbour LGA

1.3 Context for the study

Forests supporting older trees are recognised high value arboreal habitats (see Section 1.6) and various regional conservation assessment programs have mapped growth stages and old-growth forest in north-east New South Wales (RACD 1999a).

Growth-stage mapping was previously undertaken for the Coffs Harbour LGA as part of the Comprehensive Regional Assessment Aerial Photographic Interpretation (CRAFTI) project undertaken for the upper north east and lower north east comprehensive regional assessments (see RACD 1999a). The CRAFTI methodology involved growth-stage mapping and disturbance mapping to determine 'candidate old-growth'.

The CRAFTI work was undertaken to meet the assessment requirements at a scale for the whole upper and lower north east regions which stretch from Tweed Heads in the north to the Hunter region in the south, and west as far as the Armidale region. Mapping at this regional scale (i.e. 1:25,000) is not suitable at the property scale or for local government planning purposes, and little ground-truthing was conducted over freehold lands during the CRAFTI work.

These regional scale programs (RACD 1999a) did not map patches of old forest less than 5 hectares. In seeking to map high value arboreal habitats for hollow-dependent species at finer scales for the purposes of land-use assessment and planning, the Coffs Harbour City Council (Council) requires mapping at finer scales to incorporate these smaller patches.

Over the last 20 years there have been significant improvements in growth-stage mapping resources

Lace Monitor (*Varanus varius*) feeding at termite nest, Barcoongere Way

and techniques. There have been major advances in the quality and availability of very high resolution (i.e. 50 centimetre) digital imagery and technologies for viewing and interpreting these images. The preparation/development of the Coffs Harbour HV Arboreal Habitats map provided an opportunity to take advantage of these new technologies.

The term 'High Value Arboreal Habitats' (HV Arboreal Habitats) is introduced to convey the ecological importance of hollow-bearing trees as part of a wider identification and mapping of high value habitats across the Coffs Harbour LGA (see Section 1.6 for more detail). Appendix 1 includes an extract from Council's Biodiversity Action Strategy showing the overarching framework within which this project sits.

The last 20 years has seen ongoing changes to land uses in the LGA, with shifts to residential lands, horticulture and private native forestry. These changes to land management have impacted the extent and presence of HV Arboreal Habitats in the LGA. Literature now points to the significance and rapid loss of hollow-bearing trees across the landscape. As such, a new, up-to-date HV Arboreal Habitats map is required to reflect their changed extent across the LGA.

Council requires updated detailed mapped information to support future planning strategies for the LGA. The new HV Arboreal Habitats mapping will underpin a range of environmental planning and strategic management programs. The map will be suitable for use at the 1:3000 scale and will support environmental planning at the whole-of-LGA level. The map may not necessarily be suitable for individual property or development plans where further surveys may be required to establish a forest's old-growth or HV Arboreal Habitat status. However, the mapping will have a direct influence on the following Council strategies, planning instruments and guidelines:

- Open Space Strategy
- Biodiversity Action Strategy 2012–2030
- State of the Environment reporting
- *Coffs Harbour Local Environmental Plan 2013*
- *Coffs Harbour Development Control Plan 2013*
- estuary management plans
- Draft Priority Habitats and Corridors Strategy
- Preservation of trees or vegetation clause (LEP 2013)
- Significant Tree Register
- Draft Coffs Harbour Bush Regeneration Strategy
- biodiversity guidelines.

Blackbutt (*Eucalyptus pilularis*) hollow, Corindi cemetery

The development of the HV Arboreal Habitats map has been an initiative supported by Council and the Office of Environment and Heritage. It is anticipated that the HV Arboreal Habitat mapping process will be adopted by a range of stakeholders and natural resource managers.

Recently the Office of Environment and Heritage worked with Council to prepare a fine-scale vegetation map for the LGA (OEH 2012). The new HV Arboreal Habitats spatial layer will add value to and complement this product, and will also form an important component of Council's broader high value habitats projects.

Brush-tailed Phascogale (*Phascogale tapoatafa*), Barcoongere Way

Giant Tallowwood (*Eucalyptus microcorys*), Bruxner Park

1.4 Eucalypt forests and old trees in the Coffs Harbour LGA

There is very limited information on the geographical extent of old eucalypt trees and the age at which these eucalypts start to exhibit hollows. For example, of the 26 known species of eucalypt in the Coffs Harbour LGA (OEH 2012), Blackbutt (*Eucalyptus pilularis*) is the only species for which data has been collected on eucalypt longevity and hollow formation (Mackowski 1993). Fundamental ecological information is absent for the remaining 25 species.

Gibbons (2011) concluded that to manage our natural environments we must first interpret what forests and woodlands of Australia's looked like prior to European settlement. The literature suggests that 170 years of forestry, agriculture and urban development has left the majority of the Coffs Harbour area impoverished of old-growth forest and consequently lacking in hollow-bearing resources (Cerese 2012).

The first wave of timber getters to the North Coast targeted Australian Red Cedar (*Toona ciliata*) (Jervis 1940; Kass 1989; Vader 1987). They moved in to the Nambucca and Bellinger rivers in 1842 while the area around Dorrigo was not opened up by cedar getters until 1857 (Vader 1987). As this resource was depleted, and with the introduction and improvement of saw blades, the next big target became large, mature or early

mature eucalypts such as Blackbutt, various ironbarks and Tallowwood (*E. microcorys*) (Daly 1966). Large diameter eucalypt cohorts which are not yet hollow-bearing are usually more commercially viable and it is this group which were generally targeted by the timber industry. Many of the very large trees still remaining today in the Coffs Harbour LGA include Blackbutt and Flooded Gum (*E. grandis*).

The second wave of expansion was associated with pastoral squatters who sought to open grasslands to graze their ever-increasing flocks of cattle and sheep (Kitching et al. 2010). Expansion for agriculture saw further decline as large trees were ringbarked, cleared and burned to make way for agricultural pursuits (Griffiths 2002).

Large, old trees can still be found on some of the larger estuaries and some of the less fragmented forests of the Coffs Harbour LGA. Their persistence in the landscape is likely to be a result of a range of historical factors, but they remain largely isolated examples of what was once a continuous old-growth forest. Daley (1966) suggests that these trees were more than likely to have already been hollow-bearing when the first wave of timber getters came through in the 1860s.

Today, only fragmented and isolated patches of old-growth forest remain in Coffs Harbour, representing less than 26% of all forest cover on all tenure of which old-growth forests comprise less than 1% of freehold forested land. This is a result of 150 years of landscape modification that has included successive waves of forestry, farming and urbanisation leaving a sea of young trees which are many decades if not centuries away from developing hollows. Recent surveys in the region which measured eucalypt diameter at breast height (DBH) indicate the general DBH cohort for eucalypts is around 40 cm (pers. comm. D Lunney 1996–2011 Coffs Harbour Koala survey and J Turbill 2012 Bellingen Koala survey). Depending on the eucalypt species, the site condition, biotic and abiotic factors and fire frequency and intensity, hollow formation in the Coffs Harbour region is facing a formation time lag in the range of 50–300 years.

1.5 The process of hollow formation in eucalypts

Studies have shown that there are no clearly defined seasons on the NSW North Coast and therefore eucalypts are difficult to age (Pearson 2002). Apart from a few commercially valuable eucalypt species (e.g. Blackbutt), there is very little information in the literature regarding the longevity of eucalypts or the age at which trees start to form and retain hollows.

A number of studies have demonstrated the relationship between DBH and tree age (Ambrose 1982; Lindenmayer et al. 1993, 2000b; Brookhouse 2006; Koch et al. 2008). Models show that the size and number of hollows increases with the size and age of the tree. They also show that there are apparent differences between species. In dry sclerophyll forests in the Coffs Harbour area, it is likely that hollows begin to form in trees >50 cm DBH, and in wet sclerophyll forests hollows begin to form in trees >80 cm DBH (McLean 2012).

It is the older trees that provide hollows suitable for a range of fauna, and it is the older trees that provide the greatest number of hollows (Ambrose 1982; Mackowski 1993; Wormington et al. 2003; Goldingay 2009, 2012).

McLean (2012) found that fire frequency plays a significant role in the development of hollows within eucalypts, that hollows are scarce in trees under 80 years of age, and that it may take as long as 150 to 220 years for trees to develop a diversity of larger hollows.

Common Brushtail Possum (*Trichosurus vulpecula*), Moonee Caravan Park

1.6 Value of forests supporting hollow-bearing trees

Forests supporting old trees are recognised as having very high aesthetic, cultural and natural conservation values. Their protection and management is extremely important in maintaining biodiversity (Lunney 1991).

Old forests and forests with hollow-bearing trees are extremely important in the maintenance of biodiversity (fauna, flora and insect diversity) and ecological functions (e.g. nutrient and water cycles). Specific attributes of ecologically mature and old-growth forests used for foraging, nesting, basking or roosting by native animals include:

- diversity of hollows in limbs and trunks of live trees, dead trees (i.e. stags) and ground logs
- more dead wood present, including both standing timber and as ground logs
- deep litter layer or native grasses usually present as ground cover
- diversity in tree structure and age with older trees producing larger amounts of loose and shedding bark providing greater opportunities for nesting and roosting, and higher levels of food resources such as insects, nectar, pollen and sap
- mistletoe and epiphytes often present
- more availability of nest building materials and locations and perches for resting, basking and hunting forest birds and owls (DEC 2004).

The retention of a range of old trees supporting a diversity of hollows (i.e. hollows of different sizes, shapes, volumes, positions in tree and aspects) across a range of landscapes (e.g. riparian, mid-slope, hill and escarpments) has been shown to be a significant factor in maintaining overall species diversity. Many species require hollows within specific habitat or landscape types, such as riparian areas. Other species need hollows close to their foraging sites, whilst others species rely on the availability of different hollows across their home range. For example, maternity colonies of bats move between different hollows every few days and an individual Brush-tailed Phascogale (*Phascogale tapoatafa*) can use between 10–40 nest hollows within their home range each year (Soderquist et al. 1996). A range of hollows is required for these species to allow access to key foraging areas, avoid predators and cater for breeding. For example, a Stephens' Banded Snake (*Hoplocephalus stephensii*) may use 20 to 30 arboreal shelters or hollows within its home range (Fitzgerald et al. 2002). Yellow-bellied Gliders (*Petaurus australis*) live in social groups using exclusive home ranges which vary from 25 to 85 hectares (Goldingay & Possingham 1999). Family group members rely exclusively on the availability of numbers of larger tree hollows across their extensive

home range to cater for access to their variable food resource throughout different times of the year.

Squirrel Gliders (*Petaurus norfolcensis*) use tree hollows for shelter and nesting (Suckling 1995). They live in family groups of between 2 and 10 and often move between 300 and 500 metres in a night within a home range which may vary between 0.65 and 8.55 hectares according to habitat quality and availability of resources such as access to suitable hollows (Quin 1995).

Hollow diversity is also critical to maintaining predator–prey relationships for many species and is a critical limiting factor to the survival of many high order predators. For example, large forest owls depend on an abundant supply of smaller prey such as gliders and possums, all of which are hollow dependant. Where trees with hollows are scarce, habitat suitability and quality for species such as the Powerful Owl (*Ninox strenua*) is greatly reduced or removed.

Further, Smith et al. (1994) found that Greater Gliders (a common prey species for the Powerful Owl) are generally absent from forests where there are fewer than six hollow-bearing trees per hectare, whereas Mackowski (1993) states that three hollow trees per hectare becomes a limiting factor to the support of possum and glider populations in Blackbutt forests on the NSW North Coast.

In summary, any decrease in the availability and natural diversity of hollows across the forested landscape can lead to significant reduction in hollow-dependent animal species diversity and abundance, and in some cases, may result in local extinction of these species.

Hollow-bearing trees are a pivotal conservation resource and one which has been drastically reduced across Coffs Harbour's forested landscapes.

Regent Bowerbird (*Sericulus chrysocephalus*), Bruxner Park

2. Methods

This report outlines the process undertaken to map High Value Arboreal Habitats (HV Arboreal Habitats), including old-growth forest, across freehold forested areas in Coffs Harbour LGA.

The term **High Value Arboreal Habitats** (HV Arboreal Habitats) is introduced to convey the ecological importance of hollow-bearing trees as part of a wider identification and mapping of high value habitats across the LGA.

The project was carried out in five stages.

Classify (or define) HV Arboreal Habitats in Coffs Harbour LGA.

1. Use API techniques to map areas of HV Arboreal Habitat.
2. Cross-check mapping against CRAFTI candidate old-growth forest mapping.
3. Undertake field surveys to guide API work and to validate areas mapped as HV Arboreal Habitat.
4. Refine mapped boundaries of HV Arboreal Habitats and finalise mapped determinations (coding).

Regrowth surrounding a felled giant, Boambee (Photo: P Knock)

2.1 Classify HV Arboreal Habitats

A classification for HV Arboreal Habitats in Coffs Harbour LGA was developed. The four categories of HV Arboreal Habitat are shown in Table 2.

Table 2. Classification of High Value Arboreal Habitats in Coffs Harbour LGA

Category	Crown and patch/polygon size	Disturbance
Category 1, old-growth forest	>5 hectares relative crown cover is <10% regrowth >10% of trees are senescent	<50% of polygon shows signs of disturbance OR the effects of disturbance are now negligible 'negligible' disturbance is <50% of polygon with <10% regrowth / native pioneers or exotic species
Category 2	>10 hectares >5 senescent trees per hectare	Can show signs of 'significant' disturbance: >50% of polygon >10% regrowth / native pioneers or exotic species, landuse and/or point source disturbance
Category 3	5–10 hectares >5 senescent trees per hectare	
Category 4	1–5 hectares >5 senescent trees per hectare	As above or no disturbance or negligible disturbance

In this study, the definition (both forest structure and disturbance characteristics), API mapping methodology and field validation technique for category 1 old-growth forest is consistent with the *Protocol for Re-evaluating Old-growth Forest on Private Property: Private Native Forestry Code of Practice Guideline No. 2*, or 'the PNF old-growth protocol' (DECC 2007). The mapped layer which defines old-growth forest for matters relating to private native forestry (PNF) includes areas mapped with the following growth stages: <10% regrowth and either >30% or 10–30% senescence (tA and tB, respectively).

All other categories of HV Arboreal Habitats (i.e. categories 2–4) include more than five senescent trees per hectare. The literature defines the lack of hollow-bearing trees as a limiting factor in the sustainability of hollow-dependent fauna populations. Five trees per hectare was found to be a mappable unit at the scale required by Council, and was also a minimum number of hollows per hectare required to support a range of hollow-dependent fauna populations. It is argued that the number of hollow-bearing trees becomes generally limiting for forest on the north coast of NSW when there are less than about three hollow trees per hectare (Mackowski 1993, supported by extrapolations of the general habitats studied by Smith & Lindenmayer 1988). For the purposes of this study, these HV Arboreal

Stephens' Banded Snake (*Hoplocephalus stephensii*), Barcoongere Way

Habitat categories can also show signs of 'significant' disturbance. Categories 2–4 are distinguished by patch size (see Table 2).

2.2 Mapping HV Arboreal Habitats

API of forest growth stage involves recognising patterns in forest structure, understanding the structural composition of forest types and how this relates to environmental variables, and delineating growth stage boundaries and assigning a suitable code from a derived classification. For a full description of this process, refer to NSW NPWS (1996) and Resource and Conservation Division (1997). Appendix 2 includes the coding specifications used in this study and Section 2.6 discusses mapping disturbance.

Only 3D API is viable for the identification of HV Arboreal Habitats. Previous use of stereoscopes and low resolution aerial photographs has given way to the use of Stereo Analyst™ and high resolution digital imagery, and as such, this is the method used in this study.

Mapping of HV Arboreal Habitats was conducted by applying API techniques using Planar stereo/3D monitors and Stereo Analyst™ software on an ESRI ArcGIS 10.0 platform.

HV Arboreal Habitat categories 1, 2, 3 and 4 were mapped as either: verified or requiring field validation (i.e. coded as reliability 'Field Check'). Disturbance indicators were included for HV Arboreal Habitat category 1 old-growth, where appropriate, in the associated attribute table (Appendix 4). Disturbance indicators followed the 'CRAFTI API manual' (RACD 2007) and the PNF old-growth protocol (DECC 2007). See Appendix 2.

Mapping involved a three-step process:

a) Map HV Arboreal Habitat category 1 old-growth forest as either:
   i) verified old-growth, coded as reliability 'is old-growth' areas of steep topography determined through API and validated by DEM hill shade

   OR

   ii) old-growth requiring field validation, coded as reliability 'Field Check'.

b) Map other HV Arboreal Habitats (i.e. categories 2, 3 and 4) as either:
   i) verified HV Arboreal Habitats, coded as reliability = 'is HVAH'

   OR

   ii) HV Arboreal Habitats requiring field validation, coded as reliability 'Field Check'.

c) Disturbance indicators were included for HV Arboreal Habitat category 1 old-growth mapping, where appropriate, in the associated attribute table (see Appendix 4).

The mapping was undertaken by one aerial photograph interpreter. The study area was divided into API progress grids to track progress across the landscape. Consistency was achieved by referring to reference senescent trees that were visible within the interpretation sphere and remaining within the interpretation scale range of 1:2000 to 1:4000. Under magnification would result in not visibly recognising senescent features of trees and over magnification would result in over estimating senescent composition and the inability to define polygons based on an homogenous structural and disturbance pattern.

As some forest types are difficult to interpret in addition to various factors masking senescent canopy characteristics, the study undertook an inclusive approach, where larger crowns within a forest context where tagged for field validation.

Additional information used to assist in the API work included:

- previous mapping and survey work in the study area (see Appendix 3)
- image enhancement products — Stereo Analyst™ enhancement of ADS40 stereo imagery and a saturation stretch of ADS40 ortho-rectified imagery based on Roff (2009)
- 'CRAFTI API manual' (RACD 1997)

- *Private Native Forestry Code of Practice* (DECC 2008) old-growth forest layer which includes only the growth stage codes tA (<10% regrowth and >30% senescence) and tB (<10% regrowth and 10–30% senescence)
- hillshade using LIDAR-derived digital terrain model to assist interpretation of topographic variables (aspect, slope, position on slope, ridges and gullies).

Interpretation used all available supporting data to attribute each polygon to one of the categories, and if uncertain, a 'Field Check' label was assigned.

Scaly-Breasted Lorikeet (*Trichoglossus chlorolepidotus*), Moonee Reserve

2.3 Cross-check mapping against CRAFTI candidate old-growth areas

'Candidate old-growth' forest (see NPWS 1999) is classified as forest with a relative crown cover of 10–30% regrowth and either >30% or 10–30% senescent trees ('sA' and 'sB' respectively. The classification of candidate old-growth differs from the PNF old-growth definition in that it includes areas exhibiting 'significant' disturbance, and as such includes areas classified as 'disturbed old-growth'. The aerial extent of candidate old-growth is, therefore, greater than old-growth as defined under the current PNF code of practice. Within the study area, CRAFTI originally mapped some 703 hectares of candidate old-growth on freehold tenure and 5800 hectares on public tenure (NPWS 2002).

The candidate old-growth senescent components of sA and sB (hollow-bearing trees in the canopy) and allowance of disturbance, meets the HV Arboreal Habitat categories being used in this project. As such, the candidate old-growth mapping provides a key reference layer to cross-check the mapping of HV Arboreal Habitats. Any areas not mapped by this project that were mapped as CRAFTI candidate old-growth were assessed via API and tagged for field check if appropriate, based on the mapping specifications.

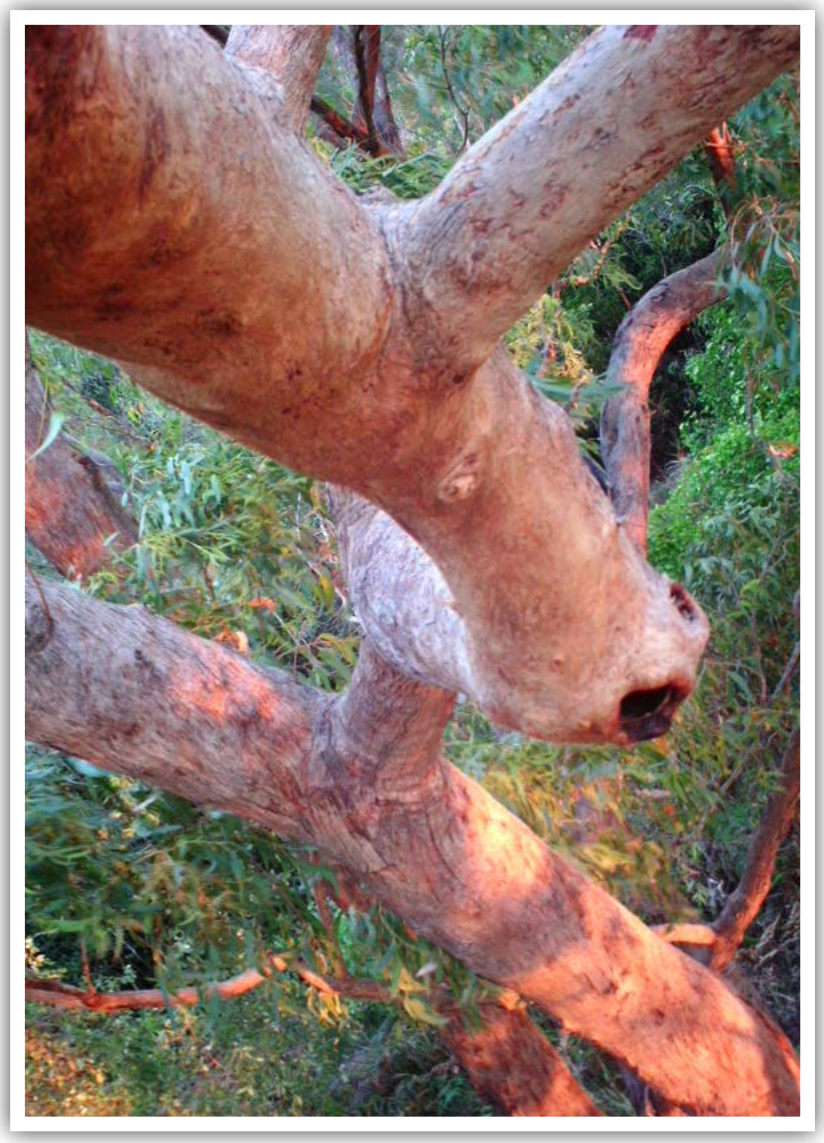
The consideration of candidate old-growth forest in the HV Arboreal Habitats project is appropriate because the imagery used to map candidate old-growth in the Coffs Harbour area was captured in 1994, some 19 years ago. Since then, the regrowth proportions of the candidate old-growth may have become mature and some disturbance indicators may now be 'negligible'.

2.4 Field validation

Field validation surveys were carried out at various stages throughout the project. For example, some rapid site surveys (see below) were conducted during the mapping stage in order to guide the mapping work (by providing reference points for photo patterns). Data from these sites were also used to refine the mapped polygons. Surveys were also conducted after the mapping stage in order to validate polygons with a 'Field Check' reliability.

Surveys were conducted in areas where access was provided by private property owners as well as areas that were visible from public roads or tracks. Field information was collected using a geographic positioning system Garmin Oregon 550. Two assessors were involved in each survey to provide consistency.

Field validation surveys were undertaken in areas mapped for 'Field Check'. Access, project time and budget constraints impacted the level of field validation. Two types of field validation surveys were conducted to ground-truth API mapping and assign a polygon to the correct HV Arboreal Habitat category.



Bastard Tallowwood (*Eucalyptus planchoniana*), Coffs Creek

Rapid site surveys were undertaken to collect information on dominant structure and disturbance. The aim of rapid site surveys was to cover as much ground as possible in those areas that were easily accessible. Therefore, there is a spatial bias to that data, with no data collected in areas where access could not be gained or where locations were remote or steep (i.e. >30 degrees). These surveys also recorded incidental records of threatened species, high conservation value areas, and areas where private native forestry operations were evident.

Point-to-plant surveys were undertaken to collect information on forest structure and disturbance within 30 metres of a maximum 10 points which are located 50 metres apart. These surveys were only conducted where field staff could not visually determine the dominant structure and or disturbance regime of an area. The point-to-plant methodology used in this study was the same as used in the PNF old-growth protocol.

Field validation surveys were carried out as follows:

a) Determine where private property access will be provided by landholders for the purposes of ground-truthing the mapping. Access was sought via landholder response to a mail out carried out by Coffs Harbour City Council.

b) Where access to freehold land mapped as reliability 'Field Check' is available, undertake rapid site surveys or point-to-plant surveys as appropriate.

c) For categories 2–4, carry out surveys in category 2 first, then categories 3 and 4 as time allows.

2.5 Review, refine and make a final determination of mapped areas

Data from the field validation surveys were used in the 3D Stereo Analyst™ mapping environment to guide and confirm polygon line and attribution (i.e. coding).

a) Review and refine mapped HV Arboreal Habitats based on field data, using Stereo Analyst™ and Planar monitor/viewer to make a final determination

- Apply 3D analysis of survey data on forest maturity and disturbance to assess the original polygon determination. Boundaries and determinations were then validated or amended.
- Use point-to-plant data to validate original determination of HV Arboreal Habitat as either category 1 old-growth, or category 2 or 3 or 4, or not HV Arboreal Habitat.
- Review surrounding areas of mapped HV Arboreal Habitats with rapid site survey data to check for potential HV Arboreal Habitats missed during mapping.
- Where access or time constraints did not resolve the original determination of mapped categories, the reliability remained coded as 'Field Check'.

b) Provide final topology layer of HV Arboreal Habitats, metadata and report.

Final checking for global errors, gross errors, consistency in mapping and other logical checks were made. Data were collated in the table shown in Appendix 4. For details of the lineage of the data please refer to the metadata statement attached as Appendix 5.

2.6 Growth stage and disturbance mapping

The recognition of growth stage and disturbance categories from API is required to be consistent with the reality on the ground. Often environmental and anthropogenic factors confuse or mask interpretation and therefore field verification is required to validate API. This is usually the case in areas of high productive forests with a low intensity land-use management regime or rainforest understorey; or areas of low fertility which are subject to frequent fire.

Complex interpretation scenarios are many and the point-to-plant methodology can assist by determining the growth stage of a forest. However, determining whether 'the effects of unnatural disturbance are now negligible' is a significant consideration when conducting API and field validation of disturbance, to determine whether an area is old-growth forest. This part of the old-growth definition and assessment primarily applies to areas identified as 'older logging' where impacts are considered negligible with time. 'Now negligible' is where past evidence of logging or other anthropogenic disturbances are evident in the form of stumps (>40 cm diameter), unnatural stags, dieback, grazing infrastructure, gaps or clusters in the canopy structure and constructed tracks, however, are not associated with regrowth, native pioneers or weeds and does not affect >50% of a mappable area. Such disturbance evidence must be associated with gaps in the canopy with regrowth or native pioneers or weeds before potential old-growth areas are dismissed. This combination needs to be present for any mapped potential old-growth area to be excluded as old-growth and must affect greater than 50% of the mapped area. The singular presence of stumps, gaps, tracks, grazing infrastructure or native pioneers or weeds is not enough alone to exclude an old-growth determination. Some disturbance evidence can be responses to natural events or in the case of stumps, be an older logging regime of which the impacts are '*now negligible*' or a point source disturbance not affecting the homogeneity of the mapped polygon (effecting <50% of the polygon).

Yellow-Bellied Glider (*Petaurus australis*), Corindi cemetery

3. Results

3.1 Mapping and refinement of HV Arboreal Habitats

An interactive approach was taken to finalise the HV Arboreal Habitats classification using the results of mapping and field validation surveys to inform the classification. During the mapping process, some grouping and splitting of the original classification occurred to better match forest identified during ground-truthing surveys. The four final classifications are shown above in Table 2.

API was conducted over 49,894 hectares of forested freehold lands in the Coffs Harbour LGA. A total 2125 hectares (339 polygons) were initially mapped as HV Arboreal Habitats.

CRAFTI candidate old-growth forests cover just 704 hectares on freehold land in the Coffs Harbour LGA, representing less than 1% of forested freehold lands. Cross-checking of the original mapped HV Arboreal Habitats against candidate old-growth mapping provided another validation option to identify areas for consideration and potential field survey.

One point-to-plant survey was carried out and 149 rapid site surveys were undertaken across the LGA. These surveys resulted in a number of amendments to the mapped HV Arboreal Habitats, including 150 polygons (623 hectares) that did not meet the HV Arboreal Habitats classification. This included three polygons where there was evidence of PNF (i.e. recent or current logging disturbances), and three polygons that were not HV Arboreal Habitats but were classified as ‘high conservation value’ vegetation owing to the noticeable absence of weeds and the intact representation of forest structure and floristic diversity.

Apart from the 150 polygons that were not HV Arboreal Habitats, other areas that were initially mapped as category 1 old-growth were downgraded to category 2 or 3 based on disturbance regimes and presence of >10% regrowth.

After reviewing and refining the map, it can be seen (Table 3) that there are 1502 hectares (189 polygons) of HV Arboreal Habitats in the LGA which represents only 3% of freehold forest. This includes ‘verified’ areas (i.e. those polygons with an initial high mapping reliability and those areas that have been field validated) and ‘potential’ areas (i.e. those areas which still require field validation).

Table 3. High Value Arboreal Habitats in the Coffs Harbour LGA

	HV Arboreal Habitats		'Verified' HVAH		'Potential' HVAH to be verified	
Category	**P'gons**	**Area (ha)**	**P'gons**	**Area (ha)**	**P'gons**	**Area (ha)**
Category 1, old-growth	29	475.86	12	255.94	17	219.92
Category 2 (>10 ha)	25	559.14	12	151.54	13	407.60
Category 3 (5–10 ha)	29	189.52	13	80.93	16	108.59
Category 4 (1–5 ha)	106	277.37	71	179.03	35	98.34
Total	**189**	**1501.89**	**108**	**667.44**	**81**	**834.45**

Notes: HVAH = High Value Arboreal Habitats
P'gons = polygons

Of the 339 polygons initially mapped as HV Arboreal Habitats within the LGA, 108 have been verified as meeting the classification for HV Arboreal Habitats. There are 81 polygons representing 835 hectares which still requiring further field validation, including 220 hectares (17 polygons) mapped as category 1 old-growth.

The difference between the number of polygons initially mapped as HV Arboreal Habitats and those that were verified is expected because the original mapping adopted an inclusive approach to forest structure and delineated areas that exhibited a larger canopy structure in contrast to surrounding areas. This step-wise method of reviewing the HV Arboreal Habitats classification highlighted areas where further field validation would be beneficial to adequately identify the HV Arboreal Habitat status of the LGA.

Turpentine (*Syncarpia glomulifera*), Bruxner Park

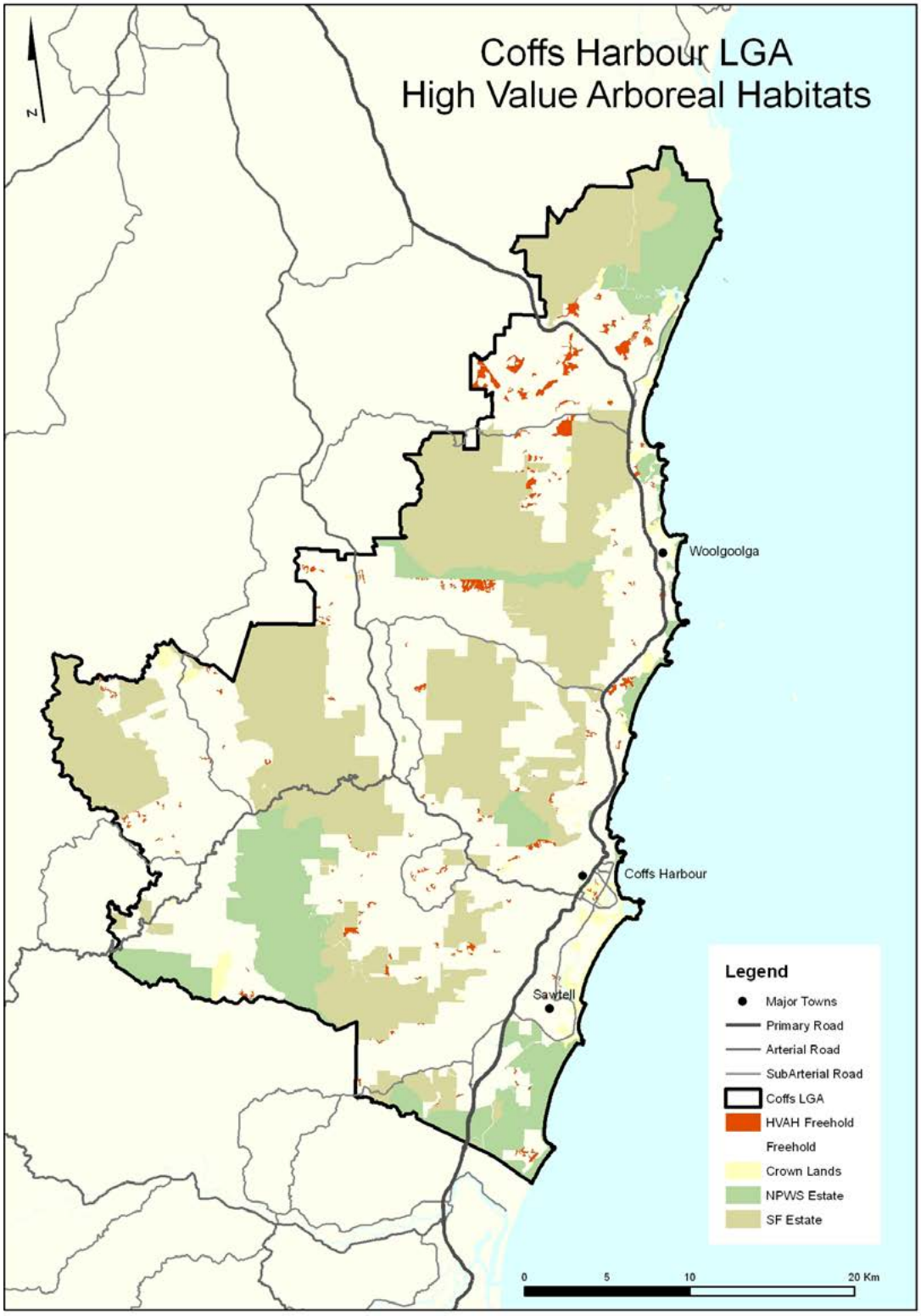


Figure 2. High Value Arboreal Habitats in Coffs Harbour LGA

3.2 Project management and costs

The use of the latest stereo API techniques and hardware, in combination with existing mapping products and field validation, allowed mapping of the study area to be accomplished within a four-month timeframe.

The mapping program consisted of three components:

1. API of 49,894 hectares to map HV Arboreal Habitats (conducted between January and April 2013 — approximately 24 days part time)
2. field validation and subsequent boundary refinement and polygon attribution (from July to August 2013 — approximately 24 days)
3. data analysis, metadata preparation and report compilation (from September to October 2013 — approximately 24 days).

Total costs of the project are summarised in Table 4.

Table 4. Summary of expenditure for this study

Description of activity	Council		OEH
	Cash	In-kind	In-kind
Private property access enquiries		500	
Preparation of specifications and classification	1,000	1,000	
API Mapping	10,000	1,000	
Field Survey	7,000	3,000	7,000
Refinement of API mapping	1,500		
Analysis and interpretation	1,500	1,000	1,000
Report preparation	6,000	2,500	
Total	**27,000**	**9,000**	**8,000**

3.3 Discussion

It is estimated that over half of the original forests of NSW have been cleared and that much of what remains is substantially disturbed or modified by grazing, logging, excessive fires, weeds and dieback (Lunney 1991). Areas of old-growth forest, in particular, have been severely reduced and now represent less than 10% of their original extent (Lunney 1991).

Australian King-parrot (*Alisterus scapularis*) on Blackbutt hollow

The current occurrence of HV Arboreal Habitats in the Coffs Harbour LGA (see Figure 2 above), reflects the land-use history of the region. Most HV Arboreal Habitats persist in the hinterland in steep and remote locations or on low site quality sites.

The final HV Arboreal Habitats map shows the major contributing influences on the contemporary distribution of these habitats to be slope and geology, followed by land-use history. The high fertility, easy accessible coastal areas experience the greatest land-use pressures and therefore the least remaining HV Arboreal Habitats. This is reflected in the low number and size of polygons in the coastal areas. The high fertile forests of the hinterland and Eastern Dorrigo have also had a history of high forestry extraction and therefore exhibit limited extent HV Arboreal Habitats. In areas of steep topographic or infertile geology where logging operations are difficult or uneconomical, HV Arboreal Habitats persist. In the north of the study area on sandstone areas, low site quality forest types are present and therefore, have attracted lower land-use demands. The Corindi Plateau and surrounds are examples of this low intensity land use. The forest types here generally exhibit smaller, less dense tree crowns, lower heights and exist in conditions that accelerate senescence, such as higher fire regimes, lower soil nutrients, shallow soil profiles and experience a lower rainfall pattern. In this area, a larger portion of the LGA's HV Arboreal Habitats have persisted to date.

The loss or depletion across the landscape of old-growth forest, and in particular, hollow-bearing trees has been recognised as a key threat to fauna species diversity (NSW Scientific Committee 2006). In NSW, fauna that are reliant on tree hollows for shelter and nests include at least 46 mammals, 85 birds, 32 reptiles and 16 frogs (Gibbons & Lindenmayer 1997,

2002). Of these species, 45 are listed as threatened on Schedule 1 and Schedule 2 of the *Threatened Species Conservation Act 1995*.

A fine-scale map was produced for the Coffs Harbour LGA to support environmental planning purposes at the 1:3000 scale. 3D imagery analysis was found to be the current best practice for fine-scale HV Arboreal Habitats mapping for the LGA. This was largely due to the remote and inaccessible areas of HV Arboreal Habitats and the high resolution offered by this process. Significant changes in habitat quality occur within short distances requiring numerous small polygons to describe the HV Arboreal Habitat patterns. The ability to map HV Arboreal Habitats at such fine scales allowed this variation to be captured and assessed.

Intensive field sampling effort was required to achieve the desired mapping scale and accuracy for the LGA. This was largely due to the fragmented occurrence of HV Arboreal Habitats across varied landscapes within the study area and the rapid changes in site quality and land-use practices both past and present. Additional field data is required to inform the HV Arboreal Habitats layer, however, a large proportion of the remaining HV Arboreal Habitat areas are found on steep lands over 30 degrees or in low site quality areas, where threats are minimal.

Only 3% of freehold forest in the LGA is HV Arboreal Habitats. As discussed earlier, the land-use history of Coffs Harbour has been varied in both activity and intensity over time. There is a need to regulate present land-use activities to make sure further loss is prevented and recruitment of hollows is guaranteed. Areas of concern include the Corindi Plateau and coastal valleys north of Moonee Beach which are subject to intensive horticulture practices, particularly blueberry production. Significant losses of HV Arboreal Habitats are trending based on native vegetation loss in this area, depicted in aerial photo imagery from 1994 to present. Historically, these low site quality areas were overlooked because quality of the timber resource was inferior compared with the high fertility wet sclerophyll forests further south. More recently, land-use activities have intensified and diversified creating significant new threats to ecological values and in this case, HV Arboreal Habitats in particular, have arisen in these areas.

The planning process for residential release areas is another activity that requires sound reassessment as many of these release areas require the clearing of native vegetation. In some cases, development proposals in ecologically significant areas has resulted in the continued loss and fragmentation of HV Arboreal Habitats and associated ecological impacts such as the depletion of coastal habitats, severing ecological corridors, hampering climate change adaptation possibilities for species, contributing to over-cleared landscapes and elevating the number of threatened species and endangered ecological community nominations and occurrence in the landscape.

Forestry operations are a contemporary contributing factor in the decline of old-growth and other HV Arboreal Habitats. Wormington and Lamb (1999) found that old-growth wet and dry sclerophyll forest of south-east Queensland contained 35 and 37 hollow-bearing trees per hectare respectively. In woodland remnants of northern Victoria that had not been systematically logged, the density of hollow-bearing trees was found to range from 17 to 32 per hectare (Bennett et al. 1994; van der Ree et al 2001; Soderquist et al.1996). The Council's HV Arboreal Habitats study found that even at the low occupancy rate of 5 hollow-bearing trees per hectare, areas of HV Arboreal Habitat categories 2–4 were difficult to locate. Based on the figures from comparable forest types in south-east Queensland, the Coffs Harbour LGA has seen a 70–90% decline in hollow-bearing tree availability. By any measure, this is a drastic loss and one that can be presumed to have had major ecological impacts.

In north-east NSW, forestry operations are required to retain 10 habitat tress and 10 recruitment trees per 2 hectares (Anon 1999b). However, modelling by Ball et al. (1999) and Gibbons (1999) indicated that a long-term reduction in densities of hollow-bearing trees due to post harvest mortality is expected. Ball et al. (1999) and Gibbons (1999) state that over time, this has the potential to reduce the actual numbers of hollow-bearing trees across an actively managed forest landscape to far less than 5 trees per hectare. Gibbons et al. (1999) indicate that for wet sclerophyll forest of south-east Australia, twice this retention rate may be needed to avoid net loss of hollows in the longer term. The large variation in the recommended number of habitat trees conserved per hectare demonstrates a lack of understanding of the optimal level of hollows that are required for sustaining populations of hollow-dependent fauna (McLean 2012).

In north-east NSW, McLean (2012) found that logging significantly reduced a stand's average DBH, and the density of hollows and hollow-bearing trees in both wet and dry sclerophyll forests. Fire frequency was found to significantly increase the likelihood of basal injury. The abundance of hollow-bearing trees and hollows significantly decreased as a consequence of increasing fire frequency and logging intensity, however, on unlogged sites, the abundance of hollow-bearing trees and hollows increased as a consequence of increased fire frequency. The use of fire to create hollows is not recommended as a blanket management technique as appropriate fire regimes (e.g. intensity and frequency) are specific to forest types and the associated hollow-dependent species which inhabit these forests.

The time taken for small and large hollows to develop in 26 species of eucalypts known from the Coffs Harbour LGA is largely unknown. This lack of tree age data has, and continues to impede landscape management of this critical resource. Hollow formation is slow, with small hollows taking at least 80 years to form (Koch et al. 2008), while larger hollows suitable for

large hollow-dependant species such as forest owls and Greater Gliders may take as long as 220 years to develop (Gibbons & Lindenmayer 2003).

A review of the literature by McLean 2012, demonstrates that many authors believe recruitment of hollow-bearing trees has not kept pace with collapse rates and removal under existing forest management policy and there will be a future shortage of this resource in the years to come. Lindenmayer (2010) has continually reiterated that logging on short term rotations is perpetuated under existing state regional forest agreements despite the listing of loss of hollow-bearing trees as a key threatening process under the New South Wales *Threatened Species Conservation Act 1995* and Commonwealth *Environment Protection and Biodiversity Conservation Act 1999.* Others, including Thompson (2008), believe that there is sufficient data to suggest that several threatened fauna species are at risk of whole-of-landscape collapse as a result of a lack of hollow resources upon which they depend. In NSW, terrestrial vertebrate species that are reliant on tree hollows for shelter and nests include at least 46 mammals, 81 birds, 31 reptiles and 16 frogs (Gibbons & Lindenmayer 1997, 2003). Of these species, 40 are listed as threatened on Schedule 1 and Schedule 2 of the Threatened Species Conservation Act.

Consequently, this study indicates that the hollow resource and remaining areas of HV Arboreal Habitats, needs to be carefully managed in Coffs Harbour. McLean's 2012 results are consistent with other studies that show that logging is likely to cause a net decline in hollow abundance (e.g. Gibbons et al. 2000b; Eyre et al. 2010). McLean also found that the effects of logging intensity on basal area and DBH are consistent with the assumption that logging removes large trees (i.e. likely to be hollow-bearing if DBH >80 cm in wet sclerophyll forest and DBH >50 cm in dry sclerophyll forest, depending on fire frequency). This has important implications for forestry and hollow-bearing paddock tree and recruitment tree management in Coffs Harbour and the rest of north-east New South Wales.

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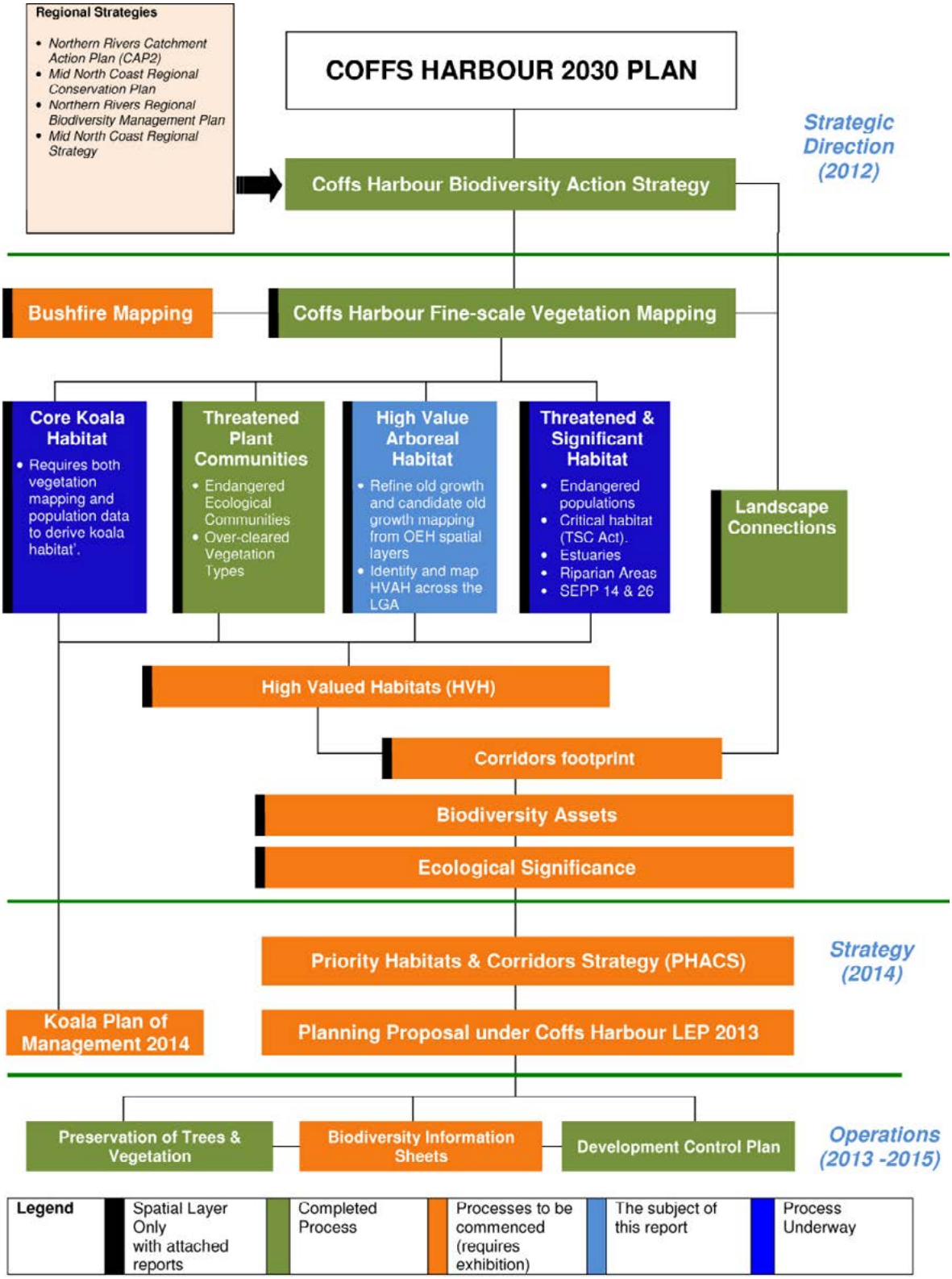
Appendix 1

Figure A5.1 from Coffs Harbour Biodiversity Action Strategy (2012)



Appendix 2

Coding specifications for HV Arboreal Habitats mapping

Mapping area and scale	
Reference scale for review of potential HV Arboreal Habitat areas	1:3000
Minimum area for category 1 old-growth category attribution	5 ha
Mapping scale for HV Arboreal Habitat areas	1:2000
Minimum area for HV Arboreal Habitats categories 2–4 attribution	1 ha
Structural composition of HV Arboreal Habitat category 1 old-growth	
Presence of regrowth	<10%
Presence of senescent trees	>10%
Eucalypt crown cover percentage	>20%
Continuous forest cover	>5 ha
Acceptable disturbance characteristics of HV Arboreal Habitat category 1 old-growth: 'negligible' disturbance indicators	
In the absence of associated regrowth clusters, native pioneers, weeds and affected by disturbance indicators as follows:	<50% of the polygon
Collective 'older logging' indicators in the absence of regrowth (stumps >40cm diameter, snig tracks, dumps, canopy gaps, structure clusters and heights). Older logging where disturbance is 'now negligible'	Older logging
Clusters of different tree heights and crown size (dominantly mature and senescent NOT regrowth)	Clusters
Gaps in the canopy with no associated regrowth, native pioneers or weeds	Gaps
Tracks	Tracks
Grazing	Grazing
Structural composition of HV Arboreal Habitats categories 2–4	
Presence of senescent trees	≥5trees/ha
Disturbance characteristics of HV Arboreal Habitats categories 2–4	
(These areas are NOT included in category 1, old-growth forest due to disturbance or area. However, are delineated as HV Arboreal Habitat categories 2–4 based on presence of ≥5 senescent trees/ha and area	
Native vegetation with significant disturbance (i.e. observed to be affecting >50% of the area of the polygon)	
Category 2	>10 hectares
Category 3	5–10 hectares
Category 4	1–5 hectares

Appendix 3

Previous old-growth mapping and surveys in the study area

See the Reference section for full publication details.

Description/Method
Aerial photograph interpretation
Resource and Conservation Division 1998. UNE - LNE CRAFTI Accuracy Assessment Report. Prepared by Rennison, B. M., and Squire, R. H. for the Resource and Conservation Division of the Department of Urban Affairs and Planning
Resource and Conservation Division 1999a. Old Growth Forest Related Projects UNE/LNE CRA Regions. NSW Comprehensive Regional Assessments project number NA 28/EH. A report undertaken by the NSW National Parks and Wildlife Service for the NSW CRA/RFA Steering Committee. Forests Taskforce, Department of the Prime Minister and Cabinet, Canberra
New South Wales National Parks and Wildlife Service 2002. Re-derivation of Successional Stages For Upper and Lower North East NSW. Draft report, NPWS Northern Directorate, Coffs Harbour
Private Native Forestry derived Old Growth layer 2007, is a subset layer of CRAFTI 1999 Candidate Old Growth layer, using only the growth stage codes tA and tB. This layer removes areas of regrowth and disturbance that represented 55% of the COG mapped layer containing areas of sA and sB.

Brown Tree Snake (*Boiga irregularis*), Barcoongere Way

Appendix 4

Example of the HVAH Mapping Attribution:

OBJECT ID *	OG_ Present	Older_ Logging	Clusters	Grazing	Gaps	Tracks	HVAH	Relia-bility	Field Pr	HVAH_Pr	Area_ha
1	OG Present	<Null>	Distur-bance	<Null>	Distur-bance	<Null>	<Null>	Field Check	1	Old-growth	9.868855
2	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	Present	Is HVAH	4	1 - 5 Ha	2.641287
5	<Null>	<Null>	<Null>	<Null>	Distur-bance	<Null>	Present	Field Check	4	1 - 5 Ha	2.017416
6	OG Present	Distur-bance	<Null>	<Null>	Distur-bance	<Null>	<Null>	Field Check	1	Old Growth	9.661284
9	OG Present	<Null>	Distur-bance	<Null>	Distur-bance	<Null>	<Null>	Field Check	1	Old-growth	11.75143
16	OG Present	Distur-bance	Distur-bance	<Null>	Distur-bance	<Null>	<Null>	Field Check	1	Old-growth	5.500142
19	<Null>	<Null>	Distur-bance	<Null>	Distur-bance	<Null>	Present	Is HVAH	3	5 - 10 Ha	5.023482

Stag of Smooth-Barked Apple (*Angophora costata*), Old Bucca Road

Appendix 5

METADATA STATEMENT

High Value Arboreal Habitats Mapping of the Coffs Harbour Local Government Area (ver 1.1)

Abstract: This dataset represents fine-scale High Value Arboreal Habitats Mapping within the Coffs Harbour Local Government Area. Forest structure and disturbance has been categorized into HVAH priorities for conservation. Mapping was conducted by a vegetation mapping 'expert' (NSW Department of Environment and Heritage) between July and October 2013, and was based on 3-D PLANAR modelling, aerial photography interpretation, field growth stage and disturbance assessment. A nominal scale of use of 1:3000 is recommended for dataset display and interpretation, as linework digitising was based on ADS40 (50cm resolution) and minimum polygon size of 1.0 ha and was captured at screen scale range between 1:2000 and 1:4000. The map is not to be used at a property level scale or for development applications where a scale of 1:3000 or greater may be required to determine the level variation of vegetation within a property. Furthermore, DAs still need to undergo the rigour of planning laws in NSW including local assessment of impacts on flora and fauna. Overall thematic accuracy range of 58-76% (interpreter assessment). The dataset is to be considered a standalone layer.

1.1 ISO-19139 Metadata:

1.2 Metadata Information:

Metadata language: eng

Metadata character set: utf8

Last update: 2013-10-02

Metadata constraints:

Security constraints:

Classification:

Classification system: Security classification not determined

Metadata contact - pointOfContact:

Individual's name: Mark Fisher

Organization's name: NSW Department of Environment and Heritage, Native Vegetation Information, Science Division

Contact's position: Land Assessment Officer

Contact information:

Phone:

Address:

Delivery point:

Country: Australia

Scope of the data described by the metadata: dataset

Scope name: dataset

Name of the metadata standard used: ANZLIC Metadata Profile: An Australian/New Zealand Profile of AS/NZS ISO 19115:2005, Geographic information - Metadata

Version of the metadata standard: 1.1

Metadata identifier: BFC9E3A2-791E-4F17-B08C-9D5E3D251A23

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1.3 Resource Identification Information:

Citation:

Title: High Value Arboreal Habitats Mapping of the Coffs Harbour Local Government Area (ver 1.1)

Alternate titles: 3-D Digital Interpretated High Value Arboreal Habitats Mapping of the Coffs Harbour Local Government Area, 3-D Digital Interpretated High Value Arboreal Habitat Mapping, Coffs Harbour, Coffs Harbour City Council High Value Arboreal Habitat Mapping Map - 2013,

Reference date - creation: 2013-10

Other citation details: NSW Office of Environment and Heritage (2013). Development of a Fine-Scale High Value Arboreal Habitat Map for the Coffs Harbour Local Government Area. Volume 1: Project Report. Office of Environment and Heritage, Coffs Harbour NSW Australia; High Value Arboreal Habitat Mapping Project for Coffs Harbour Local Government Area. Prepared for Coffs Harbour City Council.

Themes or categories of the resource: biota, environment, boundaries

Theme keywords:

Keywords: Biosphere | Vegetation | Canopy Characteristics, Biosphere | Vegetation | Forest Composition/structure

Citation:

Title: GCMD Science Keywords 5.3.8

Reference date - revision: 2006-01-01

Edition: 5.3.8

Edition date: 2012-05-17T21:34:56

Other citation details: Olsen, L.M., G. Major, K. Shein, J. Scialdone, R. Vogel, S. Leicester, H. Weir, S. Ritz, T. Stevens, M. Meaux, C.Solomon, R. Bilodeau, M. Holland, T. Northcutt, R. A. Restrepo, 2007 .NASA/Global Change Master Directory (GCMD) Earth Science Keywords.

Party responsible for the resource - custodian:

Organization's name: National Aeronautics and Space Administration (NASA)

Abstract:

This dataset represents fine-scale High Value Arboreal Habitat Mapping within the Coffs Harbour Local Government Area. Forest structure and disturbance has been categorized into HVAH priorities for conservation. Mapping was conducted by a vegetation mapping 'expert' (NSW Department of

Environment and Heritage) between July and October 2013, and was based on 3-D PLANAR modelling, aerial photography interpretation, field growth stage and disturbance assessment.

A nominal scale of use of 1:3000 is recommended for dataset display and interpretation, as linework digitising was based on ADS40 (50cm resolution) and minimum polygon size of 1.0 ha and was captured at screen scale range between 1:2000 and 1:4000.

The map is not to be used at a property level scale or for development applications where a scale of 1:3000 or greater may be required to determine the level variation of vegetation within a property. Furthermore, DAs still need to undergo the rigour of planning laws in NSW including local assessment of impacts on flora and fauna.

Overall thematic accuracy range of 58-76% (interpreter assessment)

The dataset is to be considered a standalone layer.

Purpose:

The dataset was primarily designed to identify HVAH, for display and interpretation at scales less than, or equal to, 1:3,000. Forest areas with regrowth greater than 10% and senescent trees less than 10%, have not been mapped. Disturbance has been recorded and category levels of HVAH have been attributed. Mapped areas that have not been field validated remain identified for Field Check. Users are reminded that the layer represents a model, and should only be regarded as an interpretation or prediction of real-world phenomena.

Dataset language: eng

Dataset character set: utf8

Status: completed

Maintenance:

Update frequency: unknown

Resource constraints:

Security constraints:

Classification:

Classification system: Security classification not determined

Resource constraints:

Legal constraints:

Access constraints: copyright

Resource constraints:

Legal constraints:

Access constraints: license

Resource constraints:

Legal constraints:

Access constraints: intellectual Property Rights

Resource constraints:

Legal constraints:

Use constraints:

Spatial representation type: vector

Format:

Format name: *.xml

Format version: Unknown

Spatial resolution:

Dataset's scale:

Scale denominator: 3000

Extent:

Geographic extent:

Bounding rectangle:

West longitude: 152.795444008

East longitude: 153.262029989

North latitude: -29.897385152

South latitude: -30.448434252

Extent:

Temporal extent:

Beginning date: 2013-07

Ending date: 2013-10

Credits:

Cotsell, Nigel
Black, Jeremy
Mark Cameron
Karen Caves
John Turbill
Anni Blaxland
Andrew Steed
Di Brown

Point of contact – Point Of Contact:

Individual's name: John Spry

Organization's name: Coffs Harbour City Council

Contact's position: Team Leader- GIS

Contact information:

Phone:

Voice:

Fax:

Address:

Delivery point:

City:

Administrative area:

Postal code:

Country: Australia

e-mail address:

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1.4 Data Quality - Description 1:

Scope of quality information:

Level of the data: dataset

dataset

Lineage:

Lineage statement:

LINEAGE
Source data for this layer has two components, the structure and disturbance field based site data and the other being high resolution aerial photography.

SITE DATA. 149 rapid data sites were funded by Coffs Council to inform the mapping. The rapid sites collected data on structure and disturbance at each site.

AERIAL PHOTOGRAPHY. The NSW Land and Property Management Authority (LPMA) captures airborne ADS40 4-band digital imagery at 50cm resolution for most of NSW. The Coffs Harbour (Sep 09), Dorrigo (Sep 09) and Bare Pt (June 10) 1:100k ADS40 tiles covered the Coffs LGA. Two levels of imagery were utilised for the project, the 4-band 2-dimensional orthorectified images and the Level 1 Rectified stereo image pair strips. The Level 1 data was used for 3-dimensional mapping in a GIS stereo environment. Significant spatial errors up to +- 30 metres between Level 1 and the orthorectified data were discovered.

MAPPING PROCESS. Mapping was conducted by API expert in a stereo view workstation comprising of PLANAR monitors, ESRI ArcMap software and ERDAS Stereo Analyst software. The environment allows the direct delineation and attribution of polygons in 3-D stereo view (Level 1 imagery) whilst simultaneously having a 2D context view and any number of additional datasets to guide mapping decisions. Forest areas with regrowth greater than 10% and senescent trees less than 10%, have not been mapped. Disturbance has been recorded and category levels of HVAH (P1-4) have been attributed. Areas that have not been field validated remain identified for field check. Users are reminded that the layer represents a model, and should only be regarded as an interpretation or prediction of real-world phenomena. The interpreter routinely collected field check points with GPS to help extrapolate across areas of difficult interpretability. A total of 149 API points were collected for the project but points were constrained to private access approval, publicly accessible areas and areas that were visually accessible from public roads or tracks. This fieldwork resulted in 12 OG (HVAH P1) and 96 HVAH P2-4 areas validated, 150 polygons as neither and 81 areas remain attributed for field check. A total of 339 polygons were delineated. The mapping was conducted at

on screen at a range of scales but the final reference scale is deemed to be 1:3000. Linework was digitised using live streaming with a stream tolerance average of 5 metres ie a vertex every 5 metres.

The study area was divided into grid cells for stereo mapping to keep track of progress across the landscape. The first mapping layer was assessed against CRAFTI COG (2001) successional stage mapping of old-growth for the UNE, to verify and or capture missing data as a remote sensing validation process. The layer was then examined against field data and reviewed for line and attribute amendments. A final quality review of the map was conducted by examining each polygon in isolation and reviewing it for errors and attribution anomalies. Polygons that could not be field validated due to access, remote location, steep topography, time and budget constraints, were assessed to the best of the interpreter's ability. Where a final attribution could not be made, the final attribution remained as 'Field Check'. All data stored and edited within ESRI File Geo-database format.

ACCURACY ASSESSMENT
In this study, basic accuracy assessment was pursued in two ways:
1) The current mapping was compared to CRAFTI COG 2001, and
2) Field validation of as many mapped areas as access and time allowed.

The data set has a current accuracy range of 58-76% derived from a total of 339 polygons mapped and all but 81 polygons attributed (to be field checked). A total of 258 polygons have been assessed of which 149 field validated, labels were compared to field plots to determine if the polygon label should be amended and the remainder extrapolated from field sites close by.

To improve the map product, the remaining polygons to be attributed could be field validated on a category basis, starting with HVAH P1-OG and HVAH P2 areas greater than 10 Ha. It is acknowledged that extrapolated polygon attributes could be found incorrect under field validation, however, the interpreter did not attribute a polygon unless a degree of confidence was met, otherwise the polygon remained as 'Field Check'. It is also acknowledged that senescent trees are difficult to identify in some circumstances and therefore areas of HVAH may have been over looked.

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1.5 Data Quality - Description 1:

Scope of quality information:

Level of the data: dataset

dataset

Data quality report - Topological consistency:

Date of the test: 2013-09-24T00:00:00

Conformance test results:

Test passed: true

Meaning of the result: Geometry Topology: Topology validation was performed with a tolerance of 0.2 metres and all subsequent gaps and overlapping polygons fixed. Topology is correct. Geo-database XY tolerance set at 0.2 metres and the resolution set at 0.1 metres. Record Duplication: Not Assessed Topological Relationship to Other Layers: Not applicable

Citation:

Title: ESRI ArcMap Topology Validation

Reference date - publication: 2013-09-25

Edition:

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1.6 Data Quality - Description 1:

Scope of quality information:

Level of the data: dataset

dataset

Data quality report - Completeness omission:

Date of the test: 2013-09-23T00:00:00

Conformance test results:

Test passed: true

Meaning of the result: Coverage - Is complete for study area, no omisions known. Classification - Complete with reagrds to referred attribution system, no omissions known Verification - Remote sensing interpretation covered all study area, no omisions. Field validation covered approx 50% of mapped areas.

Citation:

Title: Project Specifications

Reference date - publication: 2013-10-15

Edition:

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1.7 Data Quality - Description 1:

Scope of quality information:

Level of the data: dataset

dataset

Data quality report - Completeness commission:

Date of the test: 2013-09-23T00:00:00

Conformance test results:

Test passed: true

Meaning of the result: Coverage - Is complete for study area Classification - Complete with regards to referred attribution system Verification - Remote sensing interpretation covered all study area. Field validation covered approx 50% of mapped areas.

Citation:

Title: Project Specifications

Reference date - publication: 2013-10-15

Edition:

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1.8 Data Quality - Description 1:

Scope of quality information:

Level of the data: dataset

dataset

Data quality report - Non quantitative attribute accuracy:

Date of the test: 2013-09-22T00:00:00

Conformance test results:

Test passed: true

Meaning of the result: Two main aspects of arboreal habitat value were captured as structure and disturbance into categories for conservation as HVAH P1-OG, HVAH P2 >10Ha, HVAH P3 5-10Ha, HVAH P4 1-5Ha. HVAH attribution is based on measurable forest structure and disturbance characteristics and considered to be an accurate reflection of potential arboreal habitat. HVAH P2-4 attribution is based upon number of hollow bearing trees per hectare and captured in 3 levels of intensity. Again, a measurable reflection of real forest characteristics but as a measure of habitat value, hollow trees are only one aspect of habitat value. It is an accurate attribute measure but not comprehensive in terms of total habitat attributes.

Citation:

Title: Field Validation & CRAFTI 1999 Old Growth Mapping Specifications

Reference date - publication: 2013-09-30

Edition:

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1.9 Distribution Information:

Distributor:

Distributor information - distributor:

Individual's name: Council GIS

Organization's name: Coffs Harbour City Council

Contact's position: Team Leader - GIS

Contact information:

Phone:

Voice: 66484000

Fax: 66484199

Address:

Delivery point:

City: Coffs harbour

Administrative area: NSW

Postal code: 2450

Country: Australia

e-mail address:

Ordering process:

Terms and fees: Where this dataset is provided, without charge, to non-employees of Council under service engagement, Spatial Data Licence Agreements apply. Spatial Data Licence Agreements are issued by Council, prior to data distribution, access and use, and define the terms of data usage, on-distribution and disposal. Distribution of this spatial dataset otherwise is to be determined by Council, and is subject to the current Coffs Harbour City Council Fees and Charges policy.

Date of availability: 2013-11-30T16:21:05

Turnaround time: Requests for spatial data and related quotations should be made, by phone or in writing (email or letter), to Coffs Harbour City Council's Geographic Information Systems section. E: gis@chcc.nsw.gov.au P: (02) 6648 4000 Coffs Harbour City Council Attn: Team Leader – GIS Locked Bag 155 COFFS HARBOUR NSW 2450

Instructions:

Coffs Harbour City Council endeavours to supply spatial data within 15 business days of confirmation of quotation. Where Spatial Data Licence Agreements, data extractions, manipulations or file conversions are required, additional turnaround timeframes may apply.

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