Kempsey to Eungai Upgrading the Pacific Highway

Environmental Assessment Technical Report 2

Supplementary Ecological Assessment

April, 2007

Roads and Traffic Authority of NSW

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NCSI Certified Quality System ISO 9001

2116519A/PR_5653

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Date:	.....5 April 2007
Distribution:	..... PB File, RTA

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1. Introduction

This report presents information regarding biodiversity in relation to the proposed Kempsey to Eungai Pacific Highway Upgrade (the proposed Upgrade). This information is supplementary to that presented in the *Project Application Supporting Information - Biodiversity Assessment* (Parsons Brinckerhoff 2006) and was requested as part of the Director-General's (department of Planning) requirements for the Environmental Assessment.

Detailed biodiversity assessments for the proposed Upgrade have been undertaken throughout the route evaluation and selection phase (2001-2004), as well as during the environmental assessment and concept design phase (2004-2007) of the project. The stage one terrestrial ecology and aquatic ecology studies undertaken during the route evaluation and selection phase (Brown & Bali 2003; The Ecology Lab 2003) provided the basis for the subsequent environmental assessment - *Project Application Supporting Information - Biodiversity Assessment* (Parsons Brinckerhoff 2006). Both phases included extensive desktop based assessment and comprehensive field survey.

Desktop studies on terrestrial ecology included a thorough literature and database review as well as aerial photographic interpretation. Fieldwork included a full range of in-depth studies such as vegetation traverses, quadrat surveys, habitat mapping, visual assessment of the conditions of terrestrial fauna habitat, and a detailed terrestrial vertebrate fauna survey. The aquatic ecology study involved a review of existing information about the estuarine and freshwater environment of the area, including habitats, biota and the influence of human activities. This information was combined with fieldwork in the study area to assist in assessing the potential impacts of the proposed Upgrade. A full description of these studies and the outcomes can be found in the *Project Application Supporting Information - Biodiversity Assessment* (Parsons Brinckerhoff 2006).

1.1 Supplementary information

Following on from the earlier work, supplementary studies and assessment were requested on the following topics:

- landscape assessment
- further survey and assessment for Yellow-bellied Gliders
- mitigation measures for Green-thighed Frogs
- a translocation assessment for *Maundia triglochinoides*
- significance assessments for the threatened species, population and communities likely to be affected by the proposed Upgrade.

Each of these factors is considered separately in the following chapters.

2. Landscape context

2.1 Methods

The landscape context is the condition and nature of vegetation and habitats surrounding the study area. Many processes in a patch of vegetation are linked to processes in the surrounding landscape (Lindenmayer & Burgman 2005). The quality (including the long-term survival) of vegetation is dependent on a suite of factors that influence the patch or stand, including its position in the vegetated landscape (Todd 2003).

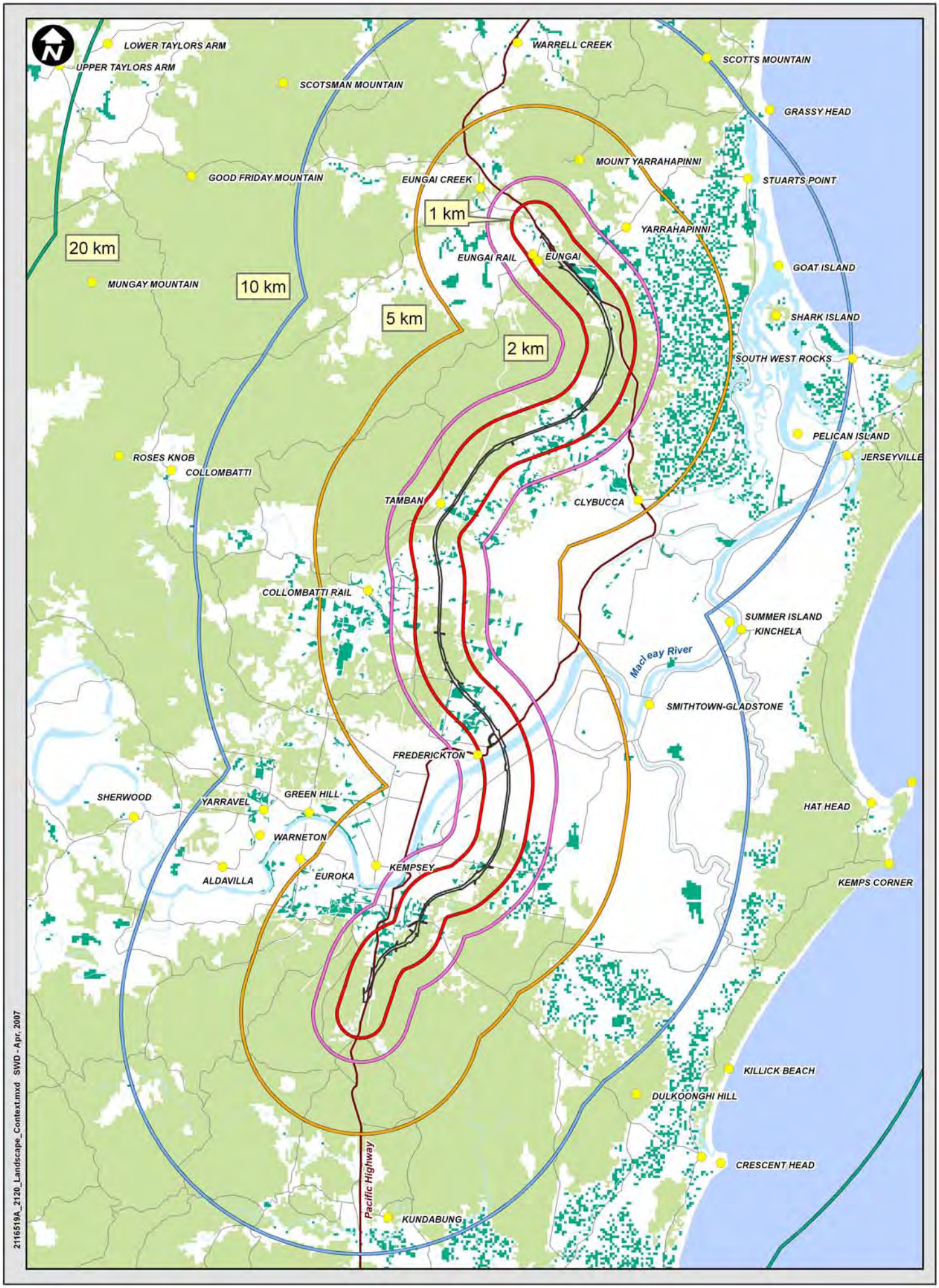
The assessment of landscape context was both qualitative and quantitative. The qualitative assessment included inspection of the following information within both the study area and the surrounding landscape, defined as 20 km from the Proposal centre-line:

- aerial photographs
- Mitchell Landscapes (NSW National Parks and Wildlife Service 2002)
- key habitats[1] and corridors (Scotts 2001, 2003; Scotts et al. 2000)
- vegetation mapping of the local area (Parsons Brinckerhoff 2006)
- broad-scale vegetation mapping of the region (National Parks and Wildlife Service 1999).

Vegetation mapping of forest ecosystems used in the landscape assessment was compiled from a combination of local mapping used in the route selection studies (Brown & Bali 2003), the Project Application Report (Parsons Brinckerhoff 2006) and broad-scale forest ecosystem mapping for the region (National Parks and Wildlife Service 1999) (Figure 2-1). Using the combined vegetation mapping, the following quantitative assessment was undertaken using a geographic information system (GIS) (ArcView), following the methods proposed by Parkes et al. (2003). For the purpose of this assessment, a patch was defined as an area (remnant) of native vegetation with a defined physical boundary occurring in fragmented landscapes. A patch may occur across one or more land tenures and consist of one or more vegetation types. The following were assessed:

- **patch size**: The size of remnant vegetation patches within the proposed construction footprint and within the wider landscape (defined in this case as a distance of 20 km from the proposed Upgrade construction footprint) was measured. For this assessment, any patch intersecting the area of interest was included and measured.
- **neighbourhood**: The degree to which remnant vegetation is connected to other areas of native vegetation is likely to influence the regenerative capacity of the site and therefore its long-term viability (Cunningham 2000). The amount of cover within a locality can also strongly influence the species that occur in the landscape (Reid 2000). The proportion of native vegetation within a set distance of the construction footprint was measured: Distances were 100 m, 1 km, 2 km and 5 km from the footprint.

[1] Key habitats as defined by Scotts (2001,2003) differs significantly from that used by the Roads and Traffic Authority in their Compensatory Habitat Policy and Guidelines (2001). Both terms are used in this document.



Vegetation Patches

< 50.0 ha >= 50.0 ha Construction boundary

0 2 4 km

Scale: 1:200,000 at A4

Figure 2-1 Vegetation patches within the landscape

- **distance to core area**: For the purposes of this assessment, a 'core area' was defined as a patch of native vegetation greater than 50 ha. For each remnant intersecting the proposed Upgrade construction footprint, the shortest distance to the edge of a 'core area' was measured.

2.2 Results

Details of the qualitative assessment of the landscape context were presented in Section 3 of the Project Application Report Supporting Information Ecological Assessment (Parsons Brinckerhoff 2006). The following presents a quantitative analysis of the landscape context of the project including patch size, neighbourhood and distance to core. These data provide information on how plants and animals may function and survive in the broader landscape, the change of connectivity between populations and the likely impacts of construction of the road on these factors.

2.2.1 Patch sizes

The size of a remnant patch of vegetation can play an important role in its long-term viability (Gilfedder & Kirkpatrick 1998; Lonsdale 1999; Parkes et al. 2003), with larger patches generally having a better prognosis for long-term survival than smaller remnants more susceptible to disturbances (Drayton & Primack 1996; Renjifo 1999). A number of factors are thought to contribute to this, including:

- 'edge effects', both biotic and abiotic (i.e. the ratio of patch perimeter to patch interior area is higher in fragmented landscapes (Saunders et al. 1991))
- species-area relationships (i.e. large areas tend to support more species than smaller ones (Burbidge et al. 1997))
- the size of resident populations, which decreases with decreasing patch size (Zanette et al. 2000)
- larger areas are more likely to retain refuges for susceptible species in or after disturbances, such as fires, floods or droughts (Lindenmayer & Burgman 2005).

Over 1,500 patches of vegetation were recorded within 20 km of the proposed Upgrade footprint (Figure 2-2). The majority (87%) of these patches were less than 10 ha in size. However, these patches represent less than 1% of the total area of vegetation. Two patches of vegetation, each greater than 1,000 ha, represent over 97% of the vegetation cover in the 20 km area (Figure 2-1). This suggests that although the proposed Upgrade lies within a fragmented landscape, significant areas of vegetation exist in the general area that will provide important habitat features for a range of biodiversity.

A similar pattern is seen in the 28 vegetation patches that overlap with the proposed construction footprint. Over 50% of the patches are less than 10 ha in size (Figure 2-3), and this contributes to less than 1% of the area of vegetation connected to the footprint. One patch is greater than 10,000 ha and contributes over 97% of the area of vegetation (Figure 2-3).

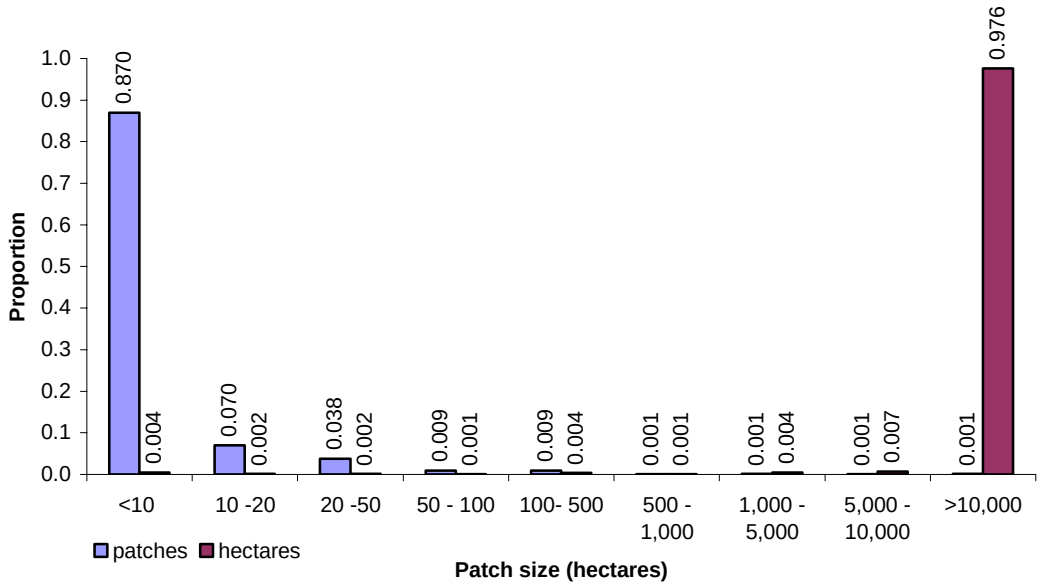


Figure 2-2 Proportion of patches and area across patch sizes within the 20 km buffer

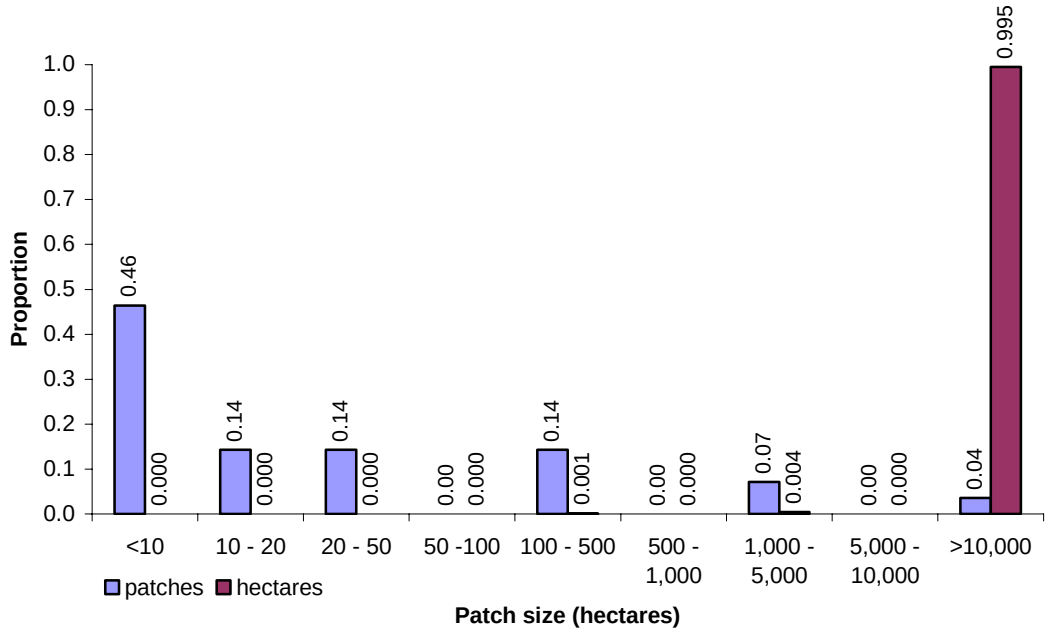


Figure 2-3 Proportion of patches and area across patch sizes within the construction footprint

2.2.2 Neighbourhood

The degree to which remnant vegetation is connected to other areas of native vegetation often influences the regenerative capacity of a site and, therefore, its long-term viability. In the longer term, populations may 'move' across the landscape, taking advantage of short-term changes that provide suitable habitat, at the same time as other local changes decrease their ability to survive at sites of current occupation (Morgan 1998). Their ability to occupy newly-suitable sites is dependent on the ability of individuals, or their propagules, to arrive at the newly-suitable site and, hence, is dependent on the connectivity between sites (Parkes et al. 2003).

Connections through the landscape may be physical linkages, such as with adjacent blocks of vegetation, or more narrow links, such as corridors. Alternatively, connections may not be through physical linkages, but may be due to dispersal of both plants and animals between blocks of native vegetation that are separated from one another (Parkes et al. 2003). A simple measure of the degree of connectivity within a site is the cover of vegetation.

Studies in woodland habitats have shown that woodland species of animal require a certain level of vegetation cover within the landscape. For example, Reid (2000) suggests that declining woodland birds drop out when native cover in the landscape falls below 30%. Similarly, McIntyre et al (2000) suggest a minimum 30% woodland cover is required to maintain ecological sustainability on grazed properties. Bennett and Radford (2004) suggest that there is a sharp decline in the species richness of woodland birds in landscapes with a habitat cover less than 10%. Similar landscape scale studies indicating thresholds have not been done in temperate coastal forests such as those found in the project locality.

At all scales assessed, the forest vegetation cover was approximately 50% (Table 2-1). This is relatively high and suggests that widespread habitats are available at a range of spatial scales in order to maintain viable populations at the local and regional scales for both flora and fauna.

This overall pattern of vegetation cover is mirrored in the three wider Mitchell Landscapes (NSW National Parks and Wildlife Service 2002) across which the proposed Upgrade lies. The three Mitchell landscapes and their degree of clearing are:

- Ingalba Coastal Hills – 44% cleared
- Manning- Macleay Coastal Alluvial Plains – 64% cleared
- Brooms Head – Kempsey Coastal Ramp – 31% cleared.

A landscape that is greater than 70% cleared is considered over cleared (NSW Department of Natural Resources 2005). None of the three landscapes are currently considered to be over cleared and the proposal would not result in any of the landscapes becoming over cleared.

The proposed Upgrade will remove approximately 280 ha of forest/woodland vegetation. At a distance of 100 m this would reduce the existing vegetation cover to approximately 14%, down from 48% (Table 2-1). However, at a distance of 1 km the extent of vegetation cover would only be reduced to 48% from 51% and at 5 km this vegetation cover reduction will not be detectable in terms of the per cent cover of vegetation (Table 2-1). This confirms that the effects of the proposed Upgrade will be greater close to the proposed Upgrade. At relatively short distances from the extent of construction (e.g. 1 km) the effects of reduction of vegetation cover would not be significant.

Table 2-1 Per cent vegetation surrounding the proposed Upgrade

Buffer distance[1]	Area of buffer (ha)	Area of vegetation (ha)	% of buffer	% of buffer following clearing[2]
100 m	820	395	48	14
1 km	8,485	4,343	51	48
2 km	17,592	9,044	51	50
5 km	48,402	24,736	51	51
10 km	110,037	54,587	49	49
20 km	276,549	133,061	48	48

Notes: 1 – buffered based on the proposed construction footprint

2 – based on 280 ha of forest vegetation being cleared.

It should be noted, however, that the proposed Upgrade lies across, and to the edge of, the Macleay River floodplain, which has been disproportionably cleared of vegetation. Although significant tracts of vegetation lie to the west of the proposed Upgrade, these include drier forest types generally not found on the floodplain. This pattern of clearing is reflected in the high proportion of Endangered Ecological Communities found on the floodplain and within the study area.

2.2.3 Distance to core

The survival of a population within a small remnant patch of vegetation may be supported by the nearby location of a larger patch of habitat, through what is known as metapopulation dynamics. A metapopulation is defined as a set of local populations that interact via individuals moving between local populations (Hanski 1999). Within a landscape, larger patches in which larger populations are secure and only rarely become extinct, can act as a source of individuals for smaller patches in which extinctions are regular, thereby maintaining the presence of a species in the smaller patches (Arnold et al. 1993; Hanski 1999; Lindenmayer & Burgman 2005).

Over 60% of patches that overlap with the extent of construction, and therefore would be affected by the proposed Upgrade, were less than 50 m away from core areas of habitat (Figure 2-4), with seven of these patches considered to be core themselves. The largest distance of a patch to a core area was 1.5 km. These data suggest that although some of the patches of vegetation are relatively small, they may have functional connectivity with larger patches in the wider landscape and hence may be able to sustain viable populations, including populations of threatened species.

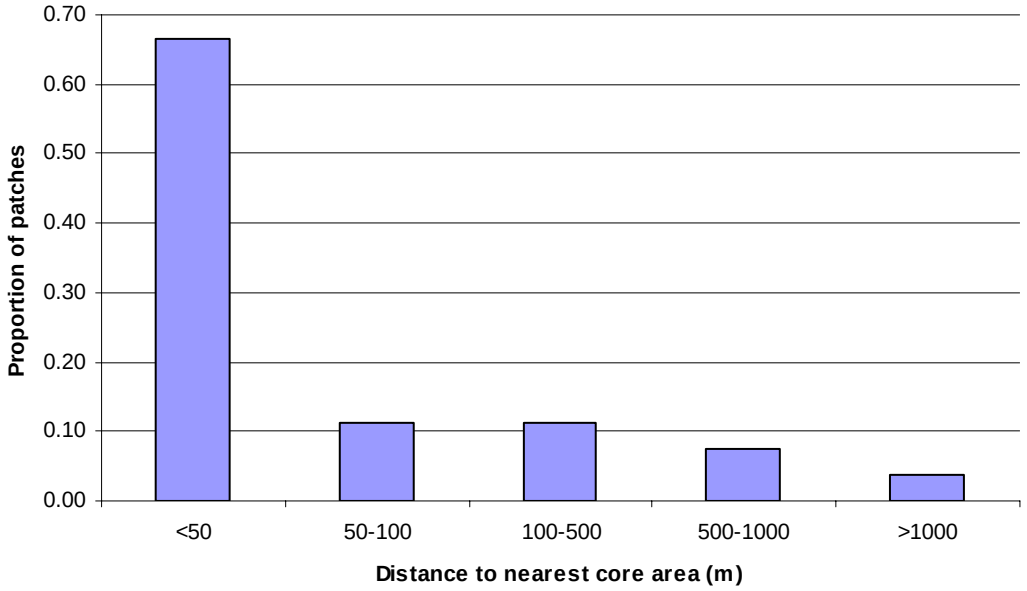


Figure 2-4 Distance to core areas from patches overlapping the extent of construction

2.3 Conclusions

The proposed Upgrade occurs in a modified landscape, but generally the landscape contains a high proportion of remnant vegetation in large patches suitable to maintain significant populations of a range of biodiversity, including threatened species. The proposed Upgrade will remove a significant amount of forest/woodland vegetation, the effects of which will be most likely felt at the local scale. However, at the wider landscape scale the impacts should not be significant. The patches that will be affected include large patches of vegetation that will continue to function as core areas of habitat, along with those that are smaller but are still functionally connected to core areas of habitat.

3. Yellow-bellied Gliders

Yellow-bellied Gliders are listed as vulnerable under the *Threatened Species Conservation Act 1995* and were recorded during earlier surveys of the study area (Parsons Brinckerhoff 2006). During the earlier surveys a single Yellow-bellied Glider was recorded close to the proposed Upgrade alignment near chainage 27,500. A tentative response during the call broadcast in January 2005 was confirmed during autumn surveys in April 2005, with three individuals calling occasionally during call broadcast and spotlight surveys. A small family group was considered likely to reside in the general vicinity, using multiple den trees (Goldingay 1992; Goldingay & Kavanagh 1991). Tree hollow surveys in this area identified several locations where a den site may occur, although precise den sites were not located.

The Director-General's requirements for the Environmental Assessment indicated that further survey should be completed for Yellow-Bellied Gliders in order to determine their extent and habitat use in the area of the earlier sightings and to determine suitable mitigation measures if necessary.

3.1 Methods

Field surveys were undertaken in autumn (19 to 22 March 2007) to coincide with previous observations of Yellow-bellied Glider in this area. Survey was completed by Ben Lewis of Lewis Ecological Surveys and Andrew McMillan of Parsons Brinckerhoff. Reporting was completed by Ben Lewis.

Survey was focussed on an area between chainages 27,000 and 28,500 at the locality of Tamban, where earlier records were obtained. This area is referred to as the study site. This section of the proposed Upgrade was chosen because it was the area where Yellow-bellied Gliders were recorded in earlier surveys.

Surveys were undertaken during a period of stable weather with no rainfall, light winds and little or no moon at a time when Pink Bloodwood (*Corymbia intermedia*) was flowering. In order to identify and subsequently map important resources the following methods were employed:

- hollow-bearing tree survey
- feed tree traverse
- stag watching
- spotlighting
- call broadcast.

A discussion of each technique is provided below.

3.1.1 Tree hollow surveys

Tree hollow surveys were undertaken throughout the study site with the objective of identifying and collecting accurate quantitative data on the distribution and number of potential den tree resources for Yellow-bellied Gliders (and other hollow-dependent fauna). A tree hollow was identified as being at least 2 m above the ground and having an obvious cavity of at least 2 cm in diameter. Once a tree hollow was identified its location

within the tree was noted (i.e. trunk, limb) and its size assigned to one of three classes including small (2-5 cm), medium (6-15 cm) and large (>15 cm). Fissures were also recorded if they appeared to represent suitable fauna habitat (i.e. opening >2 cm) and these were normally identified on decayed stags.

Additional data collected at each hollow bearing tree included tree species, height, diameter at breast height and species suitability normally broken in simple groups including bats, small gliders, large gliders, possums, phascogale, cockatoo and owls. For a hollow bearing tree to be considered suitable den habitat for Yellow-bellied Gliders, tree hollows had to be a suitable distance above the ground (>8 m which represented the lower canopy), be of medium size (6-15 cm) and be located on a more horizontal plane rather than vertical. This later feature tends to offer a greater degree of shelter from the weather.

3.1.2 Feed tree survey

The study site was systematically traversed in its entirety to identify feed trees over a period of 15 hours (30 person hours). During the traverse attention was given to trees that are known sap site trees for Yellow-bellied Gliders (i.e. Bloodwoods, Scribbly Gum and Small-fruited Grey Gum) and these were searched for incisions made by gliders.

3.1.3 Call broadcast

Call broadcast was used at 18 locations to determine the presence of Yellow-bellied Glider or illicit a response from additional individuals to determine group size (Figure 3-1). Typically the call was broadcast for brief periods of 1 to 2 minutes followed by 10 minutes of listening. The objective of this was to enable the field surveyors to collect data on the specific location of gliders without drawing individuals toward the broadcast site. Calls were broadcast through a 10 watt hand held megaphone and a 50 watt spotlight was used to search for target species at the end of the census.

3.1.4 Spotlighting

Spotlight surveys were undertaken by two observers using a 50 watt and 100 watt variable hand held spotlights for intermittent time periods (20 to 40 minutes) throughout the survey. Surveys were undertaken throughout the study site over four consecutive nights and targeted the flowering Pink Bloodwood. Approximately 5 hours (10 person hours) was spent using this technique.

3.1.5 Stag-watch surveys

Stag-watch surveys were used to confirm the presence of Yellow-bellied Glider at a select number of hollow bearing trees. Sites were selected during the tree hollow traverse with surveys commencing at 1915 hours and continuing for a 60 minute period and occasionally longer (up to 2 hours). Fauna were identified using a hand held spotlight and where relevant binoculars (8 x magnification). A total of seven sites representing 10 trees (8% of total resources) were surveyed.

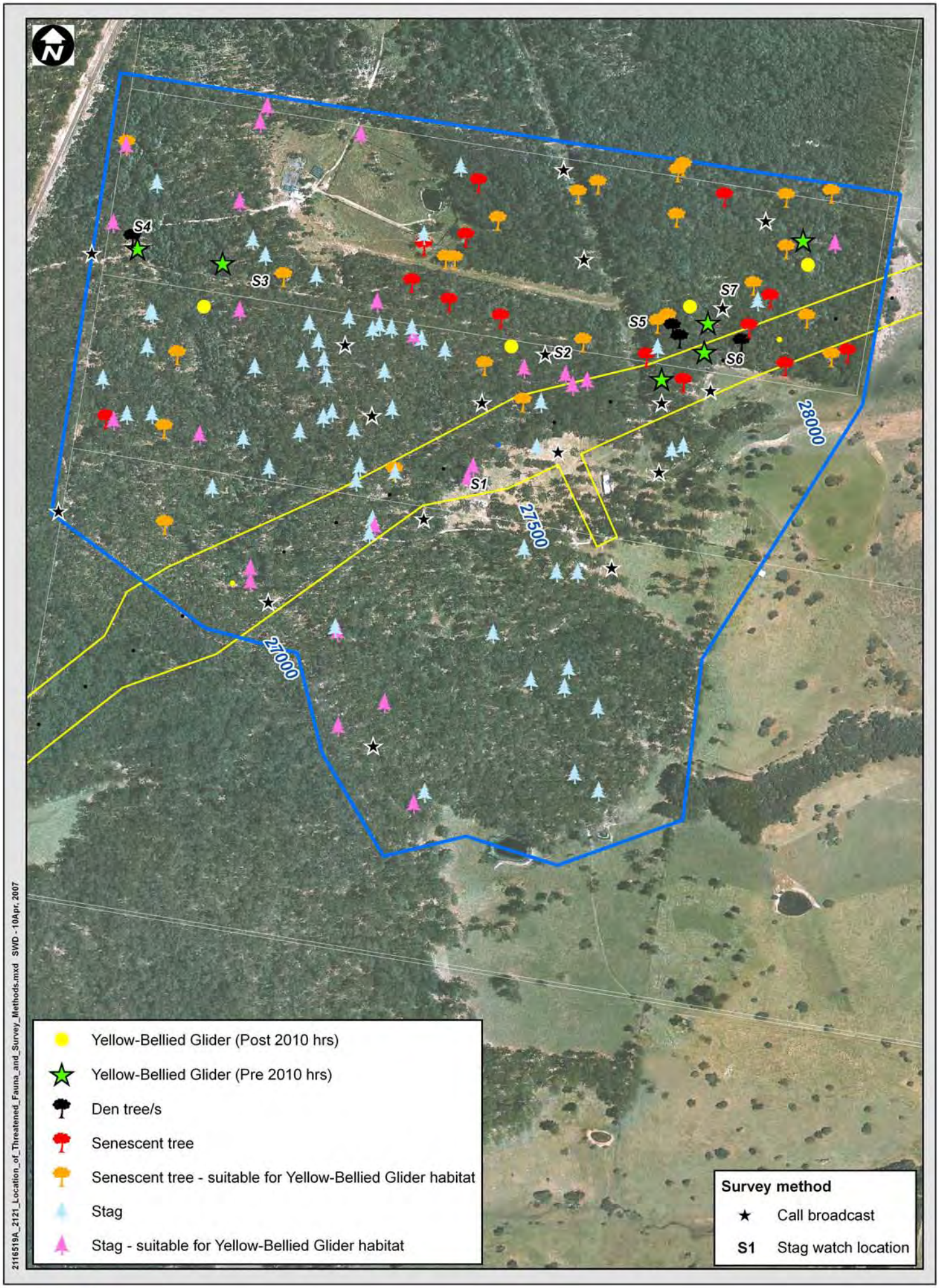


Figure 3-1 Location of threatened fauna and survey methods

3.2 Results

Yellow-bellied Gliders were recorded on each of the four survey nights (Figure 3-1). The stag watch surveys identified two den tree areas (Figure 3-1). The first occurred approximately 500 m west of the proposed Upgrade footprint, whilst the second was centred around a group of trees within and immediately adjacent to the proposed Upgrade footprint at chainage 27,900 (Figure 3-1). A detailed presentation of important life cycle resources is given below.

3.2.1 Tree hollow resources

Tree hollow surveys indicate that at least 125 senescent (later stages of life, dying) trees and stags (standing dead tree) occur within the study site (Figure 3-1). Given the number of hollow dependant fauna known (i.e. Phascogale, Masked Owl) or considered likely to occur in this area, a broad presentation of hollow resources is discussed below followed by a specific section with reference to Yellow-bellied Glider.

Abundance and distribution

At least 125 hollow-bearing trees were recorded during the survey at an average density of 1 hollow-bearing tree per hectare (Figure 3-2). Twenty-one of these occurred within the proposed Upgrade footprint and comprised seven senescent trees and 14 stags over an area of approximately 14 ha. A further 18 hollow-bearing tree resources occurred further to the east of the footprint which covered a forested area of approximately 40 ha, with these likely to become isolated to less mobile fauna including gliders following construction of the road. The remaining 86 hollow-bearing trees occurred to the west of the footprint and comprised 54 stags and 32 senescent trees over an area of approximately 65 ha.

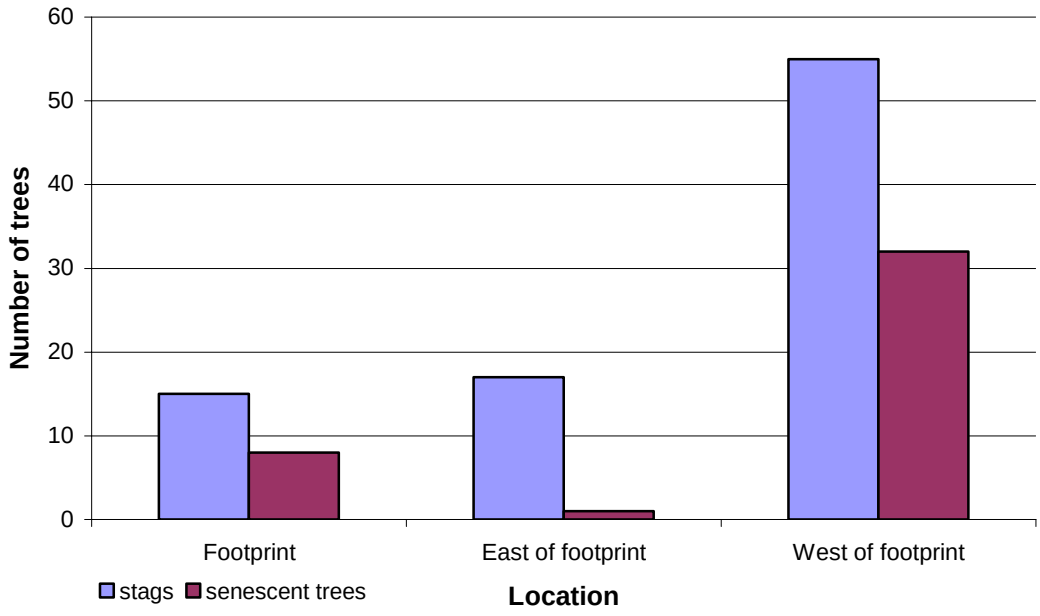


Figure 3-2 Abundance of trees in locations relative to the proposed Upgrade

Hollow-bearing tree type

The majority of the tree hollow resources identified comprised stags (84 of the 125 (67%) trees) (Figure 3-3). The remaining senescent trees comprised Coastal Blackbutt, Pink Bloodwood, Tallowwood and occasionally Scribbly Gum, Forest Red Gum, Swamp Mahogany and White Mahogany.

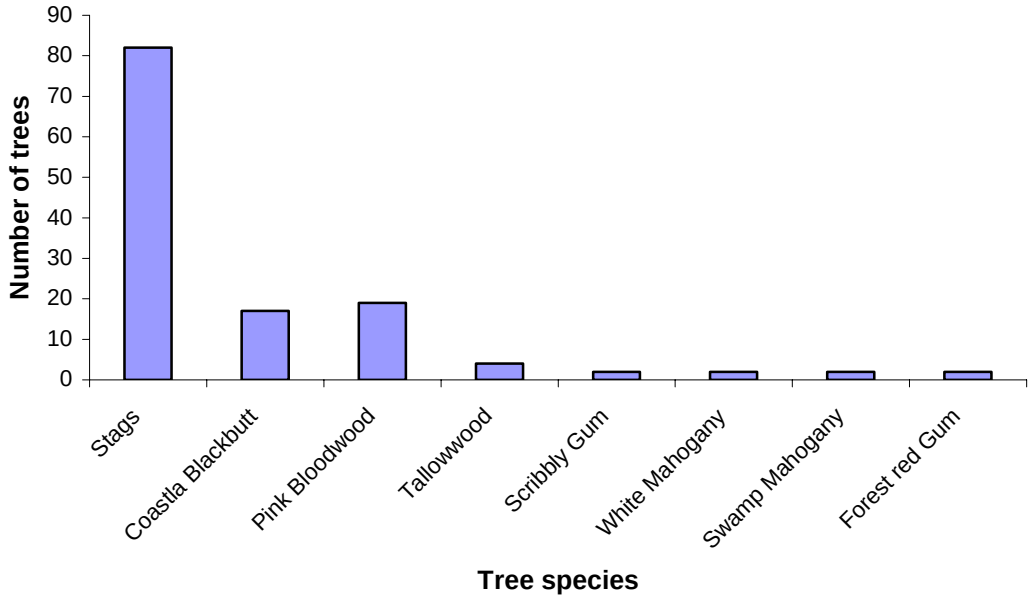


Figure 3-3 Tree species providing hollow resources

Tree hollow features

The most common tree hollow feature were limb hollows which occurred in 119 (95%) of the identified trees and typically were in the small and medium size class (Figure 3-4). The somewhat high number of large limb hollows was partly attributed to the high proportion of stags present in the study site. Trunk cavities of variable sizes were present in 65 (52%) of the identified trees with size ranges being evenly distributed and present in around 30 to 40 trees. Trunk fissures were typically present in weathered stags.

Suitability to fauna

Most tree hollows provided suitable habitat for smaller hollow dependant fauna such as bats (99%) and small gliders (70%) or less specific fauna such as phascogales (87%) (Figure 3-5). The suitability of tree hollows for larger gliders including the Yellow-bellied and Greater Gliders was identified at 53 hollow-bearing trees (42%). For larger fauna 26 hollow-bearing trees provided suitable nest sites for cockatoos including the vulnerable Glossy Black-cockatoo whilst just nine trees (7%) were considered to provide potential nest/roost sites for large forest owls. Hives of the introduced European Bee were identified in nine hollow-bearing trees (7%).

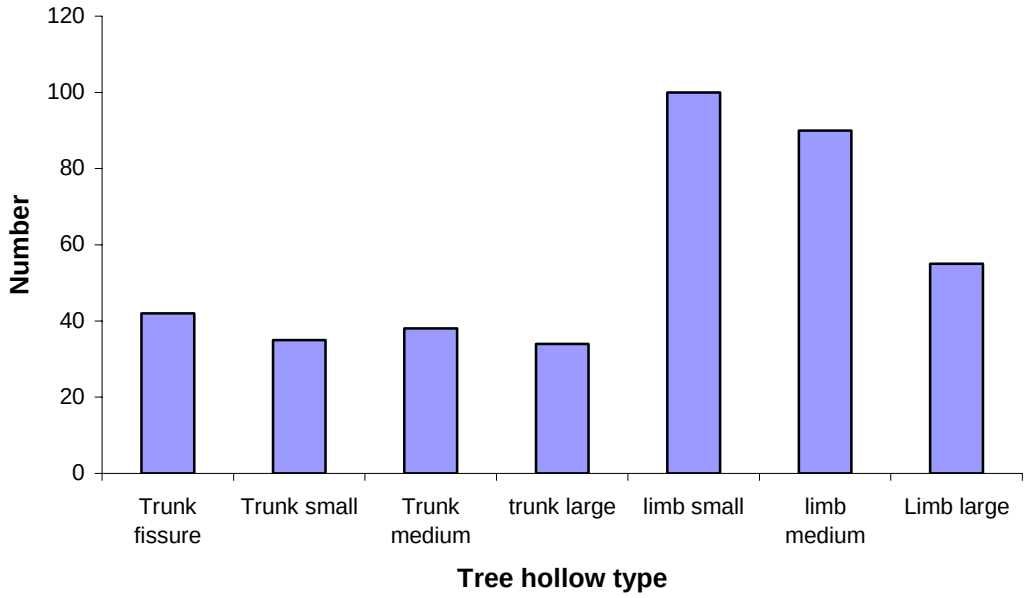


Figure 3-4 Tree hollows recorded in the study site

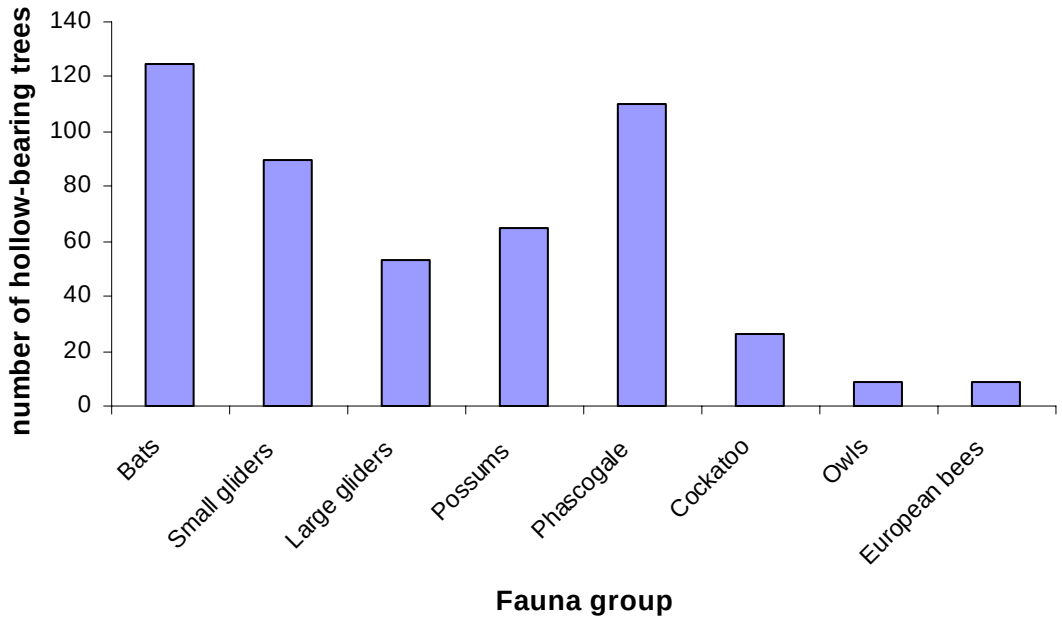


Figure 3-5 Suitability of tree hollows to broad fauna groups

3.2.2 Tree hollows and their suitability for Yellow-bellied Gliders

Fifty-three of the 125 (42%) hollow-bearing trees provided potential den resources to Yellow-bellied Gliders. Twenty-eight of these comprised senescent trees, two of which were confirmed as den trees for this species. The remaining 25 comprised stags, which are known to provide den habitat for Yellow-bellied Gliders in north eastern New South Wales.

The number of tree hollows on the footprint

Twelve hollow-bearing trees known or thought to provide potential den tree habitat to the local Yellow-bellied Glider population occurred on the proposed footprint. They comprise five senescent trees one of which is likely to provide den tree habitat. Three of these five trees were among the largest recorded in the study site and represented emergent trees that exceeded the height of the surrounding canopy. They include two Coastal Blackbutts and one Forest Red Gum. The remaining seven hollow-bearing trees comprised stags at scattered locations.

Tree hollows east of the footprint

Of the five potential den trees recorded east of the proposed Upgrade footprint, one was a senescent tree located in the north east of the study site. The remaining four trees comprised stags located in the south eastern part of the study site.

Tree hollows west of the footprint

Of the 86 hollow bearing trees identified west of the proposed Upgrade footprint, 37 provided potential den tree habitat for Yellow-bellied Gliders, with one of these confirmed during the stag watch surveys. Of these resources, 23 comprised senescent trees of various species including Coastal Blackbutt, Pink Bloodwood, Tallowwood and Scribbly Gum with the remaining 14 being stags in various rates of decay.

3.2.3 Yellow-bellied Glider feed trees

No Yellow-bellied Glider feed trees were recorded during the survey. On several occasions some small chew marks were noted in both Pink Bloodwood and Scribbly Gum but these could not be clearly distinguished from Sugar Glider marks which may also incise small areas. These areas occurred 300 to 400 m west of the proposed Upgrade footprint.

3.3 Discussion

Yellow-bellied Gliders continue to inhabit areas both within the proposed Upgrade footprint and lands further to the west, however there is no evidence to suggest they utilise habitat on the eastern side of the proposed Upgrade footprint. This is consistent with observations made in autumn 2005 and the possible record of a glider call (vocalisation) during the summer survey (Parsons Brinckerhoff 2006). The present survey was able to confirm that at least two gliders occur in the study site, although multiple sightings were made (see Figure 3-1). This is a lower number than previously reported in 2005 when up to three gliders were observed and heard in April (Parsons Brinckerhoff 2006). This lower number probably represents a breeding pair of adult gliders, with no young, or simply additional individuals went undetected as glider groups in northern New South Wales normally comprise between 4 to 6 individuals (Goldingay 1992). It is likely that habitat within the study site forms habitat within a family group home range given that gliders have been confirmed or thought to have been heard on each of the three surveys (January 2005, April 2005, March 2007).

The current survey confirmed den trees occur in the study site, however the absence of feed trees may be explained in three ways; feed trees went undetected, they occur outside the study site or have been removed during more recent clearing and logging events. Despite the area being traversed the canopy in some areas made viewing difficult particularly along drainage lines where mid stratum cover was high.

Based on the results of the current survey it is not recommended that glider poles be erected at this point, as was suggested in the earlier Project Application Report (Parsons Brinckerhoff 2006). However standard mitigation measures such as those included in Section 6 of this report should be followed with a view to reducing the impacts of the proposed Upgrade on this species.

4. Translocation plan for *Maundia triglochinoides*

Maundia triglochinoides is listed as vulnerable under the *Threatened Species Conservation Act 1995*. This species was recorded at two sites within the northern section of the study area, covering an area of approximately 350 square metres (Parsons Brinckerhoff 2006). The proposed Upgrade would fragment the northern site and remove approximately 10% of this population. At the southern site the proposed Upgrade would affect approximately one third of the population.

An ecological assessment for the proposed Upgrade including a significance assessment for impacts on *Maundia triglochinoides* was completed (see Section 7 and Appendix B). This assessment concluded that the proposal would have a significant impact on this species.

The Project Application Report (Parsons Brinckerhoff 2006) suggested that a possible mitigation measure for this species would be translocation of individuals that would be directly affected by the proposed Upgrade.

An assessment of the suitability of this species for translocation has been completed (Appendix A). The assessment concludes that with only 35 known populations of this species remaining, the protection and expansion of these populations is critical to the long-term survival of this species. However, the biology of *Maundia triglochinoides* is not well understood and past attempts at cultivation and translocation have been unsuccessful; as such the success of a translocation program is uncertain. The removal of plants for the proposed Upgrade should be used as an opportunity for further research into the reproduction and propagation of this species and potential translocation techniques. It is recommended that any attempts at translocation focus strongly on experimentation of propagation techniques, monitoring and reporting of the methods and results.

5. Green-thighed Frog breeding ponds

The Green-thighed Frog is listed as vulnerable under Schedule 2 of the *Threatened Species Conservation Act 1995* and was recorded at a number of locations along the footprint of the proposed Upgrade (Parsons Brinckerhoff 2006). The distribution of Green-thighed Frog is relatively continuous in the study area being found from the southern boundary northward to the Barraganyatti area. Metamorphs were observed at sites distributed between Seven Hills Road northward to the vicinity of Hills Road and Kawana Lane. Generally sites used for breeding comprised areas of impeded drainage either natural or augmented through the creation of roads.

The proposed Upgrade will remove habitat for this species, including known breeding habitat (Parsons Brinckerhoff 2006). An assessment of the impacts of the proposed Upgrade on this species (see Section 7 and Appendix B) suggests that the impacts will be significant.

A suggested mitigation measure to account for the loss of potential breeding habitat is the creation of artificial breeding ponds adjacent to the new road. Such breeding ponds have not been constructed or trialled previously, Although such ponds have been suggested on other sections of the Pacific Highway where the species occurs, they have not as yet been constructed or trialled. As such the creation of frog breeding ponds should be considered experimental.

A comprehensive analysis of published records of breeding in this species (Lemckert et al. 2006) has summarised a range of characteristics related to breeding:

- breeding usually takes place in ephemeral ponds (35 of 37 records were in such ponds)
- sites are usually partly or wholly within rainforest or wet sclerophyll forest (26 out of 31 sites)
- artificial water bodies such as flooded road reserves can be used for breeding
- the majority of pools recorded were leaf and shrub filled
- in the field, metamorphlings have been recorded around a pool 40 days after calling was recorded and around a dried pool 39 days after calling. In the laboratory, however, only 50% of tadpoles had metamorphosed by 70 days and 5% had not metamorphosed by 100 days (Lemckert et al. 2006).

A more detailed multifactor analysis of breeding sites is proposed (F. Lemckert, *personal communication*) and the results would be used to inform the design of the frog ponds if these data are available at the detailed design stage of the project.

In areas where known habitat for the Threatened Green-thighed Frog would be disturbed, experimental artificial habitat would be created within the road reserve during construction. This habitat would be designed to mimic, where possible, the natural situation where breeding occurs within areas of impeded drainage close to sites of intact moist native vegetation. Important elements in the design would include ensuring that some flood waters are retained for a suitable period of time in order to allow tadpoles to metamorphosize into adults, while keeping pools relatively predator free. The important characteristic to meet these criteria is that the water remains in the pond for between 40 to 100 days before the pond dries and that the site is located adjacent to moist vegetation.

Wetter vegetation within the study area corresponds generally with the Endangered Ecological Communities found in the local area and sites with these communities provide opportunities for the creation of frog ponds. Ponds should not however be located in Endangered Ecological Communities and their construction should not require clearing of any vegetation. Rather, the ponds should be within cleared areas adjacent to existing moist vegetation. Ponds should be landscaped with a range of native shrubs characteristic of the adjoining vegetation. An important element of these measures will be the implementation of a comprehensive monitoring program that looks at the time of inundation following significant rain and the use of sites by frogs. If necessary the ponds should be modified to increase their effectiveness as breeding ponds.

6. Other mitigation measures

The Project Application Report (Parsons Brinckerhoff 2006) details mitigation measures that would be implemented as part of the proposed Upgrade. Table 6-1 summarises the range of measures that would be implemented.

Table 6-1 Proposed mitigation measures relating to biodiversity

Mitigation measure	Design	Construction	Operation
▪ Refine design and identify ancillary areas in light of biological knowledge and design constrains so as to avoid and minimise impacts to biodiversity.	Y		
▪ Maintain connectivity by providing fauna underpasses at key locations identified in the project Application report (Parsons Brinckerhoff 2006).	Y		
▪ Follow the principles of Fish Friendly Waterway Crossings (Fairfull & Witheridge 2003) for the design and construction of waterway crossings.	Y	Y	
▪ Design and construct artificial frog breeding ponds suitable for the Green-thighed Frog (see Section 5). Discussions should be held with recognised experts regarding current knowledge of breeding requirements in this species. These ponds should be considered experimental and an adaptive monitoring program should be put in place to determine their effectiveness.	Y	Y	Y
▪ Finalise and implement the translocation plan for *Maundia triglochenoides* (see Section 4) in consultation with the Department of Environment and Conservation should translocation be considered a suitable option. The plan should include monitoring the effectiveness of the translocation.	Y	Y	Y
▪ Prepare and implement a flora and fauna management sub-plan as part of the Construction Environmental Management Plan.	Y	Y	Y
▪ Undertake ongoing management and monitoring of weed invasion through a weed management sub-plan as part of the Construction Environmental Management Plan.	Y	Y	Y
▪ Prepare a comprehensive offset strategy and package for the proposed Upgrade in consultation with relevant government authorities (see Section 7).	Y	Y	Y
▪ Provide for ancillary areas in order to minimise the overall impact of the construction and avoid unnecessary vegetation and habitat removal.	Y	Y	

Mitigation measure	Design	Construction	Operation
▪ Pre-clear the disturbance areas, using a trained ecologist, prior to construction activities commencing in order to: ▸ mark the limits of clearing and install temporary fencing in sensitive areas (e.g. Endangered Ecological Communities) to avoid unnecessary vegetation and habitat removal ▸ collect native seed for use in the revegetation of disturbed areas ▸ identify and place transportable habitat features such as large logs and boulders in adjacent retained areas to allow their continuation as potential fauna refuge sites ▸ implement pre-clearing surveys for fauna including, 1. Identifying (by survey) and marking all habitat trees in the area to be cleared. 2. Leaving marked habitat trees and corridors of retained trees linking marked habitat trees with the nearest uncleared (secure) habitat areas standing after initial vegetation clearing for a period of at least 48 hours (to encourage animals to disperse into adjacent uncleared habitat). 3. After the 48 hour waiting period, felling standing habitat trees and corridors, commencing with the most distant trees from secure habitat. 4. Where possible, clearing should be undertaken in the spring to autumn period to facilitate survival of displaced animals. 5. If habitat trees are in short supply (<4 suitable trees per hectare) artificial nest sites (nest boxes) should be installed in adjacent (secure) habitat before clearing.		Y	
▪ Implement 'best practice' stormwater treatment measures to maximise: ▸ onsite pollutant retention and removal ▸ infiltration and sub-surface discharge of stormwater.		Y	Y
▪ Achieve ANZECC Water Quality Guidelines (2000) for all water discharge into streams and creeks.		Y	Y
▪ Replace riparian vegetation disturbed by the project with appropriate endemic species to maintain creek bank stability.		Y	Y
▪ Rehabilitate areas within the road reserve that are not necessary for the operation of the road in a progressive manner as construction proceeds. This should include: ▸ planting of a range of locally occurring and sourced native shrubs, trees and groundcover plants ▸ inclusion of logs, dead trees and stumps in the landscaping works ▸ inclusion of foraging species, such as *Allocasuarina* for Glossy Black-cockatoos ▸ incorporation of existing natural vegetation where possible ▸ maintenance of plantings through a revegetation plan included in the Construction Environmental Management Plan.		Y	Y
▪ Implement an adaptive monitoring program for at least three years post construction, focussing on rehabilitated areas as well as mitigation strategies.		Y	Y

7. Offset strategy

As identified in the Project Application Report Supporting Information (Parsons Brinckerhoff 2006), there is the potential for a number of direct and indirect impacts to occur on biodiversity values as a consequence of the proposed Upgrade. While some of these impacts have either been avoided, minimised through design decisions or can be adequately mitigated or managed, there are some impacts that cannot be adequately mitigated. There are likely to be the following residual impacts:

- a loss and degradation of native vegetation including communities that comprise Endangered Ecological Communities as listed under the *Threatened Species Conservation Act 1995*
- a loss of habitat for a variety of native species including habitat of the threatened Brush-tailed Phascogale, Glossy Black-cockatoo, Green-thighed Frog and *Maundia triglochenoides*.

To address the residual impacts of the proposed Upgrade, the RTA would implement an offset strategy that would contribute to the long term conservation of biodiversity.

An offset is one or more appropriate actions that are put in place to counterbalance specific impacts on biodiversity. Appropriate actions are long-term management activities to improve biodiversity conservation. This can include legal protection of land to ensure security as well as direct management actions (Department of Environment and Conservation 2006).

7.1 Principles and guidelines of offsets

There is no comprehensive government policy for offsets in New South Wales, although the Department of Environment and Conservation has issued principles by which they will negotiate offsets that are not covered by an existing offset program (e.g. under the *Native Vegetation Act 2003*). The principles are:

1. Impacts must be avoided first by using prevention and mitigation measures. Offsets are then used to address remaining impacts.
2. All regulatory requirements must be met.
3. Offsets must never reward ongoing poor performance.
4. Offsets will complement other government programs.
5. Offsets must be underpinned by sound ecological principles.
6. Offsets should aim to result in a net improvement in biodiversity over time.
7. Offsets must be enduring – they must offset the impact of the development for at least the period that the impact occurs.
8. Offsets should be agreed prior to the impact occurring.
9. Offsets must be quantifiable – the impacts and benefits must be reliably estimated.
10. Offsets must be targeted – they must offset impacts on a like-for-like or better basis.
11. Offsets must be located appropriately – they must offset the impact in the same region.
12. Offsets must be supplementary – they must be beyond existing requirements and not already be funded under another scheme.
13. Offsets and their actions must be enforceable – through development consent conditions, licence conditions, conservation agreements or a contract (NSW Department of Environment and Conservation 2007).

The NSW Roads and Traffic Authority has Compensatory Habitat Policy and Guidelines (NSW Roads and Traffic Authority 2001) that state that:

- Compensatory habitat will be employed as a measure to mitigate impacts on *key habitat* areas, where it is assessed as the most ecologically sound, cost effective and practical measure available.
- Compensatory habitat will be provided only where the long-term management by an appropriate land manager is ensured and where the land tenure is secured for the purposes of conservation.
- Any additional ongoing property management requirements resulting from acquisition of compensatory habitat should be dealt with at the time of transfer to the future land manager by way of a present value lump sum payment and not by way of a continued Authority involvement.

7.2 Area of habitat

Table 7-1 presents the vegetation communities likely to be affected by the proposed Upgrade.

Table 7-1 Vegetation communities affected by the proposed Upgrade

Vegetation community	Clearing for road corridor and ancillary areas (ha)[3]	New Edge Effects (ha)[4]	Key habitat[5]
River-flat Eucalypt Forest[1]	8.2	4.7	Yes - Endangered Ecological Community
Swamp Sclerophyll Forest[1]	17.4	10.7	Yes - Endangered Ecological Community
Swamp Oak Floodplain Forest[1]	23.1	14.8	Yes - Endangered Ecological Community
Freshwater wetlands[1]	14.5	9.7	Yes - Endangered Ecological Community
Blackbutt Dry Sclerophyll Forest	157.0	88.8	Yes – Provides habitat for threatened species
Scribbly Gum Dry Sclerophyll Forest	15.4	7.6	Yes – Provides habitat for threatened species
Mahogany Dry Sclerophyll Forest[2]	5.4	2.4	Yes – Provides habitat for threatened species
Stringybark/Ironbark/Bloodwood Dry Sclerophyll Forest	3.8	0.6	Yes – Provides habitat for threatened species
Grey gum/tallowwood Dry Sclerophyll Forest	42.5	18.6	Yes – Provides habitat for threatened species
TOTAL	**287.3**	**157.9**	

Notes: 1 - listed as an Endangered Ecological Community under the *Threatened Species Conservation Act 1995;* 2 - Regionally Significant, less than 15% in conservation reserves; 3 – this figure does not include 6.8 ha of plantation. 4 – Based on a 50 m edge effect and not including areas already affected by edge effects; 5 – as defined under the NSW Roads and Traffic Authority Compensatory Habitat Policy and Guidelines (NSW Roads and Traffic Authority 2001).

All the vegetation likely to be affected is considered key habitat under the Roads and Traffic Authority *Compensatory Habitat Policy and Guidelines* (Table 7-1): Four of the communities are listed as endangered under the *Threatened Species Conservation Act 1995* and all the

communities provide habitat for a range of threatened fauna including the Glossy Black-cockatoo, Brush-tailed Phascogale and Green-thighed Frog.

Based on the current concept design, the proposed Upgrade would have a direct vegetation clearing impact on an area of 287.3. As a result, there would be a direct requirement to provide an area of at least a similar size as compensatory habitat. This area does, however include ancillary areas and the final amount of clearing may be reduced.

In addition to the direct vegetation clearing impact there will be an additional area of 157.9 ha that would be affected by new edge effects (Table 7-1). This is based on edge effects extending 50 m from the edge of the road. A comprehensive review of edge effects and their compensation (Bali 2005) suggests that only 60% of a 50 m strip of edge-affected habitat should apply to all key habitats removed along a new road corridor. This takes account of the fact that edge effects reduce the quality of habitat, but do not completely remove their habitat values.

Applying this principle to the new edge effects for the proposed Upgrade, an additional 94.7 ha of compensatory habitat should be provided. As a result, a total of area of compensatory habitat of approximately 382 ha would be required for the proposed Upgrade based on the current concept design.

The exact amount of habitat clearing will be recalculated following detailed design of the proposed Upgrade. This calculation will take the clearing requirements of the final design footprint and the actual ancillary areas into consideration, along with any recent clearing of vegetation on private properties in the local area.

7.3 Habitat types

The RTA's Compensatory Habitat Policy indicates that the type and quality of habitat to be allocated as compensation should be similar to, or better, than the habitat that is being affected. It also includes a requirement that the compensatory habitat should include as many as possible of the key species, populations or communities that have been assessed as being affected by the road construction project (NSW Roads and Traffic Authority 2001).

Nine vegetation communities are likely to be affected by the proposed Upgrade (Table 7-1), including four Endangered Ecological Communities and one regionally rare community. Blackbutt Dry Sclerophyll Forest makes up over 50% of the vegetation likely to be affected. While the full range of ecological characteristics likely to be lost by the proposed Upgrade should, in principle, be offset, it is unlikely that all habitats and species can be offset; the range of habitats available will depend on the land available as offsets. Opportunities to provide the affected characteristics within rarer communities should be investigated. For example, fauna habitat features such as tree hollows may be found in River-flat Eucalypt Forest.

7.4 Location of habitat

Wherever possible the compensatory habitat should be located close to the affected habitat (NSW Roads and Traffic Authority 2001), bearing in mind the viability of the habitat and its future management. As part of the property acquisition procedures for the proposed Upgrade, consideration could be given to purchasing additional lands adjacent, or near to, the alignment that has suitable characteristics for inclusion in the offset package and negotiating the form of protective status that the land will have.

8. Significance of impacts

Projects assessed under Part 3A of the *Environmental Planning and Assessment Act 1979* do not require assessments of significance under Section 5A of the Act (the Seven Part Test). Instead the assessment is based against heads of consideration detailed in the draft *Guidelines for Threatened Species Assessment* (Department of Environment and Conservation 2005b), indicating the significance of the impacts relative to the conservation importance of the habitat, individuals and populations likely to be affected.

Impacts are considered more significant if:

- areas of high conservation value are affected
- individual animals and/or plants and/or subpopulations that are likely to be affected by a proposal play an important role in maintaining the long-term viability of the species, population or ecological community
- habitat features that are likely to be affected by a proposal play an important role in maintaining the long-term viability of the species, population or ecological community
- the impacts are likely to be long-term in duration
- impacts are likely to be permanent and irreversible.

Threatened biodiversity listed under the *Environment Protection and Biodiversity Conservation Act 1999* are assessed following the *Principal Significant Impact Guidelines 1.1* (Department of the Environment and Heritage 2006).

Significance assessments were carried out for those species and communities that have the potential to be affected by the proposed Upgrade. The assessments are presented in Appendix B and are summarised in Table 8-1. These assessments identified a number of impacts that would arise as a result of the proposed Upgrade and concluded that the proposal is likely to have a significant effect on three Endangered Ecological Communities, one Threatened species of plant and three Threatened species of animal (Table 8-1).

Table 8-1 Likely significance of impacts on threatened biodiversity

Species or community	Likely significant impact
Endangered Ecological Communities	
Swamp Oak Floodplain Forest	**Y**
River-flat Eucalypt Forest	**Y**
Freshwater Wetlands	N
Swamp Sclerophyll Forest	**Y**
Threatened Plants	
Maundia triglochinoides	**Y**
Arthraxon hispidus (Hairy Joint Grass)	N
Persicaria elatior	N

Species or community	Likely significant impact
Threatened Animals	
Green-thighed Frog (*Litoria brevipalmata*)	**Y**
Glossy Black-Cockatoo (*Calyptorhynchus lathami*)	**Y**
Black-necked Stork (*Ephippiorhynchus asiaticus*)	N
Comb-crested Jacana (*Irediparra gallinacea*)	N
Square-tailed Kite (*Lophoictinia isura*)	N
Powerful Owl (*Ninox strenua*)	N
Masked Owl (*Tyto novaehollandiae*)	N
Sooty Owl (*Tyto tenebricosa*)	N
Osprey (*Pandion haliaetus*)	N
Hoary Wattled Bat (*Chalinolobus nigrogriseus*)	N
Golden-tipped Bat (*Kerivoula papuensis*)	N
Little Bent-wing Bat (Miniopterus australis)	N
Common Bent-wing Bat (*Miniopterus schreibersii*)	N
Eastern Freetail-bat (*Mormopterus norfolkensis*)	N
Large-footed Myotis (*Myotis adversus*)	N
Greater Broad-nosed Bat (*Scoteanax rueppellii*)	N
Yellow-bellied Sheathtail Bat (*Saccolaimus flaviventris*)	N
Yellow-bellied Glider (*Petaurus australis*)	N
Brush-tailed Phascogale (*Phascogale tapoatafa*)	**Y**
Koala (*Phascolarctos cinereus*)	N
Common Planigale (*Planigale maculata*)	N
Grey-headed Flying-Fox (*Pteropus poliocephalus*)	N
Squirrel Glider (*Petaurus norfolcensis*)	N
Aquatic Species	
Grey Nurse Shark (*Carcharias Taurus*)	N
Great White Shark (*Carcharodon carcharias*)	N
Green Sawfish (*Pristis zijsron*)	N
Black Cod (*Epinephalus daemelii*)	N

8.1 Key thresholds

Under the draft *Guidelines for Threatened Species Assessment under Part 3A of the Environmental Planning and Assessment Act 1979* (Department of Environment and Conservation 2005a), the following thresholds need to be addressed.

Whether or not the proposal, including actions to avoid or mitigate impacts or compensate to prevent unavoidable impacts will maintain or improve biodiversity values.

The term 'maintain or improve' is defined in the draft *Guidelines for Threatened Species Assessment under Part 3A* of the *Environmental Planning and Assessment Act 1979,* as: 'no net impact on threatened species or native vegetation' (Department of Environment and Conservation 2005a). The proposed Upgrade will result in the loss of up to 294.1 hectares of vegetation and habitat within the local area, including 63 hectares of Endangered Ecological Communities. A further 159.9 ha of vegetation and habitat will be subject to new edge effects. The project route and concept design has been undertaken to avoid and minimise impacts on vegetation, including Endangered Ecological Communities and the habitat of threatened species. These measures have been detailed in this document as well as in the earlier Project Application Report (PB 2006). Management measures would be addressed in the Flora and Fauna Management Plan for the project. These measures would allow for continuance of biodiversity values for the road corridor. A comprehensive offset package would also be developed in accordance with the RTA's Compensatory Habitat Policy, which would contribute to the maintenance and improvement of biodiversity values.

Whether or not the proposal is likely to reduce the long-term viability of a local population of a species, population or ecological community.

For the majority of species, populations and communities found in the local area, the proposed Upgrade is unlikely to reduce their long-term viability as detailed in the Project Application Report (PB2006) and in Volume 2, Technical Paper 1 - *Supplementary Ecological Assessment*. This is due to the process of avoiding and minimising impacts during the route selection and design phases of the project and though the implementation of mitigation measures as outlined in this document. However, the proposed mitigation measures are unlikely to fully ameliorate the impacts on seven species and communities, due largely to the extent of vegetation and habitat clearing and the loss of significant habitat features. The significance of these impacts is discussed in Volume 2, Technical Paper 1 - *Supplementary Ecological Assessment*. A comprehensive offset package would however be developed in accordance with the RTA's Compensatory Habitat Policy that would contribute to the maintenance and improvement of biodiversity values.

Whether or not the proposal is likely to accelerate the extinction of a species, population or ecological community or place it at risk of extinction.

The proposed Upgrade will remove 294.1 hectares of vegetation and habitat within the local area, including Endangered Ecological Communities and habitat for threatened species. However, with the implementation of mitigation measures, it is unlikely that a species, population or community would become extinct, despite there being significant impacts on some species at the local level as outlined in Volume 2, Technical Paper 1 - *Supplementary Ecological Assessment*. It is unlikely that the proposed Upgrade would proposal accelerate the extinction of a species, population or community?

Whether or not the proposal will adversely affect critical habitat.

Critical Habitat is listed under both the *Threatened Species Conservation Act 1995* and Environment *Protection and Biodiversity Conservation Act 1999* and both the State and Federal Directors-General maintain a register of this habitat. Critical habitat is the whole or any part or parts of an area or areas of land comprising the habitat of an endangered species, an endangered population or an endangered ecological community that is critical to the survival of the species, population or ecological community (NPWS, 1996).

To date there is no critical habitat declared within Kempsey local government area and no critical habitat is likely to be affected by the proposed Upgrade.

9. References

Arnold, GW, Steven, DE & Weeldenburg, JR 1993, 'Influences of remnant size, spacing pattern and connectivity on population boundaries and demographies of Euros *Macropus robustus* living in a fragmented landscape', *Biological Conservation*, vol. 64, pp. 219-30.

Bali, R 2005, *Discussion Paper - Compensating for Edge Effects*, Ecosense Consulting for the NSW Roads and Traffic Authority, Sydney.

Bennett, A & Radford, JQ 2004, 'Landscape-level requirements for conservation of woodland birds: are there critical thresholds in habitat cover?' in R Smithers (ed.), *Landscape Ecology of Trees and Forests*, proceedings of the Woodland Trust and the International Association of Landscape Ecology, Gloucester UK.

Brown, K & Bali, R 2003, *Kempsey to Eungai Upgrade Route Options Assessment Terrestrial Ecology.* , Unpublished report prepared by Ecopro and Ecosence Consulting for Parsons Brinckerhoff, Sydney.

Burbidge, AA, Williams, MR & Abbott, I 1997, 'Mammals of Australian Islands: factors influencing species richness. ' *Journal of Biogeography*, vol. 24, no. 6, pp. 703-15.

Cunningham, SC 2000, 'Effects of habitat fragmentation on the reproductive ecology of four plant species in Mallee woodland. ' *Conservation Biology*, vol. 14, no. 3, pp. 758-68.

Department of Environment and Conservation 2005a, *Draft guidelines for Threatened species assessment under Part 3A*, Department of Environment and Conservation, Hurstville.

——— 2005b, *Threatened species assessment guidelines*, Department of Environment and Conservation, Hurstville.

——— 2006, *Draft Lower Hunter Regional Conservation Plan*, Department of Environment and Conservation, Coffs Harbour.

Department of the Environment and Heritage 2006, *EPBC Act Policy Statement 1.1 Significant Impact Guidelines*, Department of the Environment and Heritage, Canberra.

Drayton, B & Primack, RB 1996, 'Plant species lost in an isolated conservation area in metropolitan Boston from 1894 to 1993. ' *Conservation Biology*, vol. 10, no. 1, pp. 30-9.

Fairfull, S & Witheridge, G 2003, *Why do fish need to cross the road? Fish passage requirements for waterway crossings*, NSW Fisheries, Cronulla.

Gilfedder, L & Kirkpatrick , JB 1998, 'Factors influencing the integrity of remnant bushland in subhumid Tasmania.' *Biological Conservation*, vol. 84, no. 1, pp. 89-96.

Goldingay, RL 1992, 'Socioecology of the Yellow-bellied Glider (*Petaurus australis*) in a coastal forest', *Australian Journal of Zoology*, no. 40, pp. 267-78.

Goldingay, RL & Kavanagh, RP 1991, *The Yellow-bellied Glider: a review of its ecology, and management considerations*, Royal Zoological Society of NSW.

Hanski, I 1999, *Metapopulation Ecology*, Oxford University Press, Oxford.

Lemckert, F, Mahony, M, Brassil, T & Slayter, C 2006, 'The biology of the htreatened Green-thighed frog litoria brevipalmata (Anura: Hylidae) in the cnetral and mid-north coastla areas of New South Wales', *Australian Zoologist*, vol. 33, no. 3, pp. 337-44.

Lindenmayer, DB & Burgman, M 2005, *Practical conservation biology*, CSIRO Publishing, Collingwood, Victoria.

Lonsdale, WM 1999, 'Global patterns of plant invasions and the concept of invasibility.' *Ecology*, vol. 80, no. 5, pp. 1522-36.

McIntyre, S, McIvor, JG & MacLeod, ND 2000, 'Principles for sustainable grazing in eucalypt woodlands: Landscape-scale indicators and the search for thresholds.' in P Hale, A Petrie, D Maloney & P Sattler (eds), *Management for Sustainable Ecosystems* Centre for Conservation Biology, University of Queensland, Brisbane.

Morgan, JW 1998, 'Patterns of invasion of an urban remnant of a species-rich grassland in southeastern Australia by non-native plant species. ' *Journal of Vegetation Science*, vol. 9, no. 2, pp. 181-90.

National Parks and Wildlife Service 1999, *Forest Ecosystem Classification and Mapping For The Upper And Lower North East CRA* Joint Commonwealth NSW Regional Forest Agreement Steering Committee.

NSW Department of Environment and Conservation 2007, *Guidelines for Biodiversity Certification of Environmental Planning Instruments. Issued under s.126G(5) of the Threatened Species Conservation Act 1995 - Working Draft*.

NSW Department of Natural Resources 2005, *Native Vegetation Regulation 2005 Environmental Outcomes Assessment Methodology*, NSW Government, Sydney.

NSW National Parks and Wildlife Service 2002, *Landscapes (Mitchell) of NSW*, NSW National Parks and Wildlife Service, Hurstville

NSW Roads and Traffic Authority 2001, *Compensatory Habitat Policy and Guidelines. Providing Compensatory Habitat as Amelioration for Impacts on Habitat Resulting from Road Development*, NSW Roads and Traffic Authority, Sydney.

Parkes, D, Newell, G & Cheal, D 2003, 'Assessing the quality of native vegetation: The 'habitat hectares' approach', *Ecological management and restoration*, vol. 4 (supplementary), pp. S29-38.

Parsons Brinckerhoff 2006, *Upgrading the Pacific Highway - Kempsey to Eungai. Project Application Supporting Information - Biodiversity Assessment*, Report prepared for the NSW Roads and Traffic Authority., Sydney.

Reid, JRW 2000, *Threatened and Declining Birds in the New South Wales Sheep-Wheat Belt: II Landscape Relationships - Modelling Bird Atlas Data Against Vegetation Cover*, Report prepared for the New South Wales National Parks and Wildlife Service, Hurstville.

Renjifo, LM 1999, 'Composition changes in a sub-Andean avifauna after long-term forest fragmentation. ' *Conservation Biology*, vol. 13, no. 5, pp. 1124-39.

Saunders, DA, Hobbs, RJ & Margules, CR 1991, 'Biological Consequences of Ecosystem Fragmentation: A Review', *Biological Conservation*, vol. 5, no. 1, pp. 18-32.

Scotts, D 2001, *Key habitats and corridors for fauna of north-east NSW limitations and decision rules inherent within the mapping*, NPWS, Coffs Harbour.

——— 2003, *Key habitat corridors for forest fauna. A landscape framework for conservation in north-east New South Wales. Occasional Paper 32*, NSW National Parks and Wildlife Service, Sydney.

Scotts, D, Drielsma, M & Kingma, L 2000, *Key habitats and corridors for fauna: A landscape framework for bioregional conservation planning in North-east New South Wales. II. Methods, decision rules, assumptions and mapped outputs*, NPWS, Coffs Harbour.

The Ecology Lab 2003, *Pacific Highway Upgrade, Kempsey to Eungai Aquatic Ecology Investigations - Route Options Report - Revised Final. Prepared for: Parsons Brinckerhoff*, The Ecology Lab Pty Ltd, Brookvale, NSW. .

Todd, J 2003, *Guidelines for applying the Habitat Hectares approach*, Department of Natural Resources and Environment, Melbourne.

Zanette, L, Doyle, P & Tremont, SM 2000, 'Food shortage in small fragments: Evidence from an area-sensitive passerine', *Ecology*, vol. 81, pp. 1654-66.

Appendix A

Draft translocation plan for *Maundia triglochinoides*

Translocation assessment for Maundia triglochinoides as part of the Pacific Highway upgrade, Kempsey to Eungai

April, 2006

Roads and Traffic Authority of NSW

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2116519A/PR_5653

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1. Introduction

Maundia triglochinoides is listed as Vulnerable under the *Threatened Species Conservation Act 1995.*

This species was recorded at two sites within the northern section of the proposed Kempsey to Eungai Pacific Highway upgrade (the proposed Upgrade), covering a total area of 350 square metres (Parsons Brinckerhoff 2006). The proposed Upgrade would fragment the northern site and remove approximately 10% of this population. At the southern site the proposed Upgrade would affect approximately one third of the population (Parsons Brinckerhoff 2006).

An ecological assessment for the proposed Upgrade was completed and included significance assessment for impacts on *Maundia triglochinoides.* This assessment concluded that the proposal would have a significant impact on the species (Parsons Brinckerhoff 2006).

The Director General's requirements for the environmental assessment of the proposed Upgrade include the preparation of a translocation assessment for this species. Translocation is defined as the transfer of plants or regenerative plant material to a location in the wild (Vallee et al. 2004). This report outlines the translocation assessment for *Maundia triglochinoide*s as part of the proposed Upgrade.

This report is based on information provided in the Project Application Report supporting information (Parsons Brinckerhoff 2006) and available literature. The assessment follows the methods outlined in the *Guidelines for Translocation of Threatened Plants in Australia* (Vallee et al. 2004).

Additional site visits were not undertaken because permission to access the donor site was not granted by the landowner. As such, a detailed assessment of the source site and population numbers would be required prior to the preparation of a final translocation proposal.

1.1 Current proposal

The proposed Upgrade would require the disturbance, fragmentation and removal of individuals from two out of 35 known populations within New South Wales. Remaining individuals are likely to be threatened by the proximity of the highway, in particular as a result of possible changes in hydrology, water quality and weed invasion. The proposal is likely to have a significant impact on this species.

This species occurs within drainage areas surrounded by grazing land and its habitat has been highly modified by past land uses. The proposal is unlikely to significantly alter the microhabitat conditions, except habitat that would be subject to new edge effect resulting in increased weed invasion, pollution and eutrophication from runoff and rubbish dumping (Parsons Brinckerhoff 2005).

Given that there are only 35 known populations and none occur within conservation reserves, the protection of all remaining populations is likely to be critical to the long term survival of this species.

1.2 Objectives

Translocation of *Maundia triglochinoides* would be undertaken as an ameliorative measure for development. This may include:

- salvage or rescue dig - transplantation of mature plants within the footprint to an area of habitat not affected by the development
- compensatory introduction - establishment of a population to compensate for the impact
- ameliorative enhancement - an attempt to increase population size by adding individuals to an existing population to ameliorate the loss of part or all of the population due to development (Vallee et al. 2004).

The objective of a translocation program should be to directly support the conservation of the target species, and to establish or maintain one or more self sustaining populations capable of surviving in the short and long term.

The objectives of this report are to:

- outline the biology of the species
- provide a pre-translocation assessment including whether translocation is necessary and an assessment of alternatives
- determine the number and location of plants requiring translocation
- outline the characteristics of a suitable recipient site
- determine criteria for monitoring.

2. Biology and ecology of the species

2.1 Description

Maundia triglochinoides is an emergent aquatic perennial up to 1 m tall (Photograph 2-1). It has rhizomes, generally 5 mm thick, with emergent tufts of leaves arising along their length. Leaves are up to 80 cm long and 5 to 10 mm wide, triangular in cross section and spongy (Benson & McDougall 2002).

Inflorescences are cylindrical, to 10 cm long and 2.5 cm wide. Carpels (female parts of flower) are 6 to 8 mm long, sessile (stalkless) each with a spreading beak (Harden 1993).

Photograph 2-1: ***Maundia triglochinoides***

2.2 Taxonomy

The taxonomy of a species requires clarification prior to considering translocation as hybrids, subspecies and variants may not warrant the same conservation priority as distinct species. Taxonomic uncertainty may also influence the sampling strategy and selection of source and recipient sites (Vallee et al. 2004).

Maundia triglochinoides F. Muell. is a monotypic genus. The taxonomy or this species is clear.

Family: Juncaginaceae

Genus: Maundia

Nomen number: 450645

Place of publication: Fragmenta Phytographiae Australiae 1(5): 23 (1859)

Name verified on: 23 May 2006 by Systematic Botany Laboratory

Synonyms:

- *Trichinium burtonii* F.F. Bailey– basionym published in Bailey, F.M. (1891). *Botany Bulletin*. Department of Agriculture, Queensland 2: 14
- Triglochin triglochinoides (F.Muell.) Druce- basionym published by Druce, G.C. (1917). The Botanical Exchange Club and Society of the British Isles Report for 1916, Suppl. 2: 651
- *Triglochin maundii* Thompson, J. (1961) nom illeg. Juncaginaceae. *Flora of New South Wales* 16: 77-80 (80)
- *Triglochin maundii* F. Muell. Aston, H.I. (1973), nom illeg. *Aquatic Plants of Australia*: 241

2.3 Distribution

Maundia triglochinoides is restricted to coastal New South Wales, north of Wyong and extending into southern Queensland (Figure 2-1). Although *Maundia triglochinoides* can be locally common, it is known from only a few highly scattered locations (NSW Scientific Committee 2001). There are 35 populations of this species in NSW, with 32 of these occurring in the North Coast bioregion (Department of Environment and Conservation 2007a).

Although the current southern limit of this species is Wyong, it was found previously in Sydney. Former sites around Sydney are now extinct (Department of Environment and Conservation 2007b) and are either no longer wetlands or have been greatly disturbed (NSW Scientific Committee 2001).

Within the Northern Rivers Catchment Management Area, *Maundia triglocnhinoides* is found in the Clarence Lowlands, Clarence Sandstones, Yuragir and Macleay Hastings subregions.

Figure 2-1: Distribution of *Maundia triglochinoides* (Department of Environment and Conservation 2007a)

2.4 Habitat

Maundia triglochinoides (Photograph 2-2) occurs in coastal freshwater swamps, streams, creeks or shallow freshwater 30 to 60 cm deep on heavy clay (Harden 1993). It can also occur in shallower water that can dry out (Romanowski 1998). It occurs generally in areas of low nutrients (Benson & McDougall 2002).

It occurs at low altitudes, between zero and 200 m above sea level, in areas where the annual rainfall is between 1,100 and 1,200 mm (Benson & McDougall 2002).

It is a typical understorey species in coastal floodplain swamps, wetlands and lagoons, broad-leaved paperbark forest, swamp oak floodplain forest (Department of Environment and Conservation 2006; Jacobs 1983; Winning & King 1995). It is associated with wetland species such as *Triglochin procerum* (Harden 1993).

In the Sydney region it was known to occur within alluvial woodland (NSW National Parks and Wildlife Service 2002) and riparian woodland (Steller & Bryant 2004).

Photograph 2-2: *Maundia triglochinoides* (in foreground) within drainage line in study area

2.5 Reproduction

Maundia triglochinoides flowers in warmer months, generally November to January (Benson & McDougall 2002). Flowers are thought to be wind pollinated (Benson & McDougall 2002). Numerous seeds are produced between December and January in a smooth shiny dehiscent capsule (Benson & McDougall 2002).

This species is known also to reproduce vegetatively with new tufts of leaves arising along rhizomes (Benson & McDougall 2002; Sainty & Jacobs 2003). This species has been reported to form dense stands rapidly and be invasive under some conditions (Romanowski 1998).

Northern populations rarely flower and are thought to reproduce largely vegetatively and to have limited dispersal capacity (S. Jacobs, Royal Botanic Gardens *personal communication* 4/4/07).

Both seeds and root tubers are thought to be dispersed by water (Sainty & Jacobs 2003).

2.6 Threatening processes

Recognised threats to this species include:

- habitat modification
- loss and fragmentation of habitat
- changes in hydrology and water quality
- weed invasion (Department of Environment and Conservation 2007b)
- filling of wetlands (NSW Scientific Committee 2001).

There is no current recovery plan or recovery team for *Maundia triglochinoides*.

3. Whether to translocate

3.1 Is translocation necessary?

3.1.1 Alternatives to translocation

Due to high resource requirements and potential risks, translocation should be considered as a last resort when all other options are deemed inappropriate or have failed. Translocation requires a long-term commitment for successful translocation and may be more costly in resources, time and funds than other management options. In many cases resources may be better directed towards conserving existing populations or habitat protection and management. The management of threats within existing populations may be sufficient to ensure stability of populations thus negating the need for translocation (Vallee et al. 2004).

Possible alternatives to translocation include funding recovery actions that have been identified by the Department of Environment and Conservation *(Department of Environment and Conservation 2007b)* for this species (Table 3-1). In particular, it may be possible to fund biological and ecological studies on this species.

Table 3-1: Priority actions for the recovery of *Maundia triglochinoides*

Description of priority action	Priority
Recovery strategy: Habitat management: Ongoing EIA - Advice to consent and planning authorities	
Prepare species profile and EIA guidelines and distribute to relevant consent and determining authorities.	High
Recovery strategy: Habitat management: Other	
Prepare and implement site management statements to address threats for sites on Department of Environment and Conservation lands.	High
Negotiate with other public agencies to protect sites on their lands.	High
Review classification of Crown land where sites occur to ensure appropriate classification and management for nature conservation	Medium
Ensure that council-managed land on which sites occur are appropriately classified and managed for conservation.	Medium
Recovery strategy: Habitat Protection (inc vca/jma/critical habitat nomination etc)	
Negotiate with public agencies and private landholders to increase protection status of wetlands on their land if known habitat for species.	High
Recovery strategy: Research: general biological and ecological studies	
Undertake biological and ecological studies.	Medium
Recovery strategy: Survey and/or Mapping	
Survey known sites and potential habitat, particularly in Sydney area to establish if it is locally extinct.	High

Source: Department of Environment and Conservation (2007b)

3.1.2 Success of past translocation projects

No translocations of this species have been successful in the past (S. Jacobs, Royal Botanic Gardens *personal communication* 4/4/07) and previous attempts at cultivation of *Maundia triglochinoides* have failed (Sainty & Jacobs 2003). Previous attempts have included collection and germination of seed with subsequent death of seedlings when transplanted. Mature plants that have been translocated have also failed to survive. Germination of seed has proved difficult (S. Jacobs, Royal Botanic Gardens *personal communication* 4/4/07).

3.2 Benefits and risks

Benefits of translocation programs include potential increases in population size, stability, improved survival of threatened species and increased knowledge of the species' ecology. However, translocation is costly, time consuming and success is not guaranteed. A number of risks may limit success including:

- mixing of populations resulting in outbreeding depression
- introduction of pathogens and disease
- displacement of other species
- impacts to other species from translocation activities including site preparation and monitoring (Vallee et al. 2004)
- continuing threats to the species in the recipient sites
- lack of understanding of the ecological requirements of the target species, such as symbiotic dependencies and habitat requirements
- limited post-planting maintenance and monitoring (Lindenmayer & Burgman 2005).

3.3 Conclusion

With only 35 known populations of this species remaining, the protection and expansion of these populations is critical to the long-term survival of this species. However, the biology of *Maundia triglochinoides* is not well understood and past attempts at cultivation and translocation have been unsuccessful, as such the success of a translocation program is uncertain. The removal of plants for the proposed Upgrade should be used as an opportunity for further research into the reproduction and propagation of this species and potential translocation techniques. It is recommended that any attempts at translocation focus strongly on experimentation of propagation techniques as well as comprehensive monitoring and reporting of the methods and results.

4. Source and recipient sites

4.1 Source site

Maundia triglochinoides was recorded at two sites within the northern section of the study area to the north of Seven Hills Road (Figure 4-1). Both populations occur within drainage lines surrounded by grazed grassland with remnants of Swamp Oak Floodplain Forest nearby (Photograph 4-1 and Photograph 4-2).

The proposed Upgrade would fragment the northern site and remove approximately 10% of this population. The proposed Upgrade would affect approximately one third of the southern population (approximately 350 square metres).

Remaining individuals and their habitat are likely to be threatened by the proximity of the highway, in particular as a result of possible changes in hydrology, water quality and weed invasion. Mitigation measures will be implemented to minimise potential impacts of these changes to remaining individuals. Given the poor results from previous translocation attempts for this species it is recommended that only those plants within the footprint be removed and that the threats for the remaining individuals be managed.

Photograph 4-1: *Maundia triglochinoides* within the study area showing Swamp Oak Forest in distance

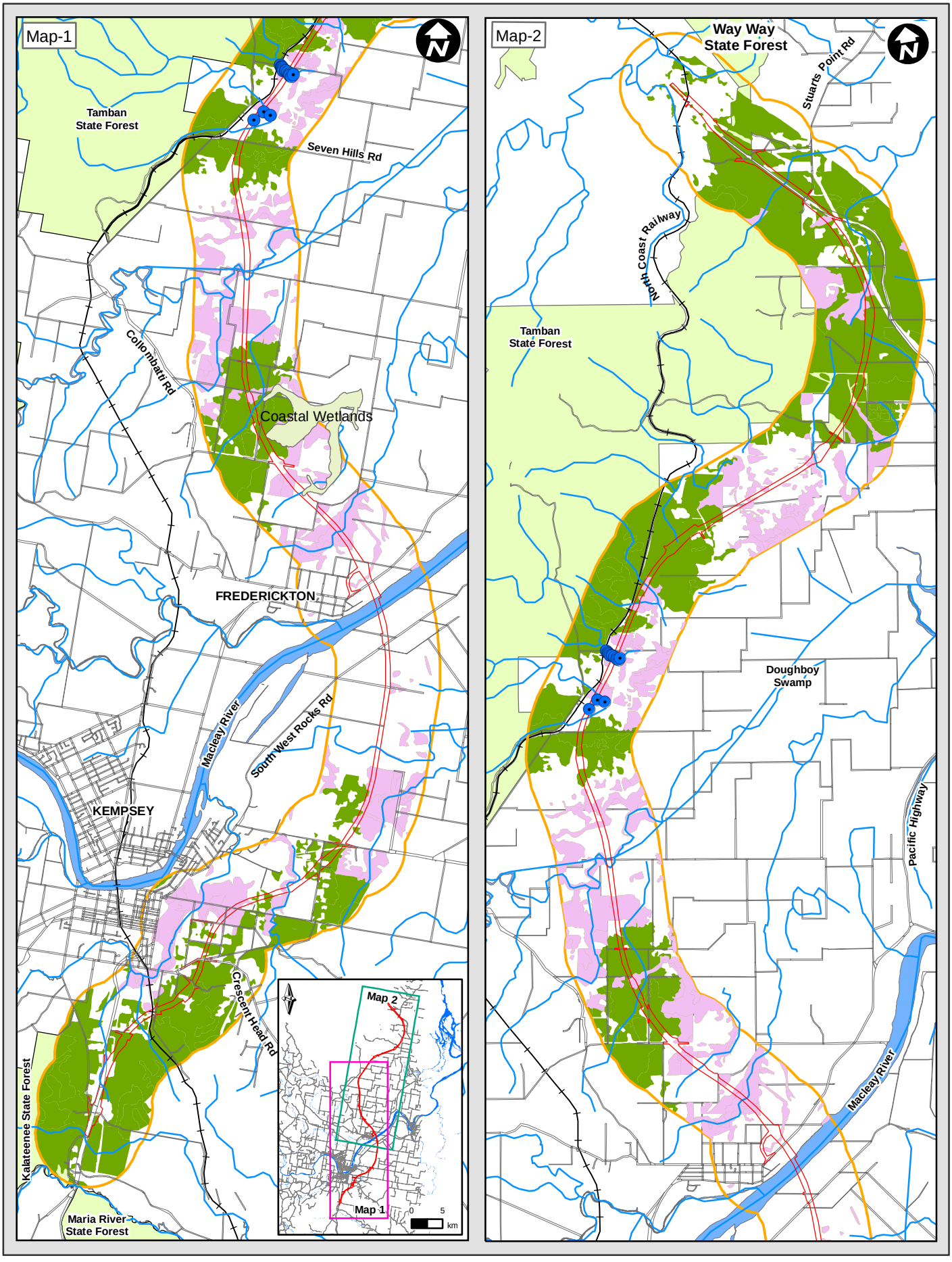

Figure 4.1: Location of Maundia triglochinoides in the Study Area

Photograph 4-2: *Maundia triglochinoides* within cleared grassland with a nearby remnant of Swamp Oak Forest (on right)

4.2 Selecting recipient sites

To ensure successful translocation and long-term survival of the population it is critical to ensure that suitable recipient sites are chosen. Recipient sites should:

- contain the preferred habitat of this species, namely:
  - shallow freshwater up to 60 cm deep
  - slow moving water
  - clay substrate
  - have low levels of nutrients
- contain suitable vegetation communities such as:
  - freshwater wetland
  - swamp oak floodplain forest
  - swamp sclerophyll floodplain forest
- be located in proximity to the donor sites to minimise potential environmental and genetic impacts
- be located within conservation areas or protected under a conservation agreement to ensure long-term protection of the population and allow ongoing active management of the site

- not be subject to recognised threats for this species (see Section 2.4) or else these threats can be managed. Thus, the recipient site must be protected from:
  - habitat modification
  - future loss and fragmentation of habitat
  - future changes in hydrology and water quality must be minimised and managed
  - weed invasion (Department of Environment and Conservation 2007b)
- be large enough to support a self-sustaining population.

4.2.1 Potential recipient sites within the study area

A number of conservation areas occur within the vicinity of the site which would provide long-term protection for this species and may provide potential recipient sites. These include:

- Eungai National Park
- Kalateen State Forest
- Tamban State Forest.

Other areas within the project locality that may provide suitable sites, but are not within conservation areas, include:

- within the two existing populations- the ponds and drainage lines where the populations occur
- within the road reserve of the proposed Upgrade
- within private properties- this would require agreement of landowners and a conservation agreement would be required in order to ensure protection of the species
- East Kempsey Swamp- *Maundia triglochinoides* has been previously recorded here (Brown & Bali 2003)
- SEPP 14 wetland:
  - Bellimbopinni 687
  - Doughbouy Swamp 478
  - Fishermans' reach/Clybucca 1027.

Further investigations would be required to determine if these or other sites would provide suitable recipient sites for translocation of the species.

If the threats at the donor sites can be managed, it is recommended that the donor site be used as the recipient site. This would help to maintain the size, genetic variation and viability of these populations. This would minimise the risks associated within translocations such as transfer of disease, mixing of populations resulting in outbreeding depression and displacement of other species would be minimised.

5. Translocation methodology

Maundia triglochinoides reproduces both vegetatively by rhizomes and by seed. Given that the translocation would be a salvage dig of plants within the proposed Upgrade footprint, the transplantation of individual plants is recommended, however, propagation from rhizomes and seed should also be considered and trialled.

It should be noted that previous attempts at cultivation of *Maundia triglochinoides* have failed (Sainty & Jacobs 2003) and the reasons for this are not known.

5.1 Experimenting with translocation techniques

Little is known about the reproductive ecology of this species and past attempts at cultivation, propagation and transplantation have been unsuccessful (S. Jacobs, Royal Botanic Gardens *personal communication* 4/4/07). For this reason it is recommended that various techniques are tested so that successful methods for translocation can be found.

If time permits, small scale pilot trials should be undertaken to allow suitable methods to be used in the full translocation. However, experimentation in the full translocation would also be beneficial as this would provide information for any future translocations. An experimental design should be developed as part of the translocation proposal.

5.1.1 Salvage of mature plants

Generally the salvage of mature plants is the least effective method of translocation (Vallee et al. 2004) and this method has not been successfully used for this species (S. Jacobs, Royal Botanic Gardens *personal communication* 4/4/07).

Transplanting harvested plants, however, offers a cost effective method of plant establishment. It is most suited to establishing small areas. Species with rhizome material or tussocks are most successfully established using this technique (Wong et al. 1999).

Transplanting mature rhizomatous plants generally give the quickest result, as the resulting plants are mature and robust, and can quickly spread. Care should be taken to minimise impact (which may cause erosion) on areas from where the transplants are harvested, and when handling the transplants to reduce damage (Department of Infrastructure Planning and Natural Resources 2004).

5.1.2 Propagation from rhizome

This species can be propagated by division of mature plants (Ralph 2003). Plants collected as part of the salvage dig could be used for propagation in a nursery for subsequent planting at a donor site.

5.1.3 Direct seeding

Direct seeding has the advantage of being cheap and less labour intensive than planting seed and plants tend to establish quicker. However, this method requires larger quantities of seed and is less reliable than planting, especially in heavy clay soils and erodable areas (Ralph 2003). Given that the preferred habitat for this species is heavy clay soils, direct seeding would not be the most appropriate method. Also, since this species is aquatic and

occurs within drainage lines and wet areas with slow moving water, direct seeding may result in seed being washed away and out of the target recipient area. As such, it is recommended that collected seed is germinated in a glass house and seedlings are planted into the recipient site/s.

5.1.4 Propagation from seed

Seed can be collected and used for propagation in a nursery. Seed can be collected between December and January.

Maundia species can be grown from fresh seed using the bog method. In this method, seed is sown into a tray which is then placed in a larger tray or container with water. This method provides waterlogged conditions required for germination of many wetland species. Generally the water level would be maintained between 3 cm below to level with the seeds. The preference of different species for degree of water logging depending on the oxygen requirements of the species for germination. The tray is usually then placed in full sun (Ralph 2003). Seedlings can then be grown in glass house until being planted into the recipient site/s.

5.1.5 Transfer of soil containing seed

Transfer of soil containing seed can be a useful method for species that require mechanical disturbance for germination. However, this method is not recommended for this species as *Maundia triglochinoides* is not known to require mechanical disturbance and it is not known if the site has a soil seed bank. Transfer of soil may also transfer soil pathogens and weeds and should only be used for transfer to adjacent degraded areas (Vallee et al. 2004).

5.1.6 Cuttings

This method involves dipping a cutting of a shoot in a hormone solution to encourage root growth and planting in pots. This method has not been trialled for this species and could be tried as part of the propagation experimentation.

5.1.7 Comparison of methods

A comparison of cost, time required and likely success of the methods is provided in Table 5-1.

Table 5-1: Comparison of methods

Method	Cost	Time	Suitability for species	Previous success	Likely success
Salvage of mature plants	Low	Short	High	Low	Unknown
Propagation from rhizome	Medium	Long	High	-	Unknown
Direct seeding	Low	Short	Low	-	Low
Propagation from seed	High	Long	Moderate	Low	Unknown
Transfer of soil containing seed	Low	Short	Low	-	Low
Cuttings	High	Long	Moderate	-	Unknown

5.2 Recipient site preparation

Weed control is critical to prevent weeds competing with transplants for moisture, nutrients and light. Herbicides should be used with care to minimise potential for watercourse pollution that may affect native fauna, such as frogs and fish (Department of Natural Resources 2002). Herbicides used at the site would depend on the weed species present and the control methods required for these species. In general, spraying would not be recommended within the vicinity of water. Weeds in this area could be treated using cut and paint methods or hand pulling.

5.3 Timing of harvesting and planting

The timing of harvesting and planting is crucial for successful plant establishment. If transplantation is at the start of the growth season (spring) the plant has an entire growth season to establish before it has to survive the non-growth season (winter). Plants transplanted out of season have to survive on the reserves developed prior to planting. If these reserves are inadequate, then survival beyond the winter season is unlikely (Wong et al. 1999). Harvesting for both propagation and immediate transplanting of this species should be undertaken in spring.

Delay in transplantation, after harvesting from source site, may result in damage and stress to plants and eventual death. Except where propagation of plants within a nursery is desired, salvaged plants should be transplanted to the recipient site on the same day they are harvested and as soon as possible. This will help to minimise stress to plants and increase survival.

Planting of propagated plants could be staggered over several years to reduce the chance of failure due to unfavourable season or event (Vallee et al. 2004) and allow modification of planting strategy based on success of planting in previous years.

Planting density recommended for riparian and wetland areas are approximately 80% vegetation coverage to reduce the risk of weed invasion (Department of Natural Resources 2002).

5.4 On-going management

On-going management of the recipient and donor sites and populations would be required including weed control, erosion management and monitoring of success. Ongoing management may include protection against herbivores, protection against sun and wind, habitat management including management of hydrological regimes, planting of associated species, weed and erosion control. Management of these sites and populations must be adaptive and be modified depending on the results of the monitoring. Details of the on-going management should be determined and outlined in final the translocation plan.

5.5 Monitoring and reporting

Monitoring is an essential component of a translocation program and will enable evaluation of success, identification of problems and allow informed management changes. In order to measure the survival and success of the translocation program the following should be quantified at both the donor and recipient sites:

- survival of individuals over time
- health, condition and size class of each plant
- reproductive status of each plant
- viability of seed produced
- recruitment of new individuals
- area of the population
- water quality, depth and flow
- extent of weed invasion and weeds of concern
- extent of erosion
- presence of other threats.

The monitoring should identify any additional management required to ensure survival of the populations and the condition of the sites. Monitoring should be undertaken regularly within the first year and would need to be continued for a number of years. The monitoring plan should be developed as part of the final translocation plan.

Reporting of the translocation methods and results of the monitoring program should be undertaken annually and be provided to the Department of Environment and Conservation. The results of the translocation should also be reported in the scientific literature, regardless of success or failure, so that others may benefit from this knowledge.

5.5.1 Success criteria for translocation

The objectives of the translocation program are to establish and maintain one or more self sustaining populations capable of surviving in the short and long term. For a population to persist in the short term there needs to be:

- successful establishment of the translocated individuals
- management and control of threats
- sufficient numbers to avoid both demographic and environmental stochasticiity
- reproduction and natural recruitment.

For a population to persist in the long term long term it also needs to possess sufficient genetic diversity to retain its evolutionary potential to adapt to long-term environmental change.

Criteria to determine if this translocation has been successful would include:

- survival of transplanted individuals - for example greater than 70% survival
- survival of plants to reproductive stage
- maintenance or expansion of area and number of plants at source population
- maintenance or expansion of area and number of plants of population at recipient site
- evidence of reproduction and natural recruitment (including flowering, seed production and rhizomatous expansion)
- weed invasion is controlled at an acceptable level

- erosion is controlled
- there is no displacement of other native species.

Criteria for successful propagation would include:

- the required number of transplants were available for the translocation
- correct labelling and documentation was maintained through cultivation
- techniques for successful propagation are determined
- a genetically representative collection was maintained (Vallee et al. 2004).

Detailed criteria would be determined as part of the monitoring plan to be developed for the translocation proposal.

5.6 Funding

Funding for the translocation would be provided by the RTA as part of their compensation package for the Upgrade. A cost estimate of the translocation would need to be prepared as part of the translocation plan to be developed once a recipient site has been selected.

6. Conclusion and recommendations

This report is a desk-top assessment based on the information provided in the Project Application Report (Parsons Brinckerhoff 2006) which were based on field surveys. Additional site visits were not undertaken because permission to access site was not granted by the landowner. A detailed assessment of the source site and population numbers would be required prior to the preparation of a full translocation proposal.

Little is known about the reproductive ecology of this species and past attempts at cultivation, propagation and transplantation have been unsuccessful. For this reason it is recommended that the removal of plants for the proposed Upgrade is used as an opportunity to research the reproduction and propagation of this species. Various techniques should be tested so that successful methods for translocation can be found and used for future translocations and management of this species.

It is recommended that a detailed translocation proposal be completed, providing information as required in the *Guidelines for Translocation of Threatened Plants in Australia* (Vallee et al. 2004), namely:

- identify recipient site/s:
  - provide details of current landuse, tenure, and written evidence of the agreement of the controlling body or owner
  - provide justification for selection of the recipient site over other sites
  - demonstrate that the introduction of the species is unlikely to have a significant impact on the natural environment.
- determine the number of individuals to be translocated and:
  - discuss this in relation to maintaining genetic variability
  - if mixing populations, provide evidence that this will benefit conservation
- develop an experimental design to test propagation and translocation methods
- develop a post-translocation monitoring plan
- develop a post-translocation management plan
- apply for approval for translocation from the Department of Environment and Conservation.

References

Benson, D & McDougall, L 2002, 'Ecology of Sydney plant species Part 9. Monocotyledon families: Agavaceae to Juncaginaceae', *Cunninghamia*, vol. 7, no. 4, pp. 695-930.

Brown, K & Bali, R 2003, *Kempsey to Eungai Upgrade Route Options Assessment Terrestrial Ecology.*, Unpublished report prepared by Ecopro and Ecosence Consulting for Parsons Brinckerhoff, Sydney.

Department of Environment and Conservation 2006, *Threatened species, populations and ecological communities*, NSW Department of Environment and Conservation, 2006, <http://www.threatenedspecies.environment.nsw.gov.au/index.aspx>.

——— 2007a, *Bionet*, Department of Environment and Conservation, <http://www.bionet.nsw.gov.au/BioNet.cfm?is_ie5up>.

——— 2007b, *Threatened species, populations and ecological communities*, NSW Department of Environment and Conservation, 2006, <http://www.threatenedspecies.environment.nsw.gov.au/index.aspx>.

Department of Infrastructure Planning and Natural Resources 2004, *Riparian Corridor Management Study. Covering all of the Wollongong Local Government Area and Calderwood Valley in the Shellharbour Local Government Area*, Report prepared for Wollongong City Council, Wollongong.

Department of Natural Resources 2002, *Watercourse revegetation using indigenous plants*, Department of Natural Resources, Albury/Wodonga.

Harden, G 1993, *Flora of New South Wales Volume 4*, University of New South Wales Press Ltd., Kensington.

Jacobs, S 1983, 'Vegetation', in C Haigh (ed.), *Wetlands in New South Wales*, NSW National Parks and Wildlife Service, Hurstville.

Lindenmayer, DB & Burgman, M 2005, *Practical conservation biology*, CSIRO Publishing, Collingwood, Victoria.

NSW National Parks and Wildlife Service 2002, *Final native vegetation mapping of the Cumberland Plain, Western Sydney*, NSW National Parks and Wildlife Service, Hurstville.

NSW Scientific Committee 2001, *Final determination to list Maundia triglochinoides as a vulnerable species*, NSW National Parks and Wildlife Service, Hurstville.

Parsons Brinckerhoff 2005, *Kempsey to Eungai Upgrading the Pacific Highway. Project Application Report*, Report prepared for the Roads and Traffic Authority of NSW, Sydney.

——— 2006, *Upgrading the Pacific Highway - Kempsey to Eungai. Project Application Supporting Information - Biodiversity Assessment*, Report prepared for the NSW Roads and Traffic Authority., Sydney.

Ralph, M 2003, *Growing Australian Native Plants from Seed for revegetation tree planting and direct seeding: Second edition*, Murray Ralph/Bushland Horticulture, Fitzroy.

Romanowski, N 1998, *Aquatic and wetland plants*, UNSW Press, Sydney.

Sainty, GR & Jacobs, SWL 2003, *Waterplants in Australia*, 4th edn, Sainty and Associates Pty Ltd, Potts Point.

Steller, D & Bryant, A 2004, *Biodiversity of the Georges River catchment*, Department of Infrastructure, Planning and Natural Resources and the NSW National Parks and Wildlife Service, Sydney.

Vallee, L, Hogbin, T, Monks, L, Makinson, B, Matthes, M & Rossetto, M 2004, *Guidelines for translocation of threatened plants in Australia*, Australian Network for Plant Conservation, Canberra.

Winning, G & King, AM 1995, *Upper Northeast Rivers region survey of freshwater wetlands*, Shortland Wetlands Centre and Department of Water Resources, Technical Services Division Report 95.059.

Wong, T, Breen, P, Somes, N & Lloyd, S 1999, *Managing urban stormwater using constructed wetlands*, Cooperative Research Centre (CRC) for Catchment Hydrology and Department of Civil Engineering, Monash University and Cooperative Research Centre (CRC) for Freshwater Ecology and Melbourne Water Corporation, Clayton, Victoria.

Appendix B

Significance assessments

Appendix B – Table of Contents

1. River-flat Eucalypt Forest 1

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1. River-flat Eucalypt Forest

Status

River-flat Eucalypt Forest on coastal floodplains of the NSW north coast is listed as an endangered ecological community under the *Threatened Species Conservation Act 1995.*

Description

River-flat Eucalypt Forest is characterised by a tall open tree layer of eucalypts, including *Eucalyptus tereticornis, E. amplifolia, E. grandis* and sometime *Angophora floribunda and A. subvelutina.*

A layer of small trees may be present, including *Melaleuca decora, M. styphelioides* (prickly-leaved teatree), *Backhousia myrtifolia* (grey myrtle), *Melia azaderach* (white cedar), *Casuarina cunninghamiana* (river oak) and *C. glauca* (swamp oak). Scattered shrubs include *Bursaria spinosa, Solanum prinophyllum, Rubus parvifolius, Breynia oblongifolia, Ozothamnus diosmifolius, Hymenanthera dentata, Acacia floribunda* and *Phyllanthus gunnii*. The groundcover is dominated by soft-leaved forbs and grasses including *Microlaena stipoides, Dichondra repens, Glycine clandestina, Oplismenus aemulus, Desmodium gunnii, Pratia purpurascens, Entolasia marginata, Oxalis perennans* and *Veronica plebeia* (NSW Scientific Committee 2005).

Habitat

River-flat Eucalypt Forest occurs on river flats of the coastal floodplains and waterlogged or periodically inundated alluvial flats and drainage lines on coastal floodplains. It is associated with silts, clay-loams and sandy loams, on periodically inundated alluvial flats, drainage lines and river terraces. It generally occurs below 50 m altitude but may occur on localised river flats up to 250 m above sea level (NSW Scientific Committee 2005).

Distribution

River-flat Eucalypt Forest was once widespread across coastal areas. It occurs on coastal floodplains of the NSW north coast, Sydney Basin and south east corner bioregions. Within New South Wales it is estimated that there is less than 30% of the original extent of coastal floodplain wetlands (which includes River-flat Eucalypt Forests) remaining. The extent of River-flat Eucalypt Forest is likely to be considerably less than the combined extent of these communities.

Small areas of River-flat Eucalypt Forests occur within conservation reserves. However, these conservation reserves are unevenly scattered across the range of the community and are unlikely to represent its full diversity. This community is unlikely to be adequately represented within conservation reserves.

119 ha of this community occur within the study area of the proposed Upgrade (Figure B1).

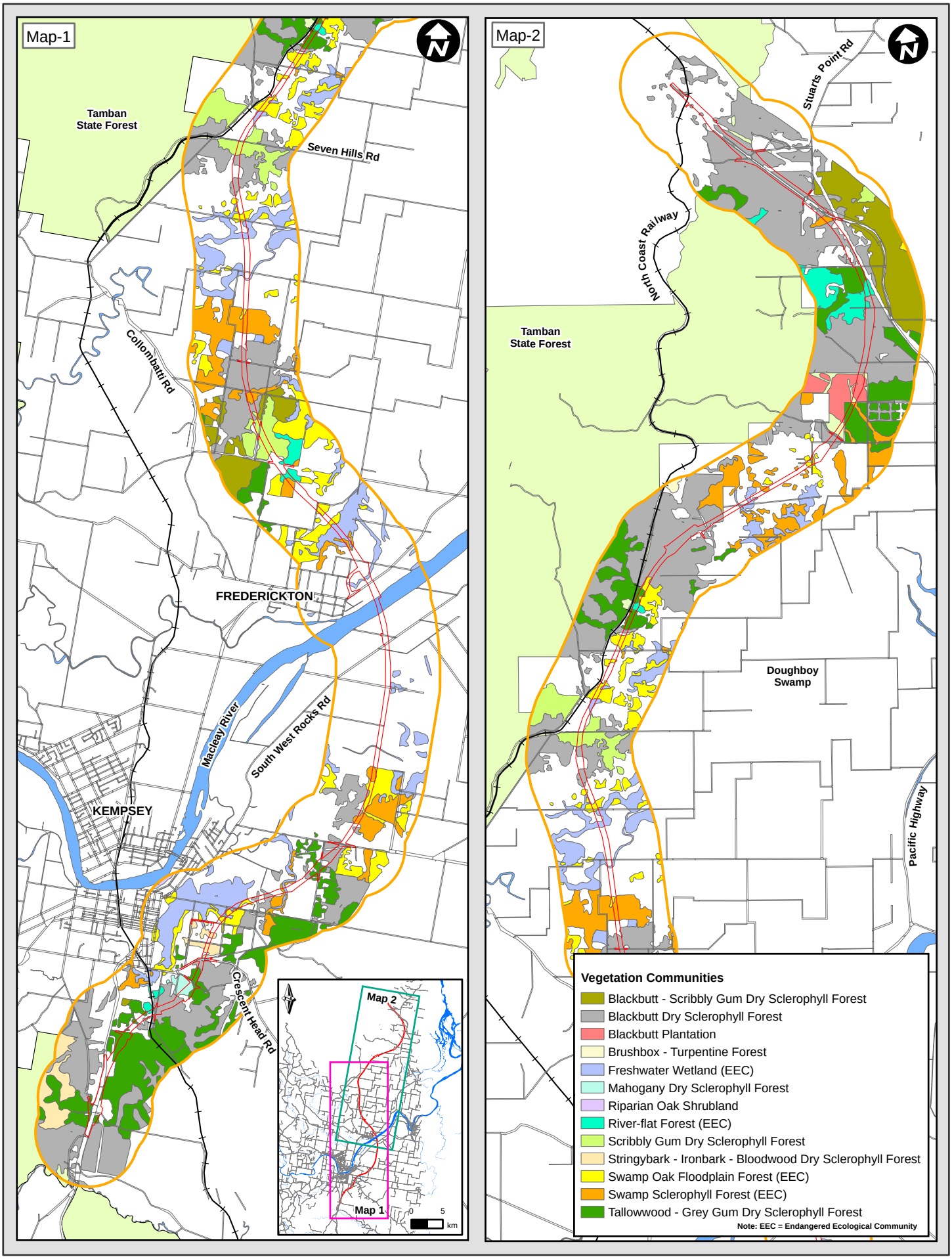


Figure B1 **Vegetation Communities within the Study Area**

2116519A_2058_Vegetation_Communities.mxd SWD - Sep, 2005

Threats

Recognised threats to this community include:

- clearing for urban and rural development, and the subsequent impacts from fragmentation
- flood mitigation and drainage works
- landfilling and earthworks associated with urban and industrial development
- grazing and trampling by stock and feral animals (particularly pigs)
- changes in water quality, particularly increased nutrients and sedimentation
- weed invasion
- climate change
- activation of acid sulfate soils
- removal of dead wood
- rubbish dumping
- frequent burning that reduces the diversity of woody plant species.

Key threatening processes that affect this community include:

- clearing of native vegetation
- alteration to the natural flow regimes of rivers, streams, floodplains and wetlands
- invasion of native plant communities by exotic perennial grasses
- predation, habitat destruction, competition and disease transmission by feral pigs
- human-induced climate change
- high frequency fire
- removal of dead wood and trees.

Specific impacts

The proposal would include the clearing of 8.2 ha of this community. A further 4.7 ha would be subject to increased edge effects.

Mitigation measures

- undertake restoration including bush regeneration, revegetation and weed control, and promote public involvement in this restoration.

1.1 Significance assessment – *Environmental Planning and Assessment Act 1979*

How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The proposal would include the removal of approximately 8.2 ha and increased edge effects to a further 4.7 ha.

Weed invasion is a recognised threat for this community and is likely to increase in this community as a further 4.7 ha would be subject to edge effects.

Activation of acid sulfate soils is listed as a threat to this community; however, mitigation measures would be implemented to prevent acid sulfate soils being washed into surrounding areas and affecting this community.

A further 106 ha of this community is known to occur within the study area and would not be affected by the proposal. However the extent of clearing represents 7% of the community within the study area and a total of 11% of the community would be lost or disturbed. This represents a significant amount of the extent both locally and regionally.

How is the proposal likely to affect current disturbance regimes?

Remnants of this community within the study area have been highly modified by past land uses and the proposal is unlikely to significantly alter the microhabitat conditions, except areas that would be subject to new edge effect (4.7 ha).

The proposal will not have an impact on the fire regime in the study area. Minor changes to the surface hydrology may occur as result of the Proposal; however not to an extent that are likely to affect the survival of the ecological community in the area.

How is the proposal likely to affect habitat connectivity?

Four patches of River-flat Eucalypt Forest occur within the study area and one of these would be fragmented by the proposal, resulting in the isolation of a narrow strip of vegetation. The proposed Upgrade would increase fragmentation of this community.

How is the proposal likely to affect critical habitat?

Critical habitat is listed under the *Threatened Species Conservation Act 1995* and the Director General of the New South Wales Department of Environment and Conservation maintains a register of such habitat. Critical habitat is the whole or any part or parts of an area or areas of land comprising the habitat of an endangered species, an endangered population or an endangered ecological community that is critical to the survival of the species, population or ecological community (NSW National Parks and Wildlife Service 1996).

Critical habitat has not been listed for River-flat Eucalypt Forests and the site is unlikely to be critical for the survival of the community.

Conclusion

The proposed development would require the removal of 8.2 ha of River-flat Eucalypt Forest, and a further 4.7 ha would be disturbed by edge effects. This represents 11% of the community within the study area. This loss and degradation of the community is significant in terms of the local and regional extent.

2. Swamp Sclerophyll Forest

Status

Swamp Sclerophyll Forest on coastal floodplains of the NSW north coast is listed as an endangered ecological community under the *Threatened Species Conservation Act 1995*.

Description

Swamp Sclerophyll Forest is typically an open forest of eucalypts and paperbarks but clearing may have altered the structure and the community can also encompass scrub, fernland, tall reedland or sedgeland.

Common canopy species include *Eucalyptus robusta*, *Melaleuca quinquenervia, Eucalyptus botryoides* and *Eucalyptus longiflolia*. A layer of small trees and/or shrubs may be present. The ground cover consists of a dense layer of sedges, ferns, forbs and grasses (NSW Scientific Committee 2004a).

Habitat

Swamp Sclerophyll Forest occurs on and waterlogged or periodically inundated alluvial flats and drainage lines on coastal floodplains. It is associated within humic clay loams and sandy loams. It generally occurs below 20 m altitude.

Distribution

Swamp Sclerophyll Forest was once widespread across coastal areas but has been extensively cleared for agriculture. It occurs on coastal floodplains of the NSW north coast, Sydney Basin and south east corner bioregions.

Within New South Wales it is estimated that there is less than 30% of the original extent of coastal floodplain wetlands (which includes swamp sclerophyll forest) remaining. The extent of swamp sclerophyll forest is likely to be considerably less than the combined extent of these communities. Within the North Coast Bioregion it is likely that less than:

- 350 ha remains in Tweed lowlands (estimated in 1985)
- 2,500 ha in the Clarence Valley (estimated in 1989)
- 700 ha on the Macleay floodplain (estimated in 1983)
- 7,000 ha in the lower hunter- central coast district (estimated in 2000)
- Small areas of Swamp Sclerophyll Forest occur within conservation reserves including: Bungawalbin, Tuckean and Moonee Beach Nature Reserves and Hat Head, Crowdy Bay, Wllingat, Myall Lakes and Garigal National Parks. However, these conservation reserves are unevenly scattered across the range of the community and are unlikely to represent the full diversity of the community. This community is unlikely to be adequately represented within conservation reserves.

445 ha of this community occur in the study area (Figure B1).

Threats

Recognised threats to this community include:

- land clearing
- fragmentation
- degradation
- flood mitigation and drainage works

- landfilling and earthworks associated with urban and industrial development
- pollution from urban and agricultural runoff
- weed invasion
- overgrazing, trampling and other soil disturbance by domestic livestock and feral animals including pigs
- activation of acid sulfate soils
- removal of dead wood
- rubbish dumping
- frequent burning resulting in a reduction of the diversity of woody plant species.

Key threatening process that affect this community include:

- clearing of native vegetation
- alteration to communities by exotic perennial grasses
- predation, habitat destruction, competition and disease transmission by feral pigs
- human-induced climate change
- high frequency fire
- removal of dead wood and trees.

Specific impacts

The proposal would include the clearing of approximately 17.4 ha of Swamp Sclerophyll Forest. A further 10.7 ha would be subject to edge effects and be likely to become degraded as a result of the project.

- Undertake restoration including bush regeneration, revegetation and weed control and promote public involvement in this restoration (Department of Environment and Conservation 2007).

2.1 Significance assessment – *Environmental Planning and Assessment Act 1979*

How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

Approximately 445 ha of Swamp Sclerophyll Forest occurs within the study area and 17.4 ha (4%) of this would be cleared for the proposal. Given the distribution of this community within the study area, this is not considered to be a significant area.

Activation of acid sulfate soils is listed as a threat to this community; however, mitigation measures would be implemented to prevent acid sulfate soils being washed into surrounding areas and affecting this community.

Fragmentation and degradation is also a recognised threat to this community. The proposal would include further fragmentation and would result in approximately 10.7 ha becoming subject to edge effects and is likely to increase weed invasion and degradation in these areas.

How is the proposal likely to affect current disturbance regimes?

Remnants of this community within the study area have been highly modified by past land uses and the proposal is unlikely to significantly alter the microhabitat conditions, except areas that would be subject to new edge effect (10.7 ha).

The proposal will not have an impact on the fire regime in the study area. Minor changes to the surface hydrology may occur as result of the Proposal; however not to an extent that are likely to affect the survival of the ecological community in the area.

How is the proposal likely to affect habitat connectivity?

Eleven patches of Swamp Sclerophyll Forest occur within the study site and three of these would be fragmented by the proposed Upgrade. The proposed development would increase fragmentation of this community.

How is the proposal likely to affect critical habitat?

Critical habitat is listed under the *Threatened Species Conservation Act 1995* and the Director General of the New South Wales Department of Environment and Conservation maintains a register of such habitat. Critical habitat is the whole or any part or parts of an area or areas of land comprising the habitat of an endangered species, an endangered population or an endangered ecological community that is critical to the survival of the species, population or ecological community (NSW National Parks and Wildlife Service 1996).

Critical habitat has not been listed for Swamp Sclerophyll Forest and the site is unlikely to be critical for the survival of the community.

Conclusion

The proposed Upgrade would require the clearing of approximately 17.4 ha of this community. It would further result in approximately 10.7 ha becoming subject to edge effects and increasing degradation through weed invasion. The proposed Upgrade is likely to have a significant impact on this community.

3. Swamp Oak Floodplain Forest

Status

Swamp Oak Floodplain Forest of the NSW North Coast is listed as an Endangered Ecological Community under the *Threatened Species Conservation Act 1995*.

Description

Swamp Oak Floodplain Forest varies from open forests to low woodlands, scrubs or reedlands with scattered trees. Species composition varies with waterlogging and latitude. In the north coast it typically has a dense to sparse tree layer dominated by *Casuarina glauca*. Other trees including *Acmena smithii, Glochidion* spp. and *Melaleuca* spp. may also occur with eucalypts uncommon. The understorey is characterised by frequent vines such as *Parsonsia stramineae, Geitonoplesium cymosum, Stephania japonica* and a sparse cover of shrubs. The ground cover varies depending on salinity but is typically dense with forbs sedges, grasses and leaf litter (NSW Scientific Committee 2004c).

Habitat

Swamp Oak Floodplain Forest occurs where groundwater is saline, or sub-saline, on waterlogged or periodically inundated alluvial flats, drainage lines, lake margins and estuarine fringes on coastal floodplains. It is associated with grey-black clay-loams and sandy loams. Generally occurs below 20 m altitude (rarely above 10 m) (NSW Scientific Committee 2004c).

Distribution

Swamp Oak Floodplain Forest was once widespread across coastal areas but has been extensively cleared for agriculture. It occurs on coastal floodplains of the NSW north coast, Sydney Basin and south east corner bioregions.

Within New South Wales it is estimated that there is less than 30% of the original extent of coastal floodplain wetlands (which includes swamp oak floodplain forest) remaining. Within the North Coast Bioregion it is likely that less than:

- 350 ha occurs on the Tweed lowlands
- 650 ha on the lower Clarence floodplain
- 400 ha on the lower Macleay Floodplain
- 3,200 ha in the lower hunter to central hunter.

Small areas of Swamp Oak Floodplain Forest occur within conservation reserves including Stotts Island, Ukerebagh and Tuckean Nature Reserves as well as Myall Lakes National Park. However, the full species diversity and community range is not well represented within conservation reserves (NSW Scientific Committee 2004c) and this community is unlikely to be adequately represented within conservation reserves.

397 ha of this community occur within the study area (Figure B1).

Threats

Recognised threats to this community include:

- land clearing
- fragmentation
- degradation

- flood mitigation and drainage works
- landfilling and earthworks associated with urban and industrial development
- pollution from urban and agricultural runoff
- weed invasion
- overgrazing, trampling and other soil disturbance by domestic livestock and feral animals including pigs
- activation of acid sulfate soils
- rubbish dumping
- frequent burning resulting in a reduction of the diversity of woody plant species.

Key threatening processes that affect this community include:

- clearing of native vegetation
- invasion by exotic perennial grasses
- predation, habitat destruction, competition and disease transmission by feral pigs
- human-induced climate change
- high frequency fire.

Specific impacts

The proposal would include the clearing of 23.1 ha. A further 14.8 ha would be affected by edge effects as a result of the proposal.

Mitigation measures

- undertake restoration including bush regeneration, revegetation and weed control (Department of Environment and Conservation 2007).

3.1 Significance assessment – *Environmental Planning and Assessment Act 1979*

How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The proposal would include the removal of 23.1 ha of Swamp Oak Floodplain Forest and increased edge effects to 14.8 ha, resulting in a total of 37.9 ha being affected by the proposal. This is equivalent to approximately 9.5% of the local distribution (Macleay Floodplain). Given the past clearing of this community the disturbance of 37.9 ha as part of this proposal is considered a significant area.

Activation of acid sulfate soils is listed as a threat to this community, however, mitigation measures will be implemented to prevent acid sulfate soils being washed into surrounding areas and affecting this community.

Weed invasion is also a recognised threat for this community and this is likely to increase in this community as a further 14.8 ha would be subject to edge effects.

How is the proposal likely to affect current disturbance regimes?

Remnants of this community within the study area have been highly modified by past land uses and the proposal is unlikely to significantly alter the microhabitat conditions, except areas that would be subject to new edge effect (14.8 ha).

The proposal would not have an impact on the fire regime in the study area. Minor changes to the surface hydrology may occur as result of the Proposal; however not to an extent that are likely to affect the survival of the ecological community in the area.

How is the proposal likely to affect habitat connectivity?

Eleven patches of Swamp Oak Floodplain Forest occur within the site. These patches are small, isolated and generally surrounded by agricultural land. However, the proposal would remove two and bisect five of these remnants resulting in the formation of 14 patches and increasing fragmentation and isolation of this community.

How is the proposal likely to affect critical habitat?

Critical habitat is listed under the *Threatened Species Conservation Act 1995* and the Director General of the New South Wales Department of Environment and Conservation maintains a register of such habitat. Critical habitat is the whole or any part or parts of an area or areas of land comprising the habitat of an endangered species, an endangered population or an endangered ecological community that is critical to the survival of the species, population or ecological community (NSW National Parks and Wildlife Service 1996). The Swamp Oak Floodplain Forest within the site has not been listed as critical habitat (Department of Environment and Conservation 2005e).

Conclusion

The proposed development would include the clearing of 23.1 ha; bisects five patches resulting in fragmentation and a further 14.8 ha being subject to edge effects. The proposal is likely to have a significant impact on this community.

4. Freshwater Wetlands

Status

Freshwater Wetlands on coastal floodplains of the NSW north coast, Sydney basin and south east corner bioregions is listed as an endangered ecological community under the *Threatened Species Conservation Act 1995*.

Description

Freshwater Wetlands vary from sedgelands and reedlands to herbfields, however, woody species of plants are generally scarce. Typically these wetlands include or are associated with ephemeral or semi-permanent standing water (NSW Scientific Committee 2004b).

The species composition is primarily determined by the frequency, duration and depth of waterlogging and may be influenced by the level of nutrients and salinity in the water and substrate. Those that lack standing water most of the time are usually dominated by dense grassland or sedgeland vegetation, often forming a turf less than 0.5 m tall and dominated by amphibious plants including *Paspalum distichum* (water couch), *Leersia hexandra* (swamp rice-grass), *Pseudoraphis spinescens* (mud grass) and *Carex appressa* (tussock sedge). Where they are subject to regular inundation and drying the vegetation may include large emergent sedges over 1 m tall, such as *Baumea articulata, Eleocharis equisetina* and *Lepironia articulata*, as well as emergent or floating herbs such as *Hydrocharis dubia* (frogbit), *Philydrum lanuginosum* (frogsmouth), *Ludwigia peploides* subsp. *montevidensis* (water primrose), *Marsilea mutica* (nardoo) and *Myriophyllum* spp. (milfoils). As standing water becomes deeper or more permanent, amphibious and emergent plants become less abundant, while floating and submerged aquatic herbs become more abundant (NSW Scientific Committee 2004b).

Habitat

This community is associated with coastal areas subject to periodic flooding and generally have standing fresh water for at least part of most years. It typically occurs on silts, muds or humic loams in low-lying parts of floodplains, alluvial flats, depressions, drainage lines, backswamps, lagoons and lakes but may also occur in backbarrier landforms where floodplains adjoin coastal sandplains. Generally occur below 20 m elevation on level areas (NSW Scientific Committee 2004b).

Distribution

Known from along the majority of the NSW coast where it occurs on low lying floodplains.

Within NSW it is estimated that less than 21,700 ha (39%) of this community remained in 1969. Continued clearing and drainage works in the 35 years since this survey, has resulted in significant decreases in its distribution. One recent estimate indicates that there is currently 90-160 square kilometres of wetlands remaining (90% of original extent). However, this is an overestimate of the extent since it includes freshwater wetlands on coastal sandplains which is excluded from this determination (NSW Scientific Committee 2004).

Vegetation surveys of this community within the North Coast bioregion are old and incomplete, however the estimates of extent in this region include:

- 3% in the NSW North Coast bioregion in 1990s
- approximately 11,200 ha on the lower Macleay floodplain in 1983
- less than 150 ha remaining on the Tweed lowlands in 1985
- approximately 10,600 ha on the lower Clarence floodplain in 1982.

Small areas of freshwater wetlands on coastal floodplains occur within conservation reserves, however, these reserves are unevenly distributed throughout the range and would be unlikely to represent the full diversity of this community. Within the north coast bioregion, freshwater wetlands occur within four conservation reserves: Ukerebagh, Tuckean and Tabbimoble Swamp Nature Reserves as well as Bungawalbin National Park. These reserves all occur within northern NSW and this community is under represented in the southern area of the bioregion. Wetlands occurring within these conservation reserves are still exposed to threats such as hydrological changes that occur outside the boundaries of these reserves and thus reservation provides only limited protection (NSW Scientific Committee 2004). This community is unlikely to be adequately represented within conservation reserves within the region.

507 ha of this community occur within the study area (Figure B1).

Threats

Recognised threats to this community include:

- flood mitigation and drainage works
- land clearing
- continuing fragmentation and degradation
- filling associated with urban and industrial development
- pollution and eutrophication from urban and agricultural runoff
- weed invasion
- overgrazing, trampling by livestock
- soil disturbance by pigs
- activation of acid sulfate soils
- dumping of landfill, rubbish and garden refuse
- native fauna is threatened by predation, particularly by mosquito fish and cane toads
- anthropogenic climate change.

Key threatening processes that affect this community include:

- clearing of native vegetation
- alteration to the natural flow regimes of rivers, streams, floodplains and wetlands
- invasion of native plant communities by exotic perennial grasses
- predation, habitat destruction, competition and disease transmission by feral pigs
- human-induced climate change (Department of Environment and Conservation 2007).

Specific impacts

The proposal would include the clearing of 14.5 ha of freshwater wetland. This impact includes the clearing of 13.5 ha of wet meadow and 1.0 ha of *Lepironia* Swamp sub-units. A further 9.7 ha would be subject to new edge effects.

Mitigation measures

- instigate enforcement and education campaigns to reduce rubbish dumping
- undertake weed control as required using removal methods that will not damage the community
- prepare and implement site-specific vegetation management plans
- maintain and restore natural drainage conditions (Department of Environment and Conservation 2007).

4.1 Significance assessment – *Environmental Planning and Assessment Act 1979*

How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The subject freshwater wetlands within the site have been partially cleared in the past and are generally surrounded by grazed grassland. The majority of the wetlands within the site (13.5 ha) are wet meadows that are generally in poor condition, have a high level of weed invasion and provide limited habitat for fauna. Approximately 1.0 ha of Lepironia swamp would be removed by the proposal which is less than 2.5% of the local distribution. Lepironia swamp within the site was generally in moderate condition.

Approximately 507 ha of freshwater wetlands occur within the study area. The proposal would require the removal of 14.5 ha of wetland composed largely of disturbed wet meadow. This corresponds to less than 3% of freshwater wetland within the study area and less than 1% of the distribution on the Macleay floodplain. This is not considered to be a significant area.

The proposal would include an increase in clearing of native vegetation and human-caused climate change which are listed as a key threatening process. The proposal may also result in an increase in a number of other recognised threats including weed invasion, pollution and eutrophication from runoff and rubbish dumping, although mitigation measures will be put in place to reduce these.

The proposal also has the potential to activate acid sulfate soils, a recognised threat for this community. Mitigation measures would limit the impacts of acid sulfate soils on this community.

How is the proposal likely to affect current disturbance regimes?

Remnants of this community within the study area have been highly modified by past land uses and the proposal is unlikely to significantly alter the microhabitat conditions, except areas that would be subject to new edge effect (9.7 ha) resulting in increased weed invasion, pollution and eutrophication from runoff and rubbish dumping.

The proposal would not have an impact on the fire regime in the study area. Minor changes to the surface hydrology may occur as result of the Proposal; however not to an extent that are likely to affect the survival of the ecological community in the area.

How is the proposal likely to affect habitat connectivity?

Freshwater wetlands within the site are composed mostly of wet meadow vegetation, occurring as small patches generally surrounded by grazed grassland. This community already occurs as fragmented patches often as narrow strips along creeks or within drainage depressions. The proposal is unlikely to significantly increase the fragmentation or isolation of wetlands within the study area.

How is the proposal likely to affect critical habitat?

Critical habitat is listed under the *Threatened Species Conservation Act 1995* and the Director General of the NSW Department of Environment and Conservation maintains a register of such habitat. Critical habitat is the whole or any part or parts of an area or areas of land comprising the habitat of an endangered species, an endangered population or an endangered ecological community that is critical to the survival of the species, population or ecological community (NSW National Parks and Wildlife Service 1996).

Critical habitat has not been listed for Freshwater Wetlands on Coastal Floodplains (Department of Environment and Conservation 2005e) and the site is unlikely to be critical for the survival of the community.

Conclusion

Freshwater wetlands within the site have been partially cleared, are generally surrounded by grazed grassland and subject to ongoing disturbance. This community is generally in poor condition. The removal of 13.5 ha of poor condition wet meadow subject to ongoing disturbance and 1.0 ha of Lepironia swamp in moderate condition is unlikely to have a significant impact on this community or its recovery.

5. *Maundia triglochinoides*

Status

Maundia triglochinoides is listed as vulnerable under the *Threatened Species Conservation Act 1995*.

Description

Maundia triglochinoides is an emergent aquatic perennial up to 1 m tall. It has rhizomes, generally 5 mm thick, with emergent tufts of leaves arising along their length. Leaves are triangular in cross section and spongy. Leaves are up to 80 cm long and 5 to 10 mm wide.

Inflorescences are cylindrical, to 10 cm long and 2.5 cm wide. Carpels (female parts of flower) are 6 to 8 mm long, sessile (stalkless) each with a spreading beak (Harden 1993).

Habitat

Occurs in coastal freshwater swamps, streams, creeks or shallow freshwater 30 to 60 cm deep on heavy clay. Generally occurs in areas of low nutrients. Associated with wetland species such as *Triglochin procerum* (Harden 1993).

Ecology

Flowering occurs in warmer months, generally November to January. Flowers are thought to be wind pollinated. It has dehiscent capsules and numerous seeds are produced between December and January (Benson & McDougall 2002). It is known to reproduce vegetatively with new tufts of leaves arising along rhizomes. Seed and root tubers are probably dispersed by water. Attempts at cultivation have been unsuccessful so far (Sainty & Jacobs 2003).

Distribution

Once widespread across coastal areas but is now restricted to areas north of Wyong. *Maundia triglochinoides* is not known to occur within any conservation reserves.

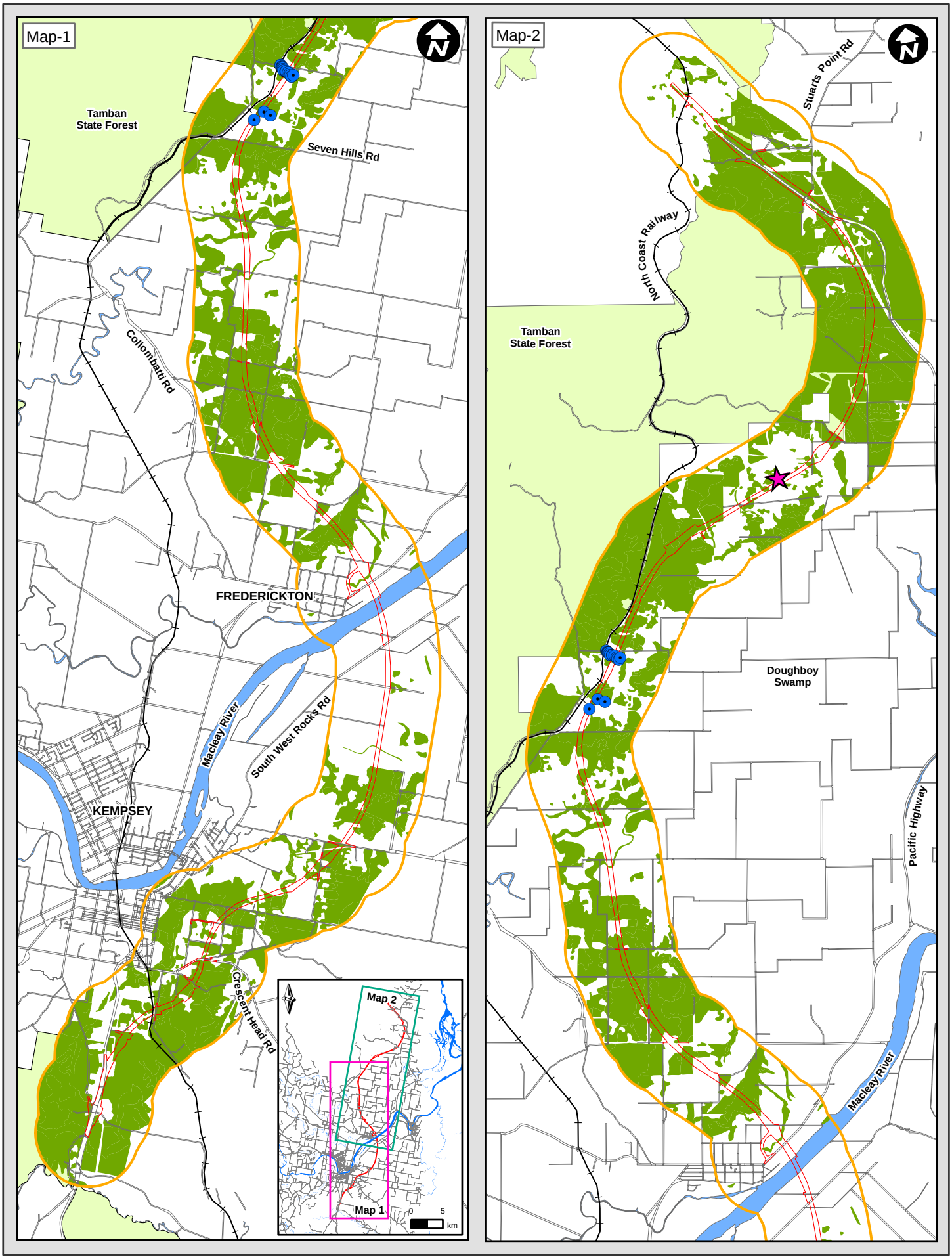
Threats

Recognised threats to this species include:

- habitat modification
- further loss and fragmentation of habitat
- changes in hydrology and water quality
- weed invasion (Department of Environment and Conservation 2005b).

Specific impacts

Maundia triglochinoides was recorded at two sites within the northern section of the study area (Figure B2). The proposed Upgrade would fragment the northern site and remove approximately 10% of this population. At the southern site the proposed Upgrade would affect approximately one third of the population.



2116519A_2088_Location_of_Significant_Flora_in_the_Study_Area.mxd SWD - Sep, 2005

0 1 2 3 4 Kilometres

Maundia Triglochinoides

Arthaxon Hispidus

Construction Footprint

Study Area

Existing Vegetation

Waterway

Existing Road

State Forest

Figure B2 **Location of Significant Flora in the Study Area**

Mitigation measures

- investigate the potential of translocation of individuals that occur within the footprint of the proposed development (see Appendix A)
- sediment and siltation devices must be used to during construction to prevent impacts to water quality
- undertake restoration including revegetation and weed control.

5.1 Significance assessment – *Environmental Planning and Assessment Act 1979*

How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Maundia triglochinoides was recorded at two sites within the northern section of the study area. The proposed Upgrade would fragment the northern site and remove approximately 10% of this population. At the southern site the proposed Upgrade would affect approximately one third of the population. Remaining individuals are likely to be threatened by the proximity of the highway, in particular due to possible changes in hydrology, water quality and weed invasion. The removal of individuals and fragmentation of the population is likely to limit pollination and dispersal of propagules and may ultimately result in a decreased gene pool. The proposal may put these populations at risk of extinction.

How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

This species occurs north of Wyong and grows in shallow freshwater, swamps or creeks. Although it can be locally common, it is known from only a few highly scattered locations and habitats in which it grows are threatened by filling, changes in hydrology, water quality and weed invasion.

This species has been recorded previously at 33 sites across New South Wales, with 30 of these occurring in the North Coast bioregion. The proposed Upgrade would require the removal of approximately 10% of one population and one third of a second population (approximately 350 square metres). Remaining individuals and their habitat are likely to be threatened by the proximity of the highway, in particular due to possible changes in hydrology, water quality and weed invasion. The disturbance to two out of 35 populations is considered to be a significant area of habitat.

Mitigation measures will be implemented to minimise potential impacts of changes in hydrology and water quality and a draft translocation plan has been prepared for individuals that will be affected.

Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

This species occurs in coastal areas of Queensland and New South Wales as far south as Wyong (Harden 1993). The site is not at the limit of distribution of this species.

How is the proposal likely to affect current disturbance regimes?

This species occurs within drainage areas surrounded by grazing land and its habitat has been highly modified by past land uses. The proposal is unlikely to significantly alter the microhabitat conditions, except habitat that would be subject to new edge effect resulting in increased weed invasion, pollution and eutrophication from runoff and rubbish dumping.

The proposed Upgrade would not have an impact on the fire regime in the study area. Minor changes to the surface hydrology may occur as result of the proposed Upgrade; however, these have been minimised through the design process.

How is the proposal likely to affect habitat connectivity?

The proposal would result in the fragmentation and isolation of the northern population of *Maundia triglochinoides*.

How is the proposal likely to affect critical habitat?

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations and ecological communities. Under the *Threatened Species Conservation Act 1995*, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for this species (Department of Environment and Conservation 2005e). Given that there are only 35 known populations and none occur within conservation reserves, the protection of all remaining populations is likely to be critical to the long term survival of this species.

Conclusion

The proposal would require the disturbance, fragmentation and removal of individuals from two out of 35 known populations within New South Wales. Remaining individuals are likely to be threatened by the proximity of the highway, in particular due to possible changes in hydrology, water quality and weed invasion. The proposal is likely to have a significant impact on this species.

6. *Arthraxon hispidus* (Hairy Joint Grass)

Status

Arthraxon hispidus is listed as vulnerable under both the *Threatened Species Conservation Act 1995* and the *Environment Protection Biodiversity Conservation Act 1999*. It has a ROTAP (Rare or Threatened Australian Plant) conservation code of 3V meaning that it has a geographic range of more than 100 km in Australia and is a Vulnerable species at risk of long-term disappearance through continued depletion (Briggs & Leigh 1996).

Description

Arthraxon hispidus is a creeping perennial grass that tends to die back in winter. It roots at the lower nodes and has branching erect to semi-erect purplish stems. Leaf blades are 2 to 6 cm long and 0.7 to 1.5 cm wide with long white hairs along the margins. It flowers in summer to autumn when it produces 2 to 5 greenish to purple racemes (flowering stalks) held above the plant on a long thin stalk (Harden 1993).

Habitat

Arthraxon hispidus prefers moist shady areas in or on the margin of rainforest and in wet eucalypt forest. It is often found near creeks or swamps (NSW National Parks and Wildlife Service 2002b).

Distribution

It occurs in northern tablelands and north coast of NSW north from Gibraltar Range. Also occurs across a wide are in south-eastern Queensland and from Japan to central Eurasia (NSW National Parks and Wildlife Service 2002b; Royal Botanic Gardens 2005). *Arthraxon hispidus* is not known to occur within any protected areas within New South Wales.

It was recorded at one location within the study area (Figure B2).

Threats

Recognised threats to this species include:

- clearing of habitat for agriculture and development
- inappropriate fire regimes
- over-grazing by domestic stock
- competition from introduced grasses such as Paspalum and Kikuyu
- slashing or mowing of habitat (NSW National Parks and Wildlife Service 2002b).

Specific impacts

Direct impacts to this species have been avoided by moving the alignment to avoid the population within the study area. This species is dependent on moisture regime particularly seepage from upper slopes and the road has been designed to minimise changes to drainage and groundwater in this area.

Mitigation measures

- fence population to avoid impacts during construction
- minimise slashing or mowing near the population. Slashing should be avoided unless required for management of the species, its habitat or weeds.

6.1 Significance assessment - *Environmental Planning and Assessment Act 1979*

How is the proposal likely to affect the lifecycle of a threatened species and/or population?

This species reproduces vegetatively and roots at the lower nodes (Harden 1993). It is also likely to be wind pollinated. Direct impacts to this species have been avoided by moving the alignment to avoid the population within the study area.

This species is dependent on specific moisture regimes particularly seepage from upper slopes and the highway has been designed to minimise changes to drainage and groundwater in this area. The proposed development is unlikely to disrupt the lifecycle of this species.

How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

This species occurs in northern tablelands and north coast and is known from 16 locations in New South Wales (Department of Environment and Conservation 2005c). Direct impacts to this species have been avoided by moving the alignment to avoid the population within the study area. This species is dependent on moisture regimes particularly seepage from upper slopes and the road has been designed to minimise changes to drainage and groundwater in this area. The proposed development would not remove or modify a significant area of habitat.

Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

Arthraxon hispidus occurs on the northern tablelands and north coast of New South Wales north from Gibraltar Range. One record occurs further south, recorded in 2001 west of Crescent Head (Department of Environment and Conservation 2005c). The site is therefore near the southern limit of distribution of this species.

How is the proposal likely to affect current disturbance regimes?

Direct impacts to this species have been avoided by moving the alignment to avoid the population within the study area. This species is dependent on moisture regimes particularly seepage from upper slopes and the road has been designed to minimise changes to drainage and groundwater in this area. The proposal is unlikely to significantly alter the microhabitat conditions.

The proposal would not have an impact on the fire regime in the study area. Minor changes to the surface hydrology may occur as result of the Proposal; however, these have been minimised through the design process.

How is the proposal likely to affect habitat connectivity?

This species was recorded from one location within the study area. Direct impacts to this species have been avoided by moving the alignment to avoid this population. The proposed development is unlikely to result in isolation or fragmentation of populations of this species.

How is the proposal likely to affect critical habitat?

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations and ecological communities. Under the *Threatened Species Conservation Act 1995*, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for this species (Department of Environment and Conservation 2005e).

Conclusion

Impacts to this species have been avoided by moving the alignment and design features of the road. The proposal is unlikely to have a significant impact on this species.

6.2 Significance assessment - *Environment Protection and Biodiversity Conservation Act 1999*

The population of *Arthraxon hispidus* within the study area is considered to be an important population as defined under the *Environment Protection and Biodiversity Conservation Act 1999* Principal Significant Impact Guidelines (Department of the Environment and Heritage 2005) in that the population is near the limit of the species range.

Will the action lead to a long-term decrease in the size of an important population of a species?

Direct impacts to this species have been avoided by moving the alignment to avoid the population within the study area. This species is dependent on specific moisture regimes particularly seepage from upper slopes and the road has been designed to minimise changes to drainage and groundwater in this area. The proposal is unlikely to lead to a long-term decrease in the size of an important population.

Will the action reduce the area of occupancy of an important population?

Direct impacts to this species have been avoided by moving the alignment to avoid the population within the study area. The proposal would not reduce the area of occupancy of an important population.

Will the action fragment an existing important population into two or more populations?

This species was recorded from only one location within the study area. Direct impacts to this species have been avoided by moving the alignment to avoid this population. The proposed Upgrade is unlikely to result in isolation or fragmentation of populations of this species.

Will the action adversely affect habitat critical to the survival of a species?

Critical habitat has not been declared for this species. The proposed Upgrade is unlikely to impact habitat for this species as the alignment has been moved to avoid the population and the road has been designed to minimise changes to drainage and groundwater in this area.

Will the action disrupt the breeding cycle of an important population?

This species reproduces vegetatively and roots at the lower nodes. It is also likely to be wind pollinated (NSW National Parks and Wildlife Service 2002b; Royal Botanic Gardens 2005). Direct impacts to this species have been avoided by moving the alignment to avoid the population within the study area. This species is dependent on moisture regimes particularly seepage from upper slopes and the road has been designed to minimise changes to drainage and groundwater in this area. The proposed development is unlikely to disrupt the breeding cycle of this species.

Will the action modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?

This species was found to have a small extent within the study area and despite searches in the wider area further individuals were not found. Impacts to the habitat of this species have been avoided by moving the alignment and by design modifications. The proposal is unlikely to modify the availability or quality of habitat to the extent that the species is likely to decline.

Will the action result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species´ habitat?

This species occurs within cleared grassland and is already subject to edge effects. Mitigation measures such as fencing the population to prevent access and cleaning vehicles and equipment prior to working in the vicinity of this population would be implemented to minimise invasion by invasive species.

Will the action interfere substantially with the recovery of the species?

Direct and indirect impacts have been avoided by moving the alignment and by modifying the design. The proposal is unlikely to substantially interfere within the recovery of the species.

Conclusion

Direct and indirect impacts have been avoided by moving the alignment and by modifying the design. The proposed development is unlikely to have a significant impact on this species.

7. *Persicaria elatior* (Tall Knotweed)

Status

Persicaria elatior is listed as vulnerable under the *Threatened Species Conservation Act 1995* and the *Environment Protection Biodiversity Conservation Act 1999*. It has a ROTAP (Rare or Threatened Australian Plant) conservation code of 3V meaning that it has a geographic range of more than 100 km in Australia and is a vulnerable species at risk of long-term disappearance through continued depletion (Briggs & Leigh 1996).

Description

Persicaria elatior is an erect herb to 90 cm tall with leaves up to 11 cm long and 3 cm wide. A sheath (ocrea), with glandular hairs on upper margin about 0.5 mm long, encircles the stem at the base of each leaf. This species has tiny pink flowers in long, narrow spikes to 5 cm long. The flower sepals are less than 4 mm long. Most parts of the plant have stalked, glandular hairs (Department of Environment and Conservation 2005b; Harden 2000).

Habitat

Persicaria elatior grows in damp places especially beside streams and lakes or where water table is high and moisture supply is intermittent and fresh. It typically occurs on sandy, alluvial soil with medium nutrients. Also occasionally occurs in swamp forest or associated with disturbance hairs. Specifically this species occurs in riparian herbland with species such as *Pseudonaphalium luteo-album* and *Persicaria hydropiper* (Department of Environment and Conservation 2005b; Harden 2000).

Distribution

Persicaria elatior occurs in coastal regions of New South Wales as well as in Queensland. It has been recorded in south-eastern New South Wales at Mt Dromedary, Moruya State Forest near Turlinjah, the Upper Avon River catchment north of Robertson, Bermagui and Picton Lakes. In the North Coast bioregion it is known from Raymond Terrace (near Newcastle) and the Grafton area (Cherry Tree and Gibberagee State Forests) (Benson & McDougall 1999; Harden 2000). *Persicaria elatior* is not known to occur within any protected areas within New South Wales.

This species was recorded from a single location within the study area (Figure B2).

Ecology

There is limited data on the ecology of this species. It was previously thought to flower in January to February (Benson & McDougall 1999) but was observed to be flowering within the site during surveys in mid March. It produces a lenticular nut (2 to 2.5 mm long) which matures between February and April and is dispersed at maturity (Benson & McDougall 1999).

Threats

Recognised threats to this species include:

- clearing of wetland vegetation
- inadvertent clearing of moist disturbed habitat
- damage to populations along roads and tracks through maintenance activities
- hydrological changes to wetland vegetation (Department of Environment and Conservation 2005b).

Specific impacts

This species was recorded within a wet meadow in the northern section of the study area. Only one individual was recorded within the site. The proposed Upgrade would require the removal of this individual.

Mitigation measures

- road design must include measure to prevent hydrological changes in patterns of flooding and drainage to surrounding wetland vegetation
- road design must include pollution control measures to prevent deterioration of water quality
- sediment and siltation devices must be used to during construction
- undertake restoration including revegetation and weed control.

7.1 Significance assessment - *Environmental Planning and Assessment Act 1979*

How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Only one individual was recorded within the site. The proposed Upgrade would require the removal of this individual; however, its removal is unlikely to disrupt the lifecycle of a viable population.

How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

Persicaria elatior occurs in coastal regions of New South Wales as well as in Queensland where it grows in damp places especially beside streams and lakes or where water table is high and moisture supply is intermittent and fresh. Typically it occurs on sandy, alluvial soil with medium nutrients. It also occasionally occurs in swamp forest or associated with disturbance (Department of Environment and Conservation 2005b; Harden 2000). Potential habitat for this species includes wet meadows within the study area.

Persicaria elatior is known from six locations within the North Coast bioregion (Department of Environment and Conservation 2005c). Approximately 14.5 ha of potential habitat occurs within the extent of construction, however, only one individual was recorded within this area, despite targeted searches. The removal of this individual and the associated potential habitat is not considered to be a significant area.

Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

Persicaria elatior occurs in the South Coast, Central Coast and North Coast regions of NSW as well as Queensland (Benson & McDougall 1999; Harden 2000). The site is not at or near the limit of distribution of this species.

How is the proposal likely to affect current disturbance regimes?

Only one individual was recorded within the study area and this would be removed by the proposal. Its habitat has been highly modified by past land uses and the proposal is unlikely to significantly alter the microhabitat conditions for other areas of potential habitat, except areas that would be subject to new edge effect (9.7 ha).

The proposal will not have an impact on the fire regime in the study area. Minor changes to the surface hydrology may occur as result of the proposed Upgrade; however not to an extent that are likely to affect the survival of its habitat (freshwater wetlands) within the area.

How is the proposal likely to affect habitat connectivity?

One individual plant was recorded from a wet meadow. This individual would be removed as a result of the proposed Upgrade which would also bisect the wet meadow resulting in the fragmentation and isolation of surrounding potential habitat for this species.

How is the proposal likely to affect critical habitat?

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations and ecological communities. Under the *Threatened Species Conservation Act 1995*, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for this species (Department of Environment and Conservation 2005e). The individual and its habitat is unlikely to be critical to the survival of this species.

Conclusion

Only one individual of this species has been recorded within the study area despite extensive surveys. The proposed development would require the removal of this individual however; this is unlikely to have a significant impact on this species.

7.2 Significance assessment - *Environment Protection and Biodiversity Conservation Act 1999*

Persicaria elatior within the study area is not considered to be an important population as defined under the *Environment Protection and Biodiversity Conservation Act 1999* Principal Significant Impact Guidelines (Department of the Environment and Heritage 2005) because: the site is not at the limit of distribution of this species; the individual occurring within the site is unlikely to be a key source populations either for breeding or dispersal; and, the individual within the site is unlikely to be necessary for maintaining genetic diversity.

Will the action lead to a long-term decrease in the size of an important population of a species?

The site does not contain an important population of *Persicaria elatior*.

Will the action reduce the area of occupancy of an important population?

The site does not contain an important population of *Persicaria elatior*.

Will the action fragment an existing important population into two or more populations?

The site does not contain an important population of *Persicaria elatior*.

Will the action adversely affect habitat critical to the survival of a species?

Only one individual was recorded within the site. This is individual and its habitat are unlikely to be critical for the survival of this species.

Will the action disrupt the breeding cycle of an important population?

The site does not contain an important population of *Persicaria elatior*.

Will the action modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?

The site contains potential habitat for this species in wetlands and the proposed Upgrade would remove 14.5 ha of this community. However, despite extensive surveys, only one individual was recorded within the site. The removal of this individual and its habitat is unlikely to result in a long term decline of this species.

Will the action result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species´ habitat?

This species occurs within wet meadow which is surrounded by cleared grassland and is already subject to edge effects. The only known individual within the site would be removed as a result of the proposal. However, to minimise impacts to areas of potential habitat mitigation measures such as cleaning vehicles and equipment prior to working within wetlands would be implemented to minimise invasion by invasive species.

Will the action interferes substantially with the recovery of the species?

The removal of one individual would be unlikely to interfere substantially with the recovery of this species.

Conclusion

Despite extensive surveys, only one individual was recorded within the site and the removal of this is unlikely to have a significant impact on this species.

8. Green-thighed Frog (*Litoria brevipalmata*)

Status

The Green-thighed Frog is listed as vulnerable under Schedule 2 of the *Threatened Species Conservation Act 1995*.

Description

Green-thighed Frog have bright green or blue-green colour on the groin and back of the thighs. They are small frogs (to 40 mm in length), rich brown to chocolate brown on the back, sometimes with smaller black flecks. A broad black stripe runs from the snout to the flank, ending as a series of blotches (Cogger 2000).

Habitat

Green-thighed Frogs occur in a range of habitats from rainforest and moist eucalypt forest to dry eucalypt forest and heath, typically in areas where surface water gathers after rain (Barker et al. 1995). In the Northern Rivers Catchment Management Region suitable breeding habitat is semi-permanent or ephemeral ponds or depressions in a range of vegetation communities, including rainforest, wet and dry forest, heath and grassland from 60 to 450 m in elevation (Department of Environment and Conservation 2005c). Foraging and refuge habitat is within leaf litter within 300 m of breeding habitat (Anstis 2002).

Ecology

Breeding occurs following heavy rainfall in late spring and summer, with frogs aggregating around grassy semi-permanent ponds and flood-prone grassy areas (Cogger 2000).

Egg masses are often laid in temporary ponds and their survival may depend on subsequent rains. The form of the egg mass is a single layer of poorly defined, cohering capsules at the surface, often partly entwined among vegetation (Anstis 2002).

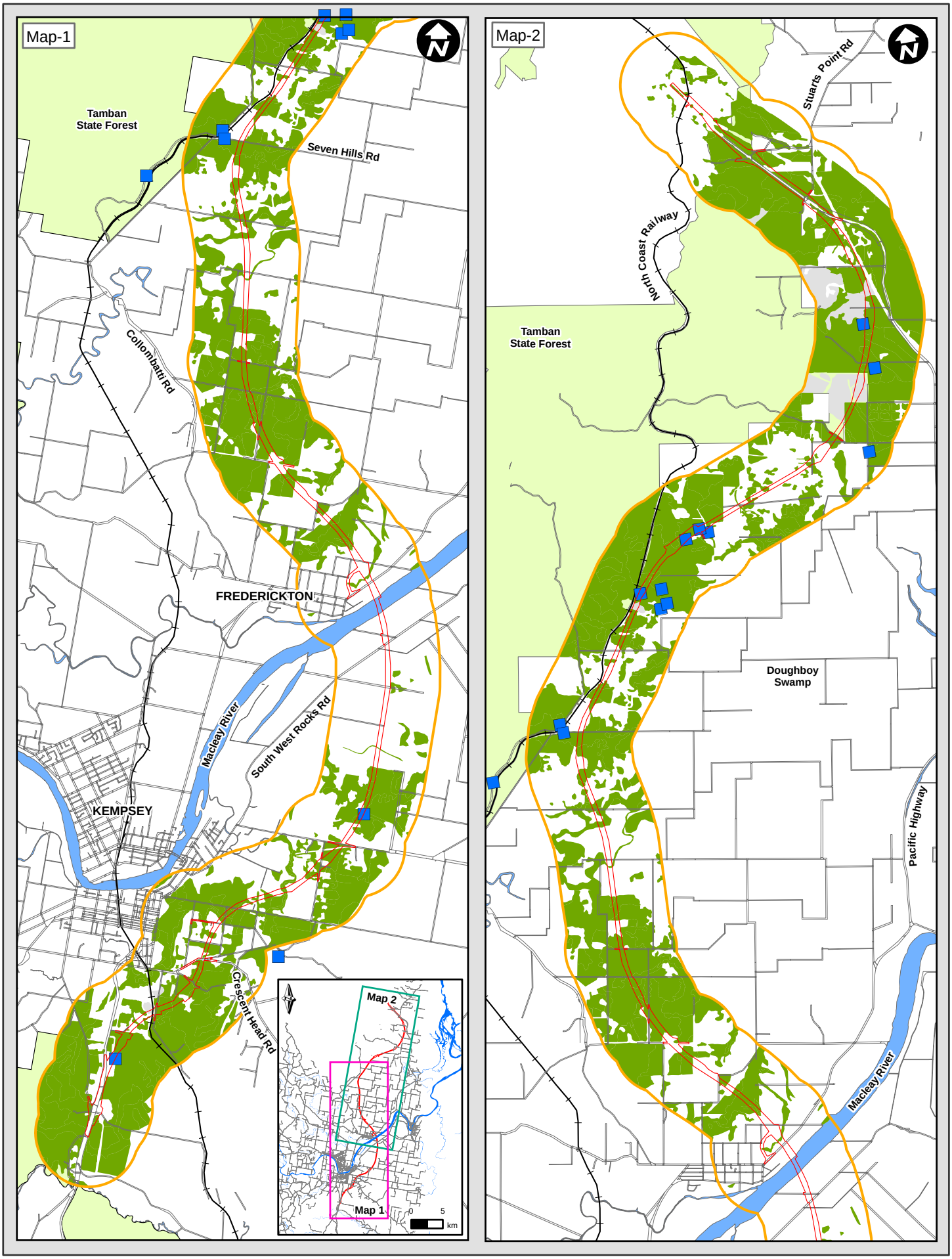
In the Northern Rivers Catchment Management region, the species calls form October to March within three days of heavy rains (more than 50 mm in a 24 hour period) (F. Lemckert, *personal communication*).

Distribution

The species is known from isolated localities along the coast and ranges from the NSW Central Coast to south-east Queensland (Barker et al. 1995).

In the study area:

The distribution of Green-thighed Frog is relatively continuous in the study area being found from the southern boundary northward to the Barraganyatti area (Figure B3). Metamorphs were observed at sites distributed between Seven Hills Road northward to the vicinity of Hills Road and Kawana Lane. Water at the remaining sites had evaporated or dispersed from those areas used as calling sites for male frogs. These sites may require more prolonged rainfall events to enable successful breeding. Generally sites used for breeding comprised areas of impeded drainage either natural or augmented through the creation of roads.



0 1 2 3 4 Kilometres

Note: Fauna may use other habitat types on an occasional basis.

Map B3 Habitat for Green Thighed Frog

Green Thighed Frog - Current Survey

Potential Habitat

Construction Footprint

Study Area

Existing Vegetation

Waterway

Existing Road

State Forest

2116519A_2056_Green_Thighed_Frog.mxd SWD - Sep, 2005

Threats

Specific threats to the Green-thighed Frog identified by Department of Environment and Conservation (2005b) include:

- changes to drainage patterns which reduce periodic local flooding
- damage to semi-permanent and ephemeral ponds and flood-prone vegetation
- clearing of habitat for agriculture or development
- habitat disturbance through timber harvesting
- reduction in water quality through grazing and pasture fertilisation
- reduction of leaf-litter and cover of fallen logs through grazing and associated burning.

Specific impacts

The proposed Upgrade involves the removal of a total of 287.2 ha of native vegetation, consisting of dry sclerophyll forest (78%), forested wetland (14%), wet sclerophyll forest (3%) and wetland (5%) that provide foraging and breeding habitat for the Green-thighed Frog.

In some areas, such as at Collombatti and Tamban State Forest, the proposed Upgrade may fragment habitat for the Green-thighed Frog.

Without mitigation measures, indirect impacts to the species include the potential siltation of watercourses during construction, polluted runoff from road surfaces, road kills and increased predation by introduced animals.

Mitigation measures

Experimental artificial breeding habitat would be created within the road reserve. This trial habitat would be designed to mimic the natural situation where breeding occurs within areas of impeded drainage close to sites of intact native vegetation. The most important elements in the design include ensuring that some flood waters are retained, for the correct period of time, and that the pond is adjacent to moist forest (F. Lemckert, *personal communication*).

8.1 Significance assessment - *Environmental Planning and Assessment Act 1979*

How is the proposal likely to affect the lifecycle of a threatened species and/or population?

The proposed Upgrade involves the removal of a total of 287.2ha of native vegetation, consisting of dry sclerophyll forest (78%), forested wetland (14%) and wet sclerophyll forest (3%) and wetland (5%). As a result, the proposal involves the removal of a significant area of breeding, foraging and refuge habitat for the species.

It is likely that the removal of habitat would disrupt the lifecycle of a local population of Green-thighed Frog.

How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The proposal involves the removal of a significant area (287.2 ha) of breeding, foraging and refuge habitat for the species. This is also considered to be a significant amount of habitat in relation to the distribution of habitat available in the local and regional area.

The proposal would include two Key Threatening Processes listed on the *Threatened Species Conservation Act 1995*:

- clearing of native vegetation
- alteration of the natural flow regimes of rivers, streams, floodplains and wetlands.

Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The species is known from isolated localities along the coast and ranges from the New South Wales central coast to south-east Queensland. The site is not at the limit of distribution for the species.

How is the proposal likely to affect current disturbance regimes?

The proposal is likely to significantly alter the microhabitat conditions in areas that would be subject to new edge effect (157.9 ha) and result in increased weed invasion, reduction in water quality and leaf litter.

The proposal would not have an impact on the fire regime in the study area. Minor changes to the surface hydrology may occur as result of the Proposal; however not to an extent that are likely to affect the survival of the ecological community in the area.

How is the proposal likely to affect habitat connectivity?

Green-thighed frogs disperse 300 m from their breeding sites, however details on the ability of the species to disperse across fragmented landscapes is not documented.

The proposed Upgrade is likely to form a physical barrier for frogs attempting to migrate to the breeding site from vegetated areas on the far side of the road or at least represent a route with a significant chance of mortality through vehicle impact.

How is the proposal likely to affect critical habitat?

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations and ecological communities. Under the *Threatened Species Conservation Act 1995*, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for this species.

Conclusion

The proposal is likely to have a significant impact on the Green-thighed Frog through the loss of habitat including known breeding sites.

9. Glossy Black-cockatoo (*Calyptorhynchus lathami*)

Status

The Glossy Black-cockatoo is listed as vulnerable under Schedule 2 of the *Threatened Species Conservation Act 1995*.

The Riverina population of Glossy Black-cockatoos is listed as Endangered under Part 2 of Schedule 1 of the *Threatened Species Conservation Act 1995*. The local population within the study area does not form part of this population and is consequently not listed as endangered.

Description

The Glossy Black-cockatoo is a dusky brown to black cockatoo with a massive, bulbous bill and a broad, red band through the tail. The red in the tail is barred black and edged with yellow. The female usually has irregular pale-yellow markings on the head and neck and yellow flecks on the underparts and underwing. They are smaller than other black cockatoos (about 50 cm in length), with a smaller crest (Pizzey & Knight 1997).

Habitat

The Glossy Black-cockatoo is dependent on *Allocasuarina* trees, and prefers woodland dominated by Allocasuarina, or open sclerophyll forests or woodlands, with middle stratum of *Allocasuarina* below *Eucalyptus* or *Angophora*; often confined to remnant patches in hills and gullies, surrounded by cleared agricultural land (Higgins 1999). Glossy Black-cockatoos prefer to live in rugged country, where extensive clearing has not taken place (NSW National Parks and Wildlife Service 1999d).

The species forages arboreally among branches of fruiting Allocasuarina. Prefers mature, sparse trees, between 2 and 10 m tall; dense regrowth (e.g. after bushfire.) It rarely forages in other shrubs or small trees of low woodlands or understorey (Arnett & Pepper 1997).

The species breeds in hollow stumps or spout of living or dead limb of eucalypt tree, or holes in trunks of tall tree. It breeds mainly within woodland or remnant woodland, but has been also recorded in dead, ringbarked eucalypt in cleared country. Entrances to hollows are either a hole in the side of a trunk, broken top of stump, or end of spout or limb (NSW National Parks and Wildlife Service 1999d).

Ecology

Glossy Black-cockatoos mostly roost in the canopy of live, leafy trees; preferring eucalypt trees, but will use other species, usually a kilometre from feeding site and during breeding season, within 30 m of nesting tree. Glossy Black-cockatoo feed exclusively on the seeds of mature *Allocasuarina* trees, occasionally taking wood-boring insect larvae, seeds of eucalypts, angophoras, hakeas and acacias (Higgins 1999).

Evidence of the bird is often indicated by a layer of cracked cones and fragments that have accumulated under favoured casuarina trees. A study in Eden, on the south coast of NSW, indicated that the Glossy Black-cockatoo is selective in its choice of food trees, choosing casuarinas that produce seeds with a high nutrient value (Crowley & Garnett 2001).

Glossy Black-cockatoos are dependent on large hollow-bearing eucalypts for nest sites. One or two eggs are laid between March and August (Garnett et al. 1999).

Distribution

The Glossy Black-cockatoos has a patchy distribution in Australia, having once been widespread across most of the south-eastern part of the country. It is now distributed throughout an area which extends from the coast near Eungella in eastern Queensland to Mallacoota in Victoria. In New South Wales, the current distribution of the Glossy Black-cockatoo covers areas from the coast to the tablelands, and as far west as the Riverina and Pilliga Scrub (NSW National Parks and Wildlife Service 1999d).

In study area:

Stands of Allocasuarina are found along the proposed route and are used by Glossy Black-cockatoos.

Glossy Black-cockatoo was recorded at ten (71%) of the 14 sites in the study area (Figure B4). Records comprise both observations of feeding birds and signs of foraging evidence (chewed cones of both *Allocasuarina littoralis* and *A. torulosa*). Extensive foraging resources were identified and subsequently mapped at sites five, eight and nine.

Important foraging and nesting resources were located at site five and to a lesser extent adjacent to site eight (south Cooks Lane), nine (Kawana Lane) and Seashore Lane (Kemps Access). Dense stands of Allocasuarina resources occur in close proximity to suitable nesting resources. Site perusals of these areas found extensive foraging evidence with birds almost always present.

Fifty-two trees were considered to provide suitable nest sites for Glossy Black Cockatoo.

Threats

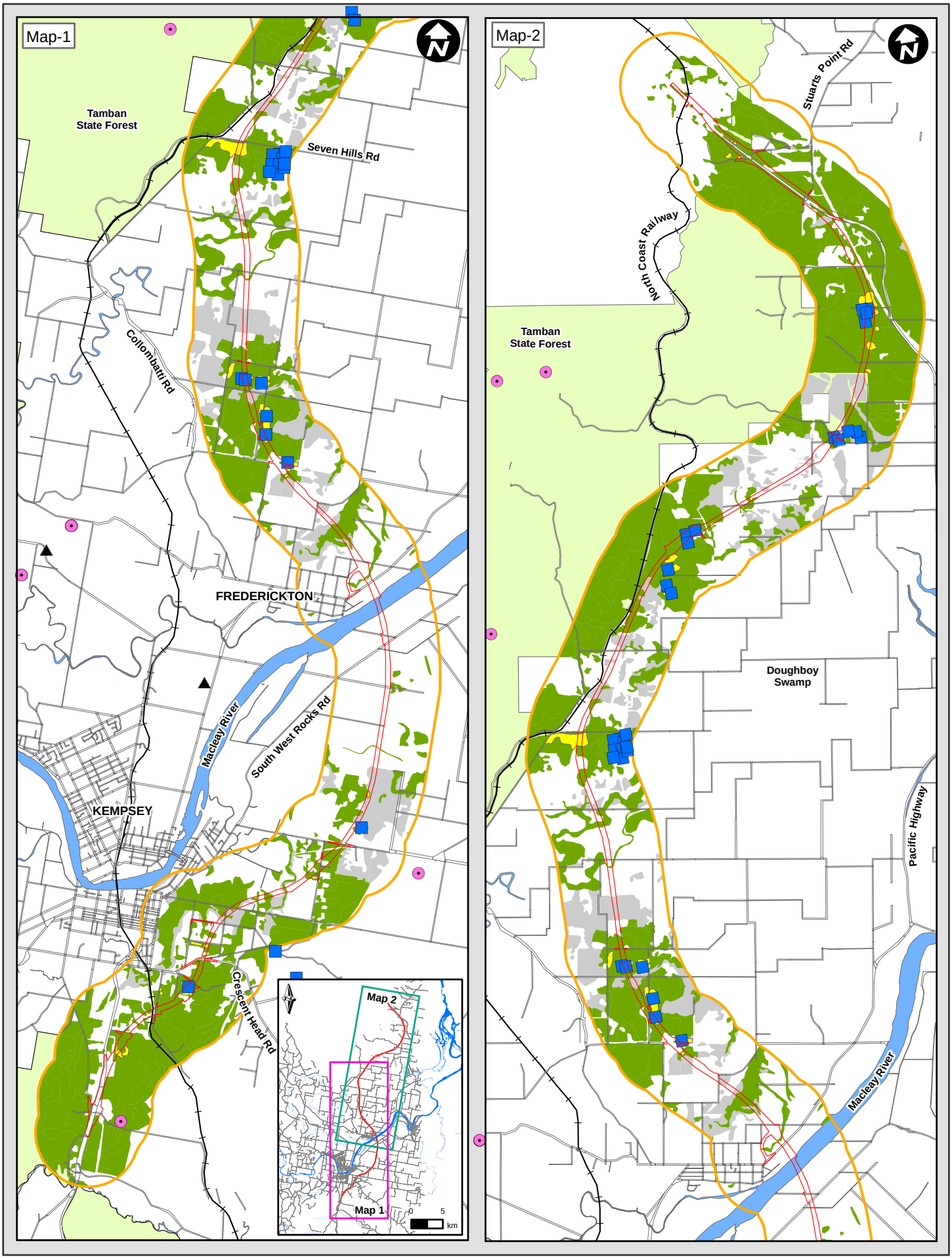
Specific threats to Glossy Black-cockatoo identified by the Department of Environment and Conservation (2005c) include:

- reduction of suitable habitat through clearing for development
- loss of tree hollows
- excessively frequent fire which reduces the abundance and recovery of she-oaks
- illegal bird smuggling and egg-collecting.

Specific impacts

The proposed route has been realigned to avoid significant stands of *Allocasuarina* resources and breeding habitat; however a total of 19.5 ha of *Allocasuarina* will be removed as part of the proposed Upgrade. This total amount comprises of dense stands (7%), moderately dense stands (73%) and light/sparse stands (20%). A total of 52 hollow-bearing trees that are suitable for this species for breeding have been recorded along and immediately adjacent to the proposed upgrade.

Glossy Black-cockatoos may be at risk of road strike where they forage along roadsides.



2116519A_2057_Glossy_Black_Cockatoo.mxd SWD - Sep, 2005

0 1 2 3 4 Kilometres

Note: Fauna may use other habitat types on an occasional basis.

Glossy Black Cockatoo (Current Survey)

Glossy Black-Cockatoo (Atlas of NSW Wildlife)

Glossy Black-Cockatoo (Birds Australia Atlas)

Allocasuarinas

Potential Habitat

Construction Footprint

Study Area

Existing Vegetation

Waterway

Existing Road

State Forest

Map B4 Habitat for Glossy Black Cockatoo

9.1 Significance assessment - *Environmental Planning and Assessment Act 1979*

How is the proposal likely to affect the lifecycle of a threatened species and/or population?

The proposed route has been realigned to avoid significant stands of *Allocasuarina* foraging resources as well as breeding habitat. However a total of 19.5 ha of *Allocasuarina* will be removed as part of the proposed Upgrade. This total amount is comprised of dense stands (7%), moderately dense stands (73%) and light/sparse stands (20%). A total of 52 hollow bearing trees that are suitable for this species for breeding have been recorded along and immediately adjacent to the proposed Upgrade.

Significantly large areas of adjoining habitat containing foraging habitats and hollow-bearing trees will be retained. Although the northern half of the study area contains some habitat resources that are likely to support lifecycle attributes for Glossy Black-cockatoo, the removal of habitat is unlikely to have a significant affect on the viability of the local population, and would not place it at risk of extinction.

How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

Areas of known and potential foraging habitat (19.5 ha) and potential nesting habitat (52 hollow-bearing trees) will be removed as a result of the proposed Upgrade. Glossy Black-cockatoos occur extensively throughout north east New South Wales suggesting that their preferred habitats occur over a wide geographic area. Therefore, the proposed Upgrade is unlikely to represent a significant area in relation to the regional distribution of habitat for the Glossy Black-cockatoo.

Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

Glossy Black-cockatoos occur in coastal and inland eastern Australia from Eungall National Park in Queensland to Wingan Inlet in eastern Victoria, with an isolated population on Kangaroo Island (Pizzey & Knight 1997). Therefore, this species is not at its distributional within the study area.

How is the proposal likely to affect current disturbance regimes?

Parts of the proposed Upgrade occur within already cleared or fragmented habitats that include a range of disturbances commonly found in agricultural landscapes. However the proposed Upgrade will require clearing of vegetation and habitats in relatively intact areas and as such will introduce new edge effects to these sites. In total, 157.9 ha of vegetation will be affected by new edge effects that may include weeds, increased levels of predation, increased noise and changed hydrological regimes.

How is the proposal likely to affect habitat connectivity?

The movements of Glossy Black-cockatoos are poorly known (Crowley & Garnett 2001), although the species appears to occupy one area permanently, though individuals and sub groups may move around within it. Glossy Black-cockatoos are known to fly large distances of up to 12 km when moving between breeding and feeding areas, and flocks are said to move locally when preferred foraging areas become depleted of food (Higgins 1999).

The proposal will not isolate habitat for the Glossy Black-cockatoo. Roads are unlikely to create a barrier to movement for this high mobile species.

How is the proposal likely to affect critical habitat?

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations and ecological communities. Under the *Threatened Species Conservation Act 1995*, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for this species (Department of Environment and Conservation, Threatened Species Unit). Significantly large areas of habitat containing foraging habitats and hollow-bearing trees occur adjacent to the site and would be retained. The habitat to be removed is unlikely to be critical to the survival of this species.

Conclusion

The proposal is likely to have a significant impact on the Glossy Black-cockatoo through the loss of foraging habitat and breeding resources. Although significant areas of habitat have been avoided through the route selection process, important areas of habitat will still be affected.

10. Black-necked Stork (*Ephippiorhynchus asiaticus*)

Status

The Black-necked Stork is listed as endangered under Schedule 1 of the *Threatened Species Conservation Act 1995.*

Description

The Black-necked Stork stands at about 1.3 m tall and has a wingspan of around 2 m, with a massive, strong, black bill. The head and neck are black with an iridescent green and purple gloss. Black panels are visible above and below the white wings. The tail is short and black, with the rest of the plumage white. The legs are long and red. The female has a yellow eye, and the male has a dark eye. Juvenile birds have a dark to pale brown plumage, gradually changing over several years to the black and white adult plumage (Pizzey & Knight 1997).

Habitat

Black-necked Storks usually inhabit swamps associated with river systems and large freshwater wetlands but sometimes appears on the coast and estuaries. Flooded pasture, grassland and woodland occasionally provides foraging habitat for this species. The species prefers mainly open fresh waters with extensive sheets of shallow water over grassland or sedgeland; shallow swamps with short emergent vegetation and abundant aquatic flora and permanent billabongs and pools on floodplains. It also uses freshwater meadows, wet heathland, seepage from springs, semi-permanent swamps with tall emergent vegetation (e.g. *Eleocharis, Typha*), melaleuca swamps, watercourses and reservoirs (Marchant & Higgins 1990).

Ecology

Black-necked Storks most often forage on fish, eels, frogs, snakes and crustaceans in shallow water. The species breeds in late summer in the north and early summer further south. Black-necked Storks construct a large nest, up to 2 m in diameter that is made in a live or dead tree, in or near a freshwater swamp. Two to four eggs are laid; incubation is by both parents (Dorfman et al. 2001). The species is apparently largely sedentary although some birds move long distances and are recorded well outside their range. Individuals or pairs may remain in an area for many years (Marchant & Higgins 1990).

Distribution

The species is widespread across coastal northern and eastern Australia, becoming increasingly uncommon further south into NSW, and rarely south of Sydney. Some birds may move long distances and can be recorded well outside their normal range (Department of Environment and Conservation 2005b).

Known habitat for Black-necked Storks occurs within conservation reserves of the North Coast region. However, the majority of habitat for this species occurs on private lands, indicating that the species and its habitats are inadequately represented within the conservation reserve system (Marchant & Higgins 1990).

In the study area:

The species was not recorded during the current study, however it has been previously been recorded in wetland habitats near the Macleay River (Department of Environment and Conservation 2005a) and suitable habitat exists (Figure B5).

Threats

Specific threats to Black-necked Storks identified by the Department of Environment and Conservation (2005b) and (Kingsford & Norman 2002) include:

- loss of wetland habitat through clearing and draining for flood mitigation, agriculture and residential development
- degradation of wetland habitats through pollution and salinisation
- modification of natural wetlands through changes in natural water flow regimes.

Specific impacts

One SEPP 14 Wetland lies within the study area, known as Collombatti Swamp (ID478) which provide potential habitat for this species. The boundary of Collombatti Swamp is approximately 100 m to the east of the construction footprint. The construction of the proposed Upgrade would be unlikely to have any direct impact on the wetland. There is potential for indirect environmental impacts (resulting from erosion, runoff and subsequent changes to water quality) on the SEPP 14 wetland. However, the proposal would include adequate safeguards so that indirect environmental impacts are ameliorated.

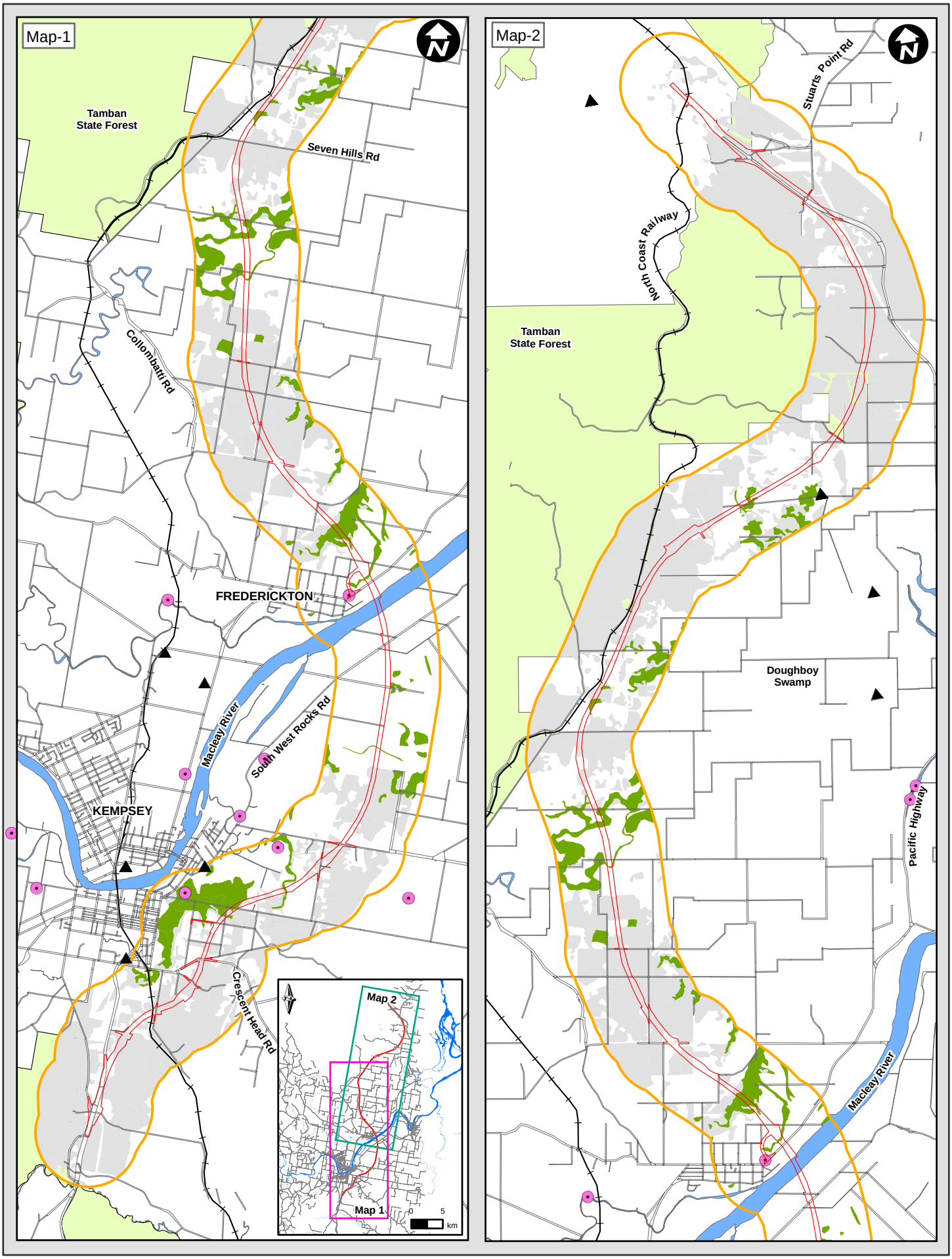
The proposal involves the removal of 14.5 ha of freshwater wetland habitat which are partially cleared and generally surrounded by grazed grassland. The majority of the wetlands within the site (93%) are wet meadows that have a high level of weed invasion and are in poor condition. Approximately 1.0 ha of Lepironia swamp in moderate condition would be removed. As a result, the proposal will result in the loss of a relatively small area of potential foraging and breeding habitat for Black-necked Storks.

Mitigation measures

Measures have been identified and incorporate into the proposal to ensure that the positioning of road embankments and bridges do not inhibit the movement and retention of floodwaters and current drainage patterns.

Areas of riparian vegetation likely to be damaged or removed during construction would be replanted on completion of the works. In addition, appropriate sediment control measures would be put in place around all proposed waterway crossings prior to construction to ensure minimal change in water quality of the waterways due to run-off.

The disturbance to acid sulfate soils will be minimised by using construction techniques in the areas mentioned above that would avoid disturbing large areas of high potential acid sulfate soils. Excavations required to build bridge piles and footings would be bunded during the entire construction process, and vegetation around the new bridge piles would be replanted. Similarly, extra sediment control measures would be put in place upstream of the SEPP 14 wetland north of Frederickton to ensure minimal change in water quality.



2116519A_2059_Black_necked_Stork.mxd SWD - Sep, 2005

0 1 2 3 4 Kilometres

Black-necked Stork (Atlas of NSW Wildlife)

Black-necked Stork (Birds Australia Atlas)

Potential Habitat

Note: Fauna may use other habitat types on an occasional basis.

Construction Footprint

Study Area

Existing Vegetation

Waterway

Existing Road

State Forest

Map B5 Habitat for Black-necked Stork

10.1 Significance assessment - *Environmental Planning and Assessment Act 1979*

How is the proposal likely to affect the lifecycle of a threatened species and/or population?

The proposed Upgrade involves the removal of 14.5 ha of freshwater wetland habitat that have been partially cleared in the past and are generally surrounded by grazed grassland. The majority of the wetlands within the site (93%) are wet meadows that have a high level of weed invasion and are in poor condition. Approximately 1.0 ha of Lepironia swamp would be removed and it was generally in moderate condition.

In the study area Black-necked Stork uses wetland habitat for foraging and potentially breeding activities within the southern half of the study area and the northern side of the Macleay River. The amount of Lepironia swamp habitat proposed for removal is considered to be a relatively small area. Given the proposed mitigation measures, it is unlikely that such habitat in adjacent areas would be significantly affected.

The removal of this habitat is unlikely to affect breeding activity of this species as a further 507 ha of wetland habitat occurs within the study area. The proposal is considered unlikely to disrupt any local population of Black-necked Storks or place it risk of extinction.

How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The proposal involves the removal of 14.0 ha of freshwater wetland habitat. Similar habitat will be retained in adjacent areas (totalling 507 ha in the study area) and would continue to provide storks with foraging resources. The removal of habitat for the proposal is not considered to be significant in a regional context.

Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Black-necked Stork has been recorded throughout Northern Australia and as far south as Bega in southern New South Wales. The study area is therefore not at the distributional limit for this species.

How is the proposal likely to affect current disturbance regimes?

Parts of the proposed Upgrade occur within already cleared or fragmented habitats that include a range of disturbances commonly found in agricultural landscapes. However the proposed Upgrade will require clearing of vegetation and habitats in relatively intact areas and as such will introduce new edge effects to these sites. In total, 9.7 ha of wetland vegetation will be affected by new edge effects that may include weeds, increased levels of predation, increased noise and changed hydrological regimes.

How is the proposal likely to affect habitat connectivity?

The proposed route will not isolate habitat for this species as it is likely that Black-necked Storks will readily fly above the proposed road to access other areas. Black-necked Storks are generally not regarded as susceptible to road strike.

How is the proposal likely to affect critical habitat?

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations and ecological communities. Under the *Threatened Species Conservation Act 1995*, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for this species. Due to the small area of vegetation to be cleared and its degraded condition, this habitat is unlikely to be critical to the survival of this species.

Conclusion

The proposal is unlikely to have a significant impact on the Black-necked Stork. Only a small area of habitat will be removed as a result of the proposed Upgrade and this does not represent significant habitat for the species in the local or regional areas.

11. Comb-crested Jacana (*Irediparra gallinacea*)

Status

The Comb-crested Jacana is listed as vulnerable under Schedule 2 of the *Threatened Species Conservation Act 1995.*

Description

The Comb-crested Jacana is small (up to 25 cm long) wetland bird, with large toes that make its feet virtually as long as its entire body. The above are parts brown and it has a white face and throat and belly, separated by a broad dark breast-band, with a big red forehead comb and red bill. It has a distinctive strident chittery call (Pizzey & Knight 1997).

Habitat

Comb-crested Jacana permanently inhabits wetlands with a good surface cover of floating vegetation, especially water-lilies. Artificial habitats include reservoirs and dams with suitable floating vegetation and anaerobic sewage ponds where scum has formed a firm mat on the surface of the water (Marchant & Higgins 1993). Additional habitat has been created by the introduction of and colonisation of wetlands by *Salvinia molesta* (Kingsford 2000).

Ecology

Comb-crested Jacana are found singly or in pairs and family groups that forage across floating vegetation, walking with a characteristic bob and flick, or flying low with toes dangling behind (Simpson & Day 1996). The species is diurnal, feeding in the day, primarily on insects and other invertebrates, as well as some seeds and other vegetation (Dostine & Morton 2000).

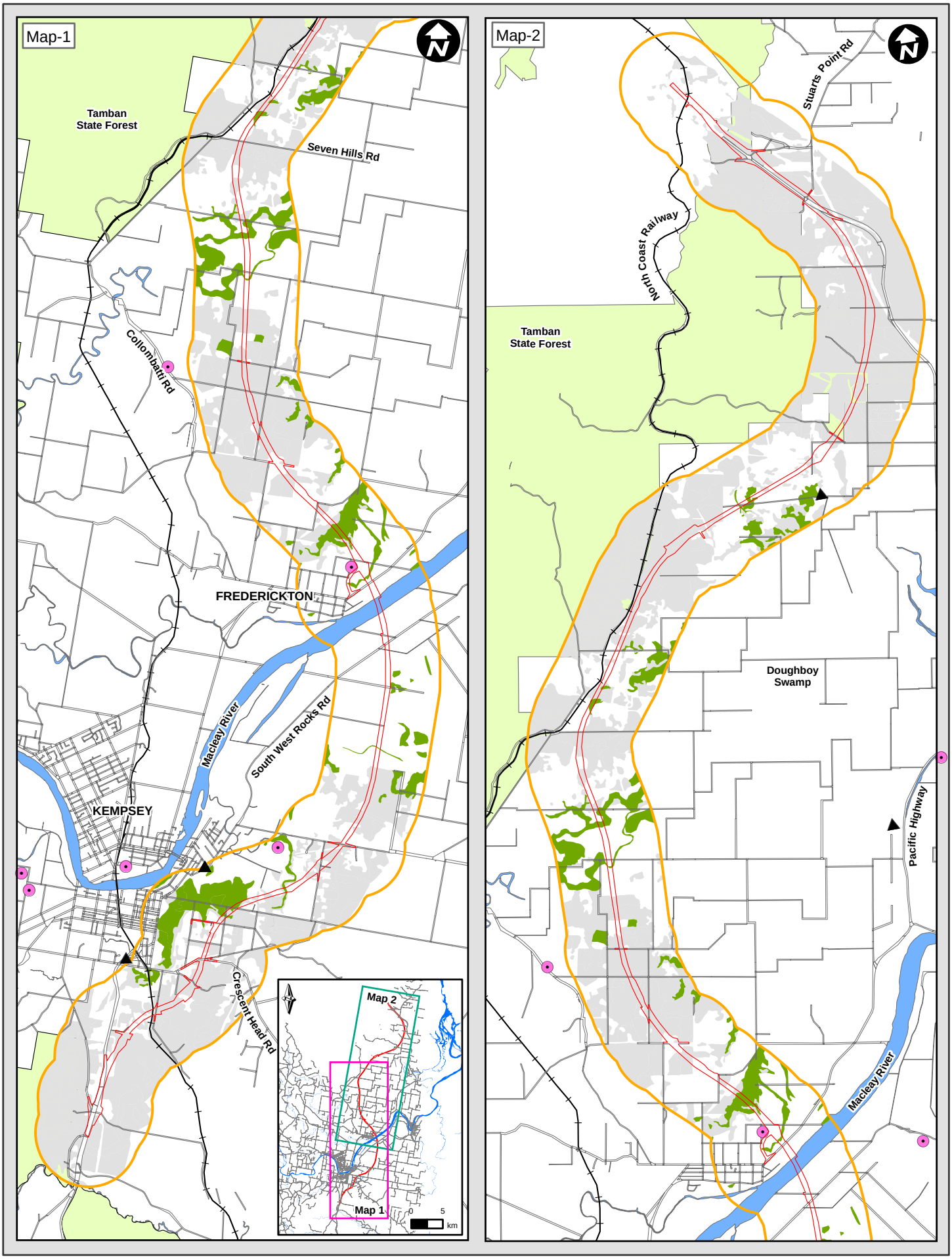
In New South Wales, Comb-crested Jacana breed in spring and summer in a fragile nest of floating vegetation comprising of sedge, grass and aquatic plants. Extra nests are built for nocturnal roosting. The male builds the nest, incubates the eggs and broods the young. Females defend up to four mated males and their territories (the floating vegetation around their nest) from other females. Young birds will dive and stay submerged with just their nostrils exposed for a very long time, while adults will also dive for safety on occasion (Marchant & Higgins 1993).

The Comb-crested Jacana moves in response to seasonal wetland conditions between permanent and seasonal wetlands (Dostine & Morton 2000).

Distribution

Comb-crested Jacana occurs throughout coastal Australia and well inland in the north from the Kimberley region of Western Australia to Sydney in New South Wales. Vagrants occasionally appear further south, possibly in response to unfavourable conditions further north in New South Wales. Within New South Wales the Comb-crested Jacana are found along the coast from the Queensland border south to the Hunter Valley and Hawkesbury districts (Department of Environment and Conservation 2005b).

The species was not recorded during the current study, however the species has been recorded previously near the Macleay River at Kempsey and Frederickton (Department of Environment and Conservation 2005a) and potential habitat exists in the study area (Figure B6).



2116519A_2060_Comb_Crested_Jacana.mxd SWD - Sep, 2005

0 1 2 3 4 Kilometres

Note: Fauna may use other habitat types on an occasional basis.

Comb-crested Jacana (Atlas of NSW Wildlife)

Comb-crested Jacana (Birds Australia Atlas)

Potential Habitat

Construction Footprint

Study Area

Existing Vegetation

Waterway

Existing Road

State Forest

Map B6 Habitat for Comb-crested Jacana

Threats

The main threat to Comb-crested Jacana is the loss and degradation of wetland habitat through clearing and draining for flood mitigation and agriculture (Department of Environment and Conservation 2005b; Kingsford 2000).

Specific impacts

One SEPP 14 Wetland lies within the study area, known as Collombatti Swamp (ID478) which provide potential habitat for this species. The boundary of Collombatti Swamp is approximately 100 m to the east of the construction footprint. The construction of the proposed Upgrade would be unlikely to have any direct impact on the wetland. There is potential for indirect environmental impacts (resulting from erosion, runoff and subsequent changes to water quality) on the SEPP 14 wetland. However, the proposal would include adequate safeguards so that indirect environmental impacts are ameliorated.

The proposal involves the removal of 14.5 ha of freshwater wetland habitat which are partially cleared and generally surrounded by grazed grassland. The majority of the wetlands within the site (93%) are wet meadows that have a high level of weed invasion and are in poor condition. Approximately 1.0 ha of Lepironia swamp in moderate condition would be removed. As a result, the proposal will result in the loss of a relatively small area of potential foraging and breeding habitat for Comb-crested Jacana.

Mitigation measures

Measures have been identified and incorporated into the proposal to ensure that the positioning of road embankments and bridges do not inhibit the movement and retention of floodwaters and current drainage patterns.

Areas of riparian vegetation likely to be damaged or removed during construction would be replanted on completion of the works. In addition, appropriate sediment control measures would be put in place around all proposed waterway crossings prior to construction to ensure minimal change in water quality of the waterways due to run-off.

The disturbance to acid sulfate soils will be minimised by using construction techniques in the areas mentioned above, that would avoid disturbing large areas of high potential acid sulfate soils. Excavations required to build bridge piles and footings would be bunded during the entire construction process, and vegetation around the new bridge piles would be replanted. Similarly, extra sediment control measures would be put in place upstream of the SEPP 14 wetland north of Frederickton to ensure minimal change in water quality.

11.1 Significance assessment - *Environmental Planning and Assessment Act 1979*

How is the proposal likely to affect the lifecycle of a threatened species and/or population?

The proposed Upgrade involves the removal of 14.5 ha of freshwater wetland habitat have been partially cleared in the past and are generally surrounded by grazed grassland. The majority of the wetlands within the site (93%) are wet meadows that have a high level of weed invasion and are in poor condition. Approximately 1.0 ha of Lepironia swamp would be removed and it was generally in moderate condition.

In the study area Comb-crested Jacana may use such wetland habitat for foraging and potentially breeding activities within the southern half of the study area and the northern side of the Macleay River. The amount of Lepironia swamp habitat proposed for removal is considered to be a relatively small area. Given the proposed mitigation measures, it is unlikely that such habitat in adjacent areas would be significantly affected.

The proposal is considered unlikely to disrupt the lifecycle of any local population of Comb-crested Jacana or place it risk of extinction.

How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The proposal involves the removal of 14.5 ha of freshwater wetland habitat. The majority of the wetlands within the site (93%) are wet meadows that have a high level of weed invasion and are in poor condition. Approximately 1.0 ha of Lepironia swamp would be removed and it was generally in moderate condition.

Construction of the proposal will not remove or modify a significant area of known habitat for Comb-crested Jacana in a regional context. Similar habitat will be retained in adjacent areas (507 ha in the study area) and continue to provide resident Comb-crested Jacana with foraging resources. The removal of this habitat is not considered to be significant.

The main pressures on the survival of the species and its habitat are the drainage of coastal wetlands for agriculture or urban development; disturbance of core breeding habitat by livestock and humans, and changes in wetland water levels in response to drought or other events (Kingsford & Norman 2002). The proposal does not include any of these threats.

Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The species is found in habitats from the Kimberley region, Cape York Peninsula, east and south east Queensland to the Hunter region of New South Wales (Department of Environment and Conservation 2005b). The study area is not at the distributional limit for the Comb-crested Jacana.

How is the proposal likely to affect current disturbance regimes?

Parts of the proposed Upgrade occur within already cleared or fragmented habitats that include a range of disturbances commonly found in agricultural landscapes. However the proposed Upgrade will require clearing of vegetation and habitats in relatively intact areas and as such will introduce new edge effects to these sites. In total, 9.7 ha of wetland vegetation may be affected by new edge effects that may include weeds, increased levels of predation, increased noise and changed hydrological regimes.

How is the proposal likely to affect habitat connectivity?

The proposed route is unlikely to isolate access to areas of habitat for Comb-crested Jacana. Comb-crested Jacana are capable of long distance movements (Dostine & Morton 2000), and it is likely that this species will readily fly above the road to access areas of habitat. Flights of the species are usually short and low (Marchant & Higgins 1993), however Comb-crested Jacana are generally not regarded as susceptible to road strike.

How is the proposal likely to affect critical habitat?

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations and ecological communities. Under the *Threatened Species Conservation Act 1995*, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for this species (Department of Environment and Conservation, Threatened Species Unit). Due to the small area of vegetation to be cleared and its degraded condition, this habitat is unlikely to be critical to the survival of this species.

Conclusion

The proposal is unlikely to have a significant impact on the Comb-crested Jacana. Only a small area of habitat will be removed as a result of the proposed Upgrade and this does not represent significant habitat for the species in the local or regional areas.

12. Square-tailed Kite (*Lophoictinia isura*)

Status

The Square-tailed Kite is listed as vulnerable under Schedule 2 of the *Threatened Species Conservation Act 1995*.

Description

The Square-tailed Kite is a long-winged, medium-sized raptor with a red-like body colour (Simpson & Day 1996). Adults have a white face with thick black streaks on the crown and finer streaks elsewhere. The saddle, rump and central upper tail coverts are blackish with grey-brown barring. The underparts are predominantly grey-brown with black tips on the grey, square-tipped tail and wing edges. The long fingered, upswept wings have a large white patch at the base of the barred 'fingers' on the outer ends of the wings a is a reddish (Pizzey & Knight 1997).

Habitat

On the coast this species is found in a variety of timbered habitats including dry woodlands and open forests particularly those on fertile soil, however it shows a particular preference for inland timbered watercourses (Debus et al. 1993; Pizzey & Knight 1997). Square-tailed Kites will range into open habitats nearby, but not into extensive treeless regions. It will also forage over partially cleared pastoral land and coastal heath. A common feature of Square-tailed Kite habitat is the presence of profuse eucalypt blossom and attendant nectivorous birds on which the preys (Marchant & Higgins 1993) Rough-barked Apple (*Angophora floribunda*) appears to be an important nest tree (Debus et al. 1993).

Ecology

Square-tailed Kites are specialist hunters of passerines, especially honeyeaters. The species has also been observed to eat frogs, insects and reptiles. Breeding is from July to February, with nest sites generally located along or near watercourses near surrounding forest or woodland, in a fork or on large horizontal limbs of living trees (Debus et al. 1993).

Relatively little is known of the home range of the square-tailed kite, however Debus et. al (1993) documented that a pair of kites utilised 5 to 6 km of river. In another area, two pairs occupied a 4,850 ha property and in another area, one pair moved progressively over an area of 70 square kilometres during a 12 month period. The species appears to occupy large hunting ranges of more than 100 square kilometres (NSW National Parks and Wildlife Service 1999f).

Distribution

The Square-tailed Kite ranges along coastal and subcoastal areas from south-western to northern Australia, Queensland, New South Wales and Victoria. In New South Wales, scattered records of the species throughout the state indicate that the species is a regular resident in the north, north-east and along the major west-flowing river systems (Department of Environment and Conservation 2005b). It is a summer breeding migrant to the south-east, including the New South Wales south coast, arriving in September and leaving by March (Debus et al. 1993).

Square-tailed Kites were observed adjacent to the northern part of Tamban State Forest (Figure B7). It has been recorded previously adjacent Cooks Lane & Kemps Access at Kempsey near the Macleay River and at Frederickton (Department of Environment and Conservation 2005a). The fauna surveys did not record any raptor nests consistent with this species.

Threats

Specific threats to Square-tailed Kite identified by the Department of Environment and Conservation (2005b) include:

- clearing, logging, burning, and grazing of habitats resulting in a reduction in nesting and feeding resources
- disturbance to or removal of potential nest trees near watercourses
- illegal egg collection and shooting.

Specific impacts

The proposed Upgrade involves the removal of a total of 272.8 ha of native forest, consisting of dry sclerophyll forest (82%), forested wetland (14%) and wet sclerophyll forest (3%) that provide foraging habitat for the Square-tailed Kite.

12.1 Significance assessment - *Environmental Planning and Assessment Act 1979*

How is the proposal likely to affect the lifecycle of a threatened species and/or population?

The proposed Upgrade involves the removal of a total of 272.8 ha of native forest, consisting of dry sclerophyll forest (82%), forested wetland (14%) and wet sclerophyll forest (3%) that provide potential foraging habitat for the Square-tailed Kite.

Similar foraging habitats in adjacent areas will remain unaffected. No raptor nests consistent with the species were recorded during field surveys and potential breeding locations along water course would not require habitat removal.

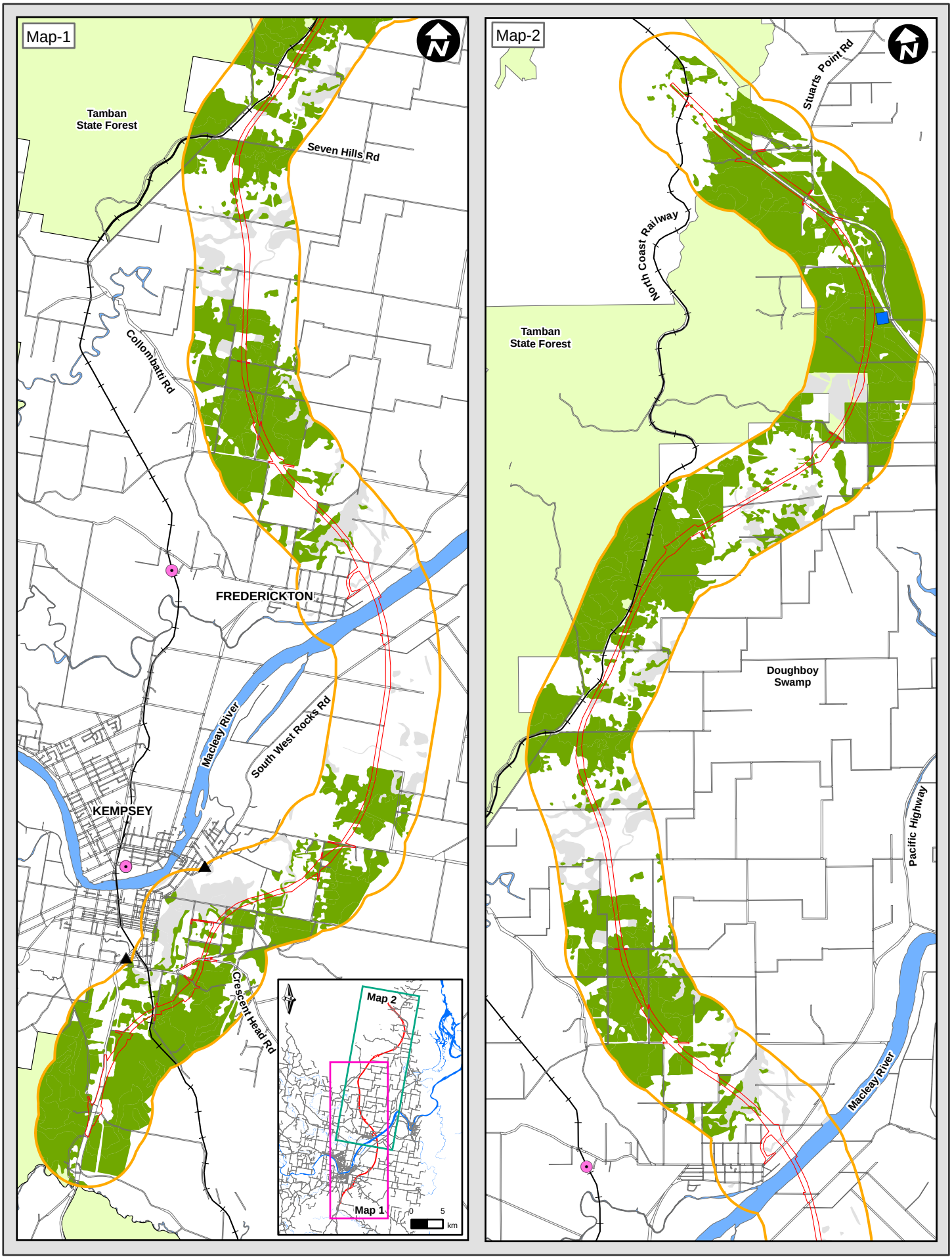
The proposal is unlikely to affect the breeding cycle of any local population of Square-tailed Kite or place it risk of extinction.

How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The proposed Upgrade involves the removal of a total of 272.8 ha of native forest. Clearing of native vegetation is listed as a Key Threatening Process under the *Threatened Species Conservation Act 1995*. Similar habitat will be retained in adjacent areas (5,090 ha in the study area) and continue to provide resident Square-tailed Kite with foraging resources. The removal of this habitat is not considered to be significant in a regional context.

Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The species ranges along coastal and sub-coastal areas from south Western Australia, the Pilbara and Kimberley regions, eastern Queensland, New South Wales to Victoria (Debus et al. 1993). The study area is not at the distributional limit for the Square-tailed Kite.



2116519A_2061_Square-tailed_Kite.mxd SWD - Sep, 2005

0 1 2 3 4 Kilometres

Square-tailed Kite (Current Survey)

Square-tailed Kite (Atlas of NSW Wildlife)

Square-tailed Kite (Birds Australia Atlas)

Note: Fauna may use other habitat types on an occasional basis.

Construction Footprint

Study Area

Existing Vegetation

Potential Habitat

Waterway

Existing Road

State Forest

Map B7 Habitat for Square-tailed Kite

How is the proposal likely to affect current disturbance regimes?

Parts of the proposed Upgrade occur within already cleared or fragmented habitats that include a range of disturbances commonly found in agricultural landscapes. However the proposed Upgrade will require clearing of vegetation and habitats in relatively intact areas and as such will introduce new edge effects to these sites. In total, 148.2 ha of forest/woodland vegetation will be affected by new edge effects that may include weeds, increased levels of predation, increased noise and changed hydrological regimes.

How is the proposal likely to affect habitat connectivity?

The proposed route will not isolate habitat for Square-tailed Kite, and this species is highly mobile, allowing it to access other areas of habitat on either side of the proposed route. Square-tailed Kite are generally not regarded as susceptible to road strike.

How is the proposal likely to affect critical habitat?

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations and ecological communities. Under the *Threatened Species Conservation Act 1995*, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for this species. The site provides only marginal foraging habitat for this species and extensive areas of similar foraging habitats in adjacent areas will remain unaffected. The site is unlikely to be critical to the survival of this species.

Conclusion

The proposal is unlikely to have a significant impact on the Square-tailed Kite in that suitable habitat including both foraging and nesting resources are widely available in the wider region.

13. Large Forest Owls

Three large forest owls have been considered together as a group because of the similarity of habitats and the likely impacts of the proposed Upgrade. The three species are:

- Powerful Owl
- Masked Owl
- Sooty Owl.

13.1 Powerful Owl (*Ninox strenua*)

Status

The Powerful Owl is listed as vulnerable under Schedule 2 of the *Threatened Species Conservation Act 1995.*

Description

The Powerful Owl is a typical hawk-owl, with staring yellow eyes and no facial-disc and is one of the largest forest owl species in Australasia (Simpson & Day 1996). Adults reach 60 cm in length, have a wingspan of up to 140 cm and weigh up to 1.45 kg (Pizzey & Knight 1997). The upper parts of the Powerful Owl are dark, greyish-brown with indistinct off-white bars. The underparts are whitish with dark greyish-brown V-shaped markings. Juvenile Powerful Owls have a white crown and underparts that contrasts with its small, dark streaks and dark eye patches. The slow, deep and resonant double hoot call of this species may be heard at any time of the year, but it is more vocal during the winter breeding season (NSW National Parks and Wildlife Service 1998).

Habitat

The Powerful Owl inhabits a range and mosaic of vegetation types, from woodland and open sclerophyll forest (on productive sites) to tall open wet forest and rainforest, with mesic gullies and permanent streams (Debus & Chafer 1994). The owl requires large tracts of forest or woodland habitat but can also occur in fragmented landscapes. The species breeds and hunts in open or closed sclerophyll forest or woodlands and occasionally hunts in open habitats. It roosts by day in dense vegetation comprising species such as Turpentine (*Syncarpia glomulifera*), Black She-oak (*Allocasuarina littoralis*), Blackwood (*Acacia melanoxylon*), Rough-barked Apple (*Angophora floribunda*), Cherry Ballart (*Exocarpus cupressiformis)* and a number of eucalypt species. Open eucalypts on hillsides are used infrequently (Higgins 1999).

Powerful Owls nest in large tree hollows (at least 0.5 m deep), in large eucalypts (diameter at breast height of 80 - 240 cm) that are at least 150 years old. The nest sites are situated 12 – 40 m above the ground, often at the head of a gully, or on the face of a hill (Kavanagh & Debus 1994). During the breeding season, the male Powerful Owl roosts in a "grove" of up to 20-30 trees, situated within 100-200 m of the nest tree where the female shelters (NSW National Parks and Wildlife Service 1998).

Ecology

The main prey items are medium-sized arboreal marsupials, particularly the slow-moving Greater Glider, as well as Common Ringtail Possum and Sugar Glider. There may be marked regional differences in the prey taken by Powerful Owls (Kavanagh et al. 1995). For example in southern NSW, Ringtail Possum make up the bulk of prey in the lowland or coastal habitat. At higher elevations, such as the tableland forests, the Greater Glider may constitute almost all of the prey for a pair of Powerful Owls (Kavanagh 1992). Birds comprise about 10% of the diet, with flying foxes important in some areas (Schulz 1997b).

As most prey species require hollows and a shrub layer, these are important habitat components for the species (Department of Environment and Conservation 2005d).

It is possible that this species forages along the forest edge where it consumes hares, rabbits and open country birds. Each bird must catch as many as 80 to 100 possums and gliders a year with catches at two to three day intervals to survive. Allowing for breeding and the rearing of one or two young owls, each territory may have to produce about 250-300 possums a year (or their equivalent) for the owls to survive (Kavanagh et al. 1995).

Powerful Owls are monogamous and mate for life, often up to 30 years or more. Nesting occurs from late autumn to mid-winter, but is slightly earlier in north-eastern New South Wales (late summer - mid autumn). Clutches consist of two dull white eggs and incubation lasts approximately 38 days (Higgins 1999). Outside of the breeding season, mated males and females roost apart, although always within calling distance. During the day, the birds roost on bar branches, often 20 m in the air, where they can gain a clear view of the surrounding area (Debus & Chafer 1994). Pairs of Powerful Owls are believed to have high fidelity to a small number of hollow-bearing nest trees and will defend a large home range of 400 - 1,450 ha (Debus 1995).

Distribution

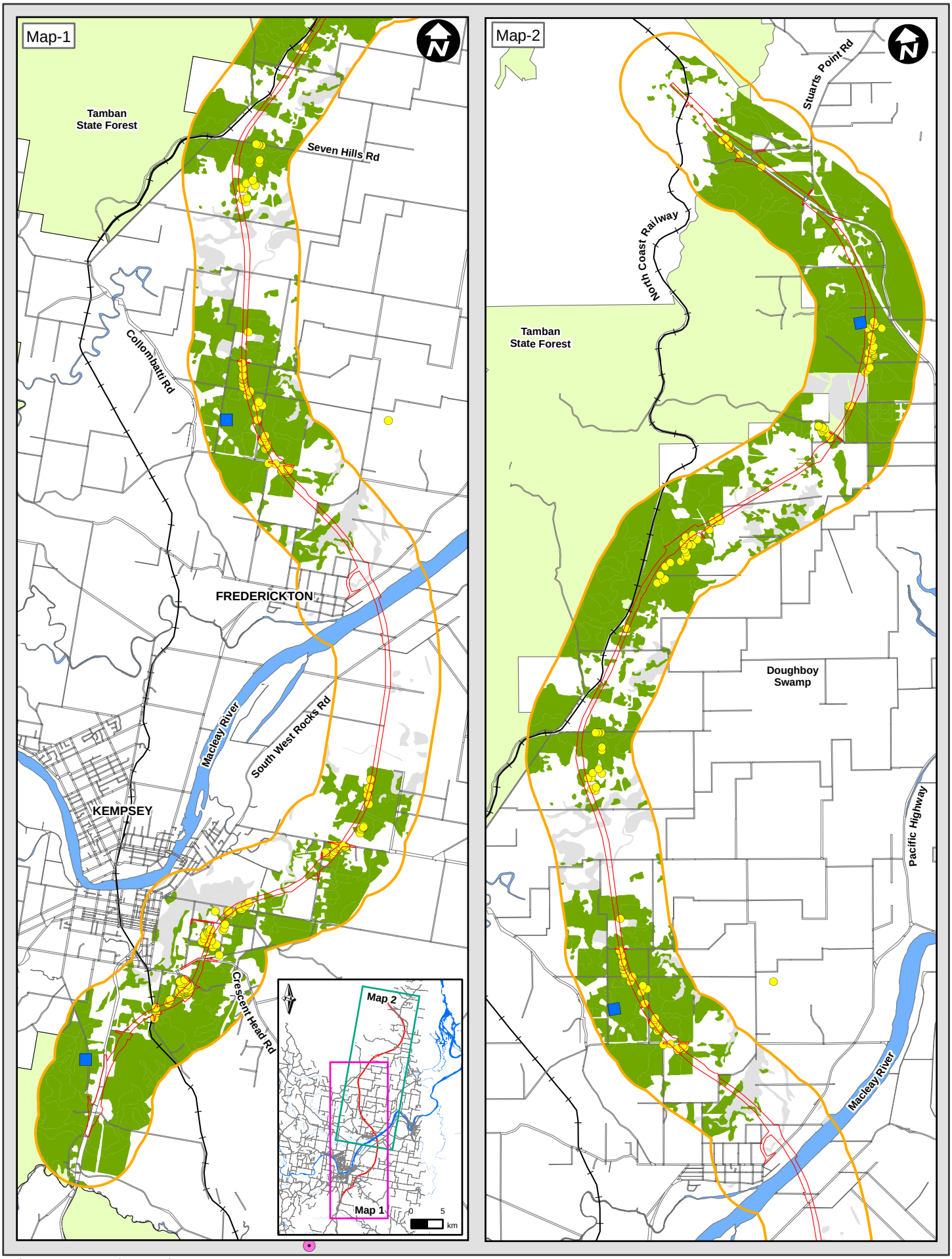
The Powerful Owl is endemic to eastern and south-eastern Australia, mainly on the coastal side of the Great Dividing Range from Mackay to south-western Victoria. In New South Wales, it is widely distributed throughout the eastern forests from the coast inland to tablelands, with scattered, mostly historical records on the western slopes and plains. Powerful Owl are now uncommon throughout its range where it occurs at low densities (Department of Environment and Conservation 2005d).

In the north coast bioregion it has been recorded from the Tweed, Brunswick, Richmond, Clarence, Bellinger, Macleay, Hastings, Manning and Hunter River valleys (Department of Environment and Conservation 2005c).

Currently, the majority of potential habitat for the Powerful Owl is restricted to conservation reserves and State Forests, although this species also occurs within large areas of forest on other public lands and on private land, including suburban bushland. The Powerful Owl has been recorded in many national parks and State forests throughout its range in NSW ((Department of Environment and Conservation 2005c; Kavanagh & Debus 1994).

In the study area:

Powerful Owls were recorded at four spatially distributed sites throughout the study area (Figure B8). A total of 28 hollow-bearing trees that have the potential be used by this species were recorded along and immediately adjacent to the proposed upgrade.



2116519A_2062_Powerful_Owl.mxd SWD - Sep, 2005

0 1 2 3 4 Kilometres

Note: Fauna may use other habitat types on an occasional basis.

Map B8 Powerful Owl

- Powerful owl (Current Survey)
- Powerful Owl (Atlas of NSW Wildlife)
- Habitat Tree
- Potential Habitat
- Construction Footprint
- Study Area
- Existing Vegetation
- Waterway
- Existing Road
- State Forest

Threats

Specific threats to Powerful Owl identified by the Department of Environment and Conservation (2005d) include:

- historical loss and fragmentation of suitable forest and woodland habitat from land clearing for residential and agricultural development. This loss also affects the populations of arboreal prey species, particularly the Greater Glider which reduces food availability for the Powerful Owl
- inappropriate forest harvesting practices that have changed forest structure and removed old growth hollow-bearing trees. Loss of hollow-bearing trees reduces the availability of suitable nest sites and prey habitat
- can be extremely sensitive to disturbance around the nest site, particularly during pre-laying, laying and downy chick stages. Disturbance during the breeding period may affect breeding success
- high frequency hazard reduction burning may also reduce the longevity of individuals by affecting prey availability
- road kills
- secondary poisoning
- predation of fledglings by foxes, dogs and cats.

Specific impacts

The proposal involves the total removal of 272.8 ha of native forest/woodland vegetation affected by different degrees of disturbance, and includes foraging areas and hollow-bearing trees that may potentially be used for breeding by Powerful Owl.

No hollow-bearing trees actively used by this species for breeding were, however, recorded in or near the construction footprint.

13.2 Masked Owl (*Tyto novaehollandiae*)

Status

The Masked Owl is listed as vulnerable under Schedule 2 of the *Threatened Species Conservation Act 1995.*

Description

The Masked Owl is a medium-sized owl (40 - 50 cm long), with dark eyes set in a prominent flat, heart-shaped facial disc that is encircled by a dark border. The feet are large with fully feathered legs down to the toes. Masked Owls have several colour forms, with wide variation in plumage. The upperparts are grey to dark brown with buff to rufous mottling and fine, pale spots. The wings and tail are well barred. The underparts are white to rufous-brown with variable dark spotting. The palest birds have a white face with a brown patch around each eye with the darkest birds having a chestnut-coloured face. Masked Owl are cryptic in nature and are often confused with the Barn Owl (Pizzey & Knight 1997).

Habitat

The Masked Owl inhabits dry sclerophyll forest, wet sclerophyll gullies and woodland generally with a low sparse understorey, however is known to utilise open and partially cleared habitats (Marchant & Higgins 1993). Kavanagh et al. (1995) suggest that the species may have a preference for forest types with a dry and open understorey and mosaic of dense and sparse groundcover.

The Masked Owl is a shy and secretive species that roosts by day predominantly in tree hollows, although occasionally in thick foliage and caves. Nest and roost sites are often associated with large hollows in wet sclerophyll gullies where hollows may be used for several years (Debus & Rose 1994; Department of Environment and Conservation 2005d). Nests have been located in vertical trunk or spout hollows 10 to 30 m above ground (Debus & Rose 1994). Large roomy hollows are preferred for nesting, with depths varying from 0.4 to 5 m (Kavanagh et al. 1995). Nest trees are often an isolated stem or emergent above the canopy. Most recorded nest sites have been in live eucalypts, however the species has also been observed nesting in dead trees (Gibbons & Lindenmayer 1997).

Ecology

The Masked Owl preys upon some species of hollow-dependent marsupial, however it is primarily a predator of small terrestrial mammals in eucalypt forest and woodland, and on ecotones between these and open areas (Debus & Rose 1994). The female is larger than the male and it is thought that each sex takes a different range of prey animals. However, in general this species feeds mainly on terrestrial mammals up to the size of a rabbit. Rats feature prominently in their diet (Kavanagh 1996). In Tasmania this species is known to prey on native and introduced rodents, bandicoots, sugar gliders, ring-tailed possums, rabbits, bats and birds including raptors and domestic poultry (Marchant & Higgins 1993).

Masked Owls are highly mobile and pairs occupy a large home range of approximately 500 to 1,000 ha. The species mates for life and maintains permanent territories. Like other Tyto owls, Masked Owl are an opportunistic species and may breed at any time of the year, with most eggs laid from March to July (Kavanagh 1996).

Distribution

The Masked Owl occurs from sea level to 1,100 m, predominantly within 300 km from the coast (Garnett & Crowley 2000). The Masked Owl is sparsely distributed along the entire New South Wales coastline where it is most abundant in the western plains. Overall records for this species fall within approximately 90% of New South Wales, excluding the most arid north-western corner. In northern New South Wales, it has been recorded from the Tweed, Richmond, Clarence, Hastings, Manning and Hunter river valleys. There is no seasonal variation in its distribution (Department of Environment and Conservation 2005d).

The Masked Owl is known to occur in most large conservation reserves in the North Coast bioregion. It is known from many State Forests and private lands in this region where studies suggest logging may not disrupt its occupancy in forest ecosystems. Due to the species large home range and high mobility, it is uncertain whether the presence of owl in conservation reserves ensures their long-term survival (Department of Environment and Conservation 2005d).

In the study area:

Masked Owl was recorded at four sites in the northern half of the study area (Figure B9). The group of records associated with three sites located between Tamban State Forest and Doughboy Swamp probably represent a resident pair or multiple pairs foraging across private and state forest tenure. An individual was heard and observed at dusk on two occasions suggesting a roost or nest may occur on or in close proximity to the proposed footprint. Tree hollow surveys identified several suitable nest sites in this area and would require additional surveys to locate the nest/roost site.

Threats

Specific threats to Masked Owl identified by the Department of Environment and Conservation in the Draft Recovery Plan for large forest owls (Department of Environment and Conservation 2005d) include:

- loss of mature hollow-bearing trees and changes to forest and woodland structure, which leads to fewer such trees in the future
- clearing of habitat for grazing, agriculture, forestry or other development
- a combination of grazing and regular burning is a threat, through the effects on the quality of ground cover for mammal prey, particularly in open, grassy forests
- secondary poisoning from rodenticides
- being hit by vehicles.

Specific impacts

The proposal involves the total removal of 272.8 ha of native forest/woodland vegetation affected by different degrees of disturbance, and includes foraging areas and 28 hollow-bearing trees that may potentially be used for breeding by Masked Owl. However, no hollow-bearing trees actively used by this species for breeding were recorded in or near the construction footprint.

Other impacts include potential road mortality from collision with motor vehicles as a result of the proposed road.

13.3 Sooty Owl (*Tyto tenebricosa*)

Status

The Sooty Owl is listed as vulnerable under Schedule 2 of the *Threatened Species Conservation Act 1995*.

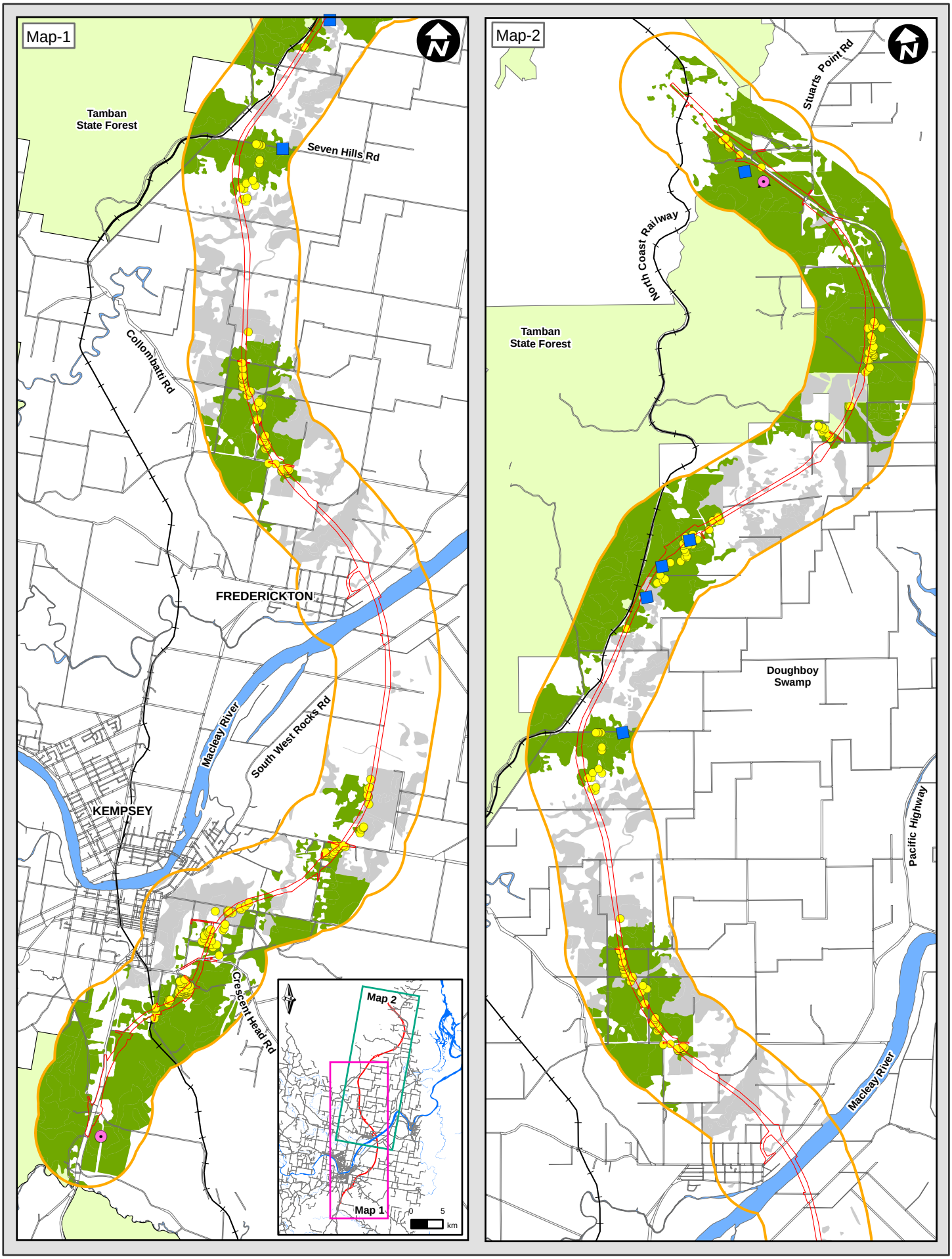
Description

A Sooty Owl is a medium-sized owl (45 cm long), with dark eyes set in a prominent flat, heart-shaped facial disc. Dark sooty-grey in colour, with large eyes in a grey face, fine white spotting above and below, and a pale belly. The plumage of the fledglings is similar to the adult, but has tufts of down on the head and underparts (Pizzey & Knight 1997).

Habitat

The Sooty Owl inhabits tall, wet forests particularly rainforest gullies with eucalypt emergents in south-eastern Australia. This species has been associated with forests occurring at low elevations (less than 300 m). It appears to have an association with sheltered east-south facing sites, with a tall (greater than 4 m) dense understorey layer (Debus 1994). The Sooty Owl also appears to be associated with sites having a low tree basal area, hence reflecting the rainforest or scrub component of its preferred habitat.

The Sooty Owl has been found to have an association with forests where the Common Ringtail Possum and Sugar Glider are present (Kavanagh et al. 1995). Hollows are important to the Sooty Owl both as roost and nest sites, and also because much of the species' prey consists of hollow-dependent mammals (Gibbons & Lindenmayer 1997).



2116519A_2065_Masked_Owl.mxd SWD - Sep, 2005

0 1 2 3 4 Kilometres

- Masked Owl (Current Survey)
- Masked Owl (Atlas of NSW Wildlife)
- Masked Owl (Birds Australia Atlas)
- Habitat Tree

Note: Fauna may use other habitat types on an occasional basis.

- Construction Footprint
- Study Area
- Existing Vegetation
- Potential Habitat
- Waterway
- Existing Road
- State Forest

Map B9 Habitat for Masked Owl

The Sooty Owl nests in very large hollows estimated to have a diameter between 40 to 60 cm. The depth of nesting hollows has been found to range between 40 cm and 3 m. Nests are usually located in large, high tree cavities, and occupied hollows have been located 16 to 30 m above the ground. Nesting cavities are also used for diurnal roosting, and are located within dense foliage in rainforest gully trees, caves and the underside of rocky overhangs (Debus 1994).

Ecology

The Sooty Owl roosts by day in the hollow of a tall forest tree or in heavy vegetation and hunts during the night (Debus 1994). This species consumes a relatively wide variety of prey, including small terrestrial rodents and marsupials (Common Ringtail Possum and Sugar Glider), other medium to large arboreal mammals, birds, frogs and reptiles (Kavanagh et al. 1995). Sooty Owls breed erratically, at any time but generally has only one brood each year, fledglings being observed between April to June and also in autumn (Marchant & Higgins 1993).

Sooty Owls are regarded to be a sedentary species with a large home range. Territories may extend over an area of between 200 and 800 ha per pair (Debus 1994; Marchant & Higgins 1993). The home range is likely to vary with habitat productivity (Gibbons & Lindenmayer 1997).

Distribution

Sooty Owls extend from the coast, where they are most abundant, to the western plains. Overall records for this species fall within approximately 90% of New South Wales, excluding the most arid north-western corner. There is no seasonal variation in its distribution.

The Sooty Owl is known to occur in most large conservation reserves and State Forests in the North Coast bioregion. The species has been recorded from Tenterfield. Urbenville, Coffs Harbour, Grafton, Dorrigo, Walcha and Taree districts (Truyard Pty Ltd 1993). Due to the species large home range and high mobility, it is uncertain whether the presence of owl in conservation reserves ensures their long-term survival (Department of Environment and Conservation 2005a).

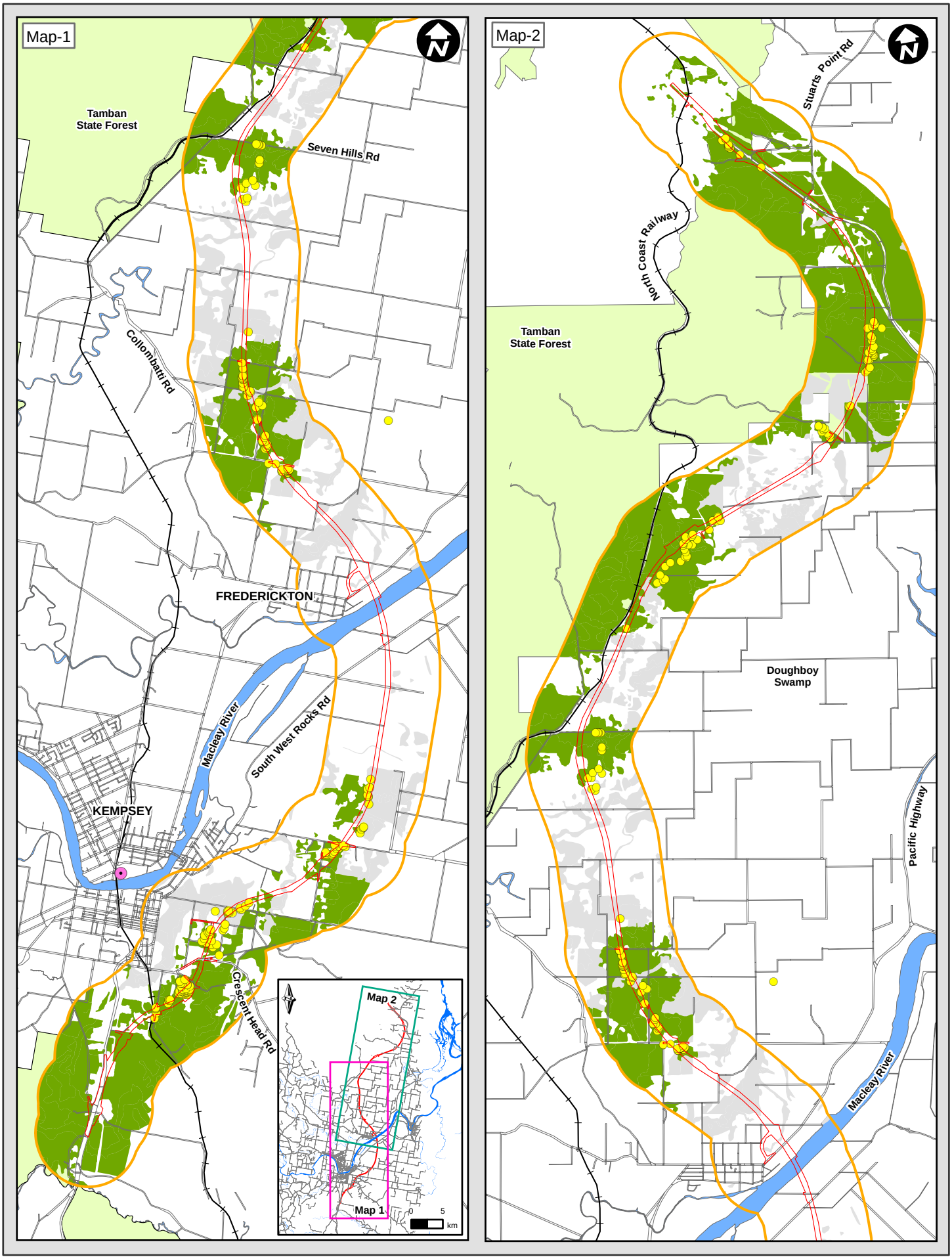
In the study area:

The species was not recorded during the current study, however the species has been recorded previously near the Macleay River at Kempsey (Department of Environment and Conservation 2005a) and suitable habitat exists (Figure B10).

Threats

Specific threats to Sooty Owl identified by the Department of Environment and Conservation in the Draft Recovery Plan for Large Forest Owls (Department of Environment and Conservation 2005d) include:

- loss of mature hollow-bearing trees and changes to forest and woodland structure, which leads to fewer such trees in the future
- clearing of habitat for grazing, agriculture, forestry or other development
- a combination of grazing and regular burning is a threat, through the effects on the quality of ground cover for mammal prey, particularly in open, grassy forests
- secondary poisoning from rodenticides.



2116519A_2066_Sooty_Owl.mxd SWD - Sep, 2005

0 1 2 3 4 Kilometres

- Sooty Owl (Atlas of NSW Wildlife)
- Sooty Owl (Birds Australia Atlas)
- Habitat Tree

Note: Fauna may use other habitat types on an occasional basis.

- Construction Footprint
- Study Area
- Existing Vegetation
- Potential Habitat
- Waterway
- Existing Road
- State Forest

Map B10 Habitat for Sooty Owl

Specific impacts

The proposal involves the total removal of 272.8 ha of native vegetation affected by different degrees of disturbance, and includes foraging areas and 28 hollow-bearing trees that may potentially be used for breeding by Sooty Owl.

No hollow-bearing trees actively used by this species for breeding were recorded in or near the construction footprint.

Other impacts include potential road mortality from collision with motor vehicles as a result of the proposed road.

13.4 Significance assessment - *Environmental Planning and Assessment Act 1979*

How is the proposal likely to affect the lifecycle of a threatened species and/or population?

The proposal involves the removal of 272.8 ha of native vegetation affected by different degrees of disturbance. This vegetation includes foraging areas and 28 hollow-bearing trees that may potentially be used for breeding by large forest owls. No hollow-bearing trees actively used by these species for breeding were recorded in or near the construction footprint. Similar foraging habitats, covering 4,300 ha in the study area, and in adjacent areas will remain unaffected.

How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The proposal involves the removal of 272.8.6 ha of native vegetation affected by different degrees of disturbance. This vegetation includes foraging areas and 28 hollow-bearing trees that may potentially be used for breeding by large forest owls. No hollow-bearing trees actively used by these species for breeding were recorded in or near the construction footprint. Similar habitat, covering 4,300 ha, will be retained in adjacent areas continuing to provide resident owls with foraging and breeding resources. The removal of this habitat is not considered to be significant in a regional context.

Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The study area is not at the distributional limit of any of the species of large forest owl.

How is the proposal likely to affect current disturbance regimes?

Parts of the proposed Upgrade occur within already cleared or fragmented habitats that include a range of disturbances commonly found in agricultural landscapes. However the proposed Upgrade will require clearing of vegetation and habitats in relatively intact areas and as such will introduce new edge effects to these sites. In total, 148.2 ha of forest/woodland vegetation will be affected by new edge effects that may include weeds, increased levels of predation, increased noise and changed hydrological regimes.

How is the proposal likely to affect habitat connectivity?

The proposed route will not isolate habitat for these highly mobile species. Large forest owls will readily fly above the road to access other areas of foraging habitat.

How is the proposal likely to affect critical habitat?

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations and ecological communities. Under the *Threatened Species Conservation Act 1995*, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for these species. The site is unlikely to be critical to the survival of the species.

Conclusion

The proposal is unlikely to have a significant impact on the large forest owls. Suitable habitat is available, and will remain so, adjacent to the proposed Upgrade.

14. Osprey (*Pandion haliaetus*)

Status

The Osprey is listed as vulnerable under Schedule 2 of the *Threatened Species Conservation Act 1995.*

Description

The Osprey is a large, water-dependent bird of prey, with a wing-span of up to 1.7 m. In flight it can be recognised by its distinctly bowed wings that are dark brown above, and barred underneath, and with white underwing coverts. Perched, the upperparts are dark brown and the underparts are white. The female has a dark streaky collar. The head is mainly white with a blackish stripe through the eye (Pizzey & Knight 1997).

Habitat

The Osprey uses littoral habitats, terrestrial wetlands and coastal lands of tropical and temperate Australia and offshore islands, ranging inland along rivers. Extensive sheets of clear open water, fresh, brackish or saline water are needed for fishing (Marchant & Higgins 1993).

Osprey will nest up to 40 km from the sea in mangroves; on cliffs, rocks, rock stacks, islets; sometimes on ground on rocky headlands, coral cays, deserted beaches, sand hills and open saltmarshes. Osprey readily builds their nest on manmade structures, such as telephone poles, channel markers, and specially designed nest platforms (Department of nvironment and Conservation 2004). In some areas nests are placed almost exclusively on artificial structures (e.g. on the Richmond River at Ballina).

Ecology

The Osprey is a fish-eating specialist, with live fish accounting for about 99% of its diet. The bird occasionally eats small terrestrial vertebrates, seabirds and crustacean, and usually feeds on prey at nesting sites (Clancy 2005).

Ospreys breed from July to September in New South Wales. The incubation of 2-3 eggs, is about 40 days. The female remains with young almost until they fly, usually after about nine weeks in the nest (Marchant & Higgins 1993).

Osprey nests are large structures made of stick, driftwood, seaweed, nark and also use washed up flotsam such as sponges, corpses of birds, rope, plastic and other man made debris. Nest sites are in the upper fork or broken trunk of dead tree or dead crown of live tree species including *Eucalyptus, Melaleuca, Angophora, Araucaria cunninghamii*, occasionally in low bushes *Nitraria schoberi, Capparis*; in woodlands near water, usually within 1 km of shore, estuary or river (Department of Environment and Conservation 2004).

Distribution

Ospreys are found right around the Australian coast line, except for Victoria and Tasmania. They are common around the northern coast, especially on rocky shorelines, islands and reefs (Pizzey & Knight 1997). The species is uncommon to rare or absent from closely settled parts of south-eastern Australia. There are a handful of records from inland areas (Department of Environment and Conservation 2005b).

In the study area:

Ospreys were recorded on two occasions foraging over the Macleay River (Figure B11). One individual was recorded near Kempsey (on River) and on another occasion near Frederickton. No nest or perch sites were recorded in the general vicinity of the proposed Upgrade.

Threats

Specific threats to Osprey identified by the Department of Environment and Conservation (2005b) include:

- removal of large trees near the coast that could be used as nest sites
- disturbances to water quality, such as from the disposal of treated effluent or stormwater runoff that increases turbidity in feeding areas
- ingestion of fish containing discarded fishing tackle.

Specific impacts

No active nests, perches or areas of suitable breeding habitats are likely to be significantly affected by the proposal. The proposed mitigation measures would ensure that foraging resources within the Macleay River would not be significantly affected.

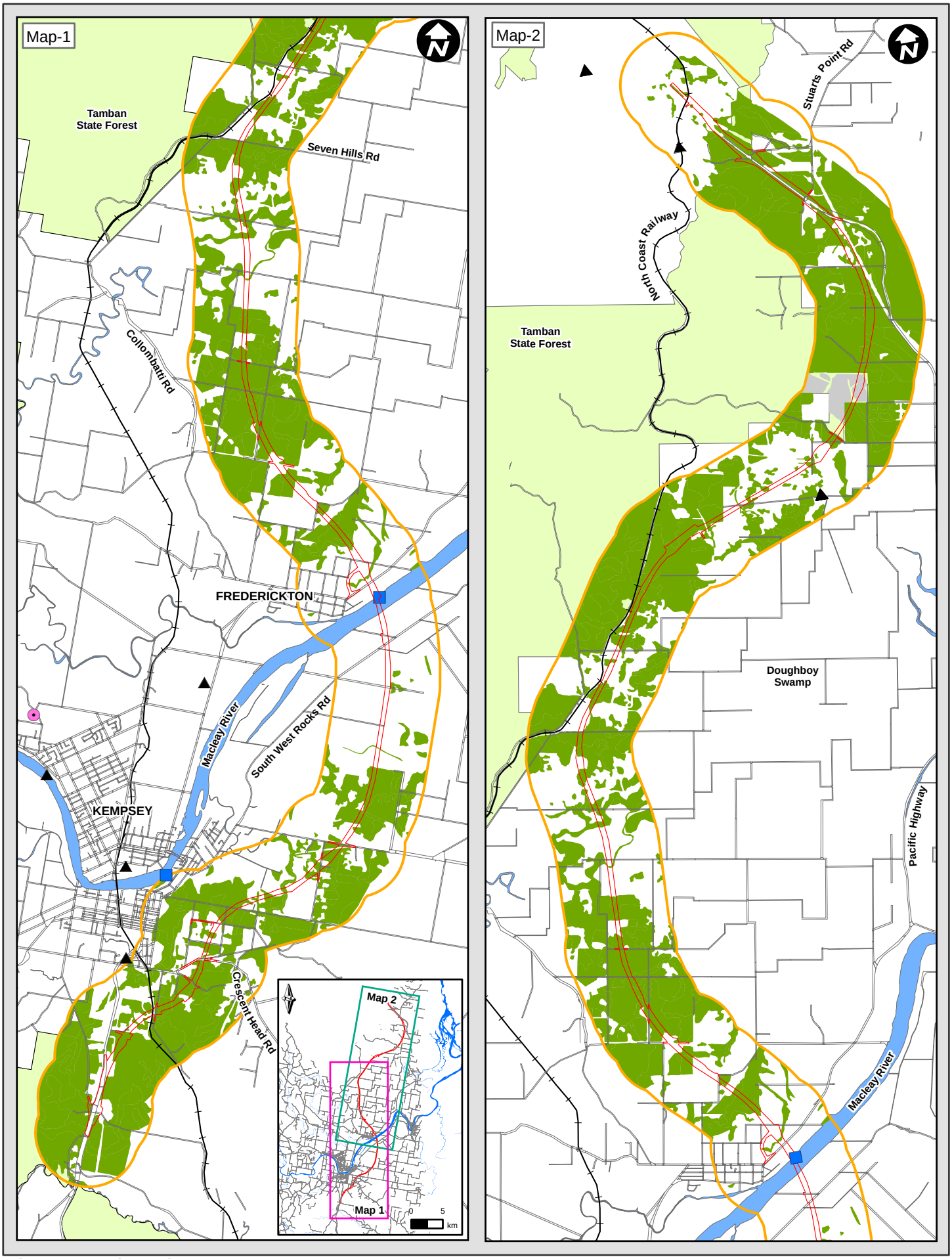
Mitigation measures

Little aquatic disturbance within the study area is expected once construction of any waterway crossings is completed, provided that crossings are designed according to NSW Fisheries guidelines and damage to any aquatic habitat and riparian vegetation during construction is minimised (Fairfull & Witheridge 2003). Areas of riparian vegetation likely to be damaged or removed during construction would be replanted on completion of the works. In addition, appropriate sediment control measures would be put in place around all proposed waterway crossings prior to construction to ensure minimal change in water quality of the waterways due to run-off. It is also unlikely that commercial and recreational fishing activities will be significantly affected by any proposed waterway crossings, provided that appropriate fish passage is maintained.

14.1 Significance assessment - *Environmental Planning and Assessment Act 1979*

How is the proposal likely to affect the lifecycle of a threatened species and/or population?

No active nests, perches or areas of suitable breeding habitats are likely to be affected by the proposal. The proposed mitigation measures would ensure that foraging resources within the Macleay River would not be significantly affected. As such, the life cycle of this species if unlikely to be affected.



0 1 2 3 4 Kilometres

Osprey (Current Survey)

Osprey (Atlas of NSW Wildlife)

Osprey (Birds Australia Atlas)

Potential Habitat

Note: Fauna may use other habitat types on an occasional basis.

Construction Footprint

Study Area

Existing Vegetation

Waterway

Existing Road

State Forest

Map B11 Habitat for Osprey

2116519A_2063_Osprey.mxd SWD - Sep, 2005

How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

Construction of the proposed Upgrade will not remove or modify a significant area of known habitat for Osprey in a regional context. Important habitat resources (e.g. the Macleay River and adjoining habitat) will not be affected.

Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

Ospreys are found right around the Australian coastline, except for Victoria and Tasmania. The study area is not at the distributional limit for Osprey.

How is the proposal likely to affect current disturbance regimes?

Parts of the proposed Upgrade occur within already cleared or fragmented habitats that include a range of disturbances commonly found in agricultural landscapes. However the proposed Upgrade will require clearing of vegetation and habitats in relatively intact areas and as such will introduce new edge effects to these sites. In total, 159.9 ha of vegetation will be affected by new edge effects that may include weeds, increased levels of predation, increased noise and changed hydrological regimes.

How is the proposal likely to affect habitat connectivity?

The Osprey is mostly sedentary and forages over wider areas during the non-breeding season, being very faithful to nest sites and nest site territories in the breeding season, returning to the same site in successive years (Clancy 2005).

Ospreys are highly mobile and it is likely that Osprey will readily fly above the road to access foraging habitats. Ospreys are not generally regarded as susceptible to road strike.

The proposed route will not isolate areas of habitat for this species.

How is the proposal likely to affect critical habitat?

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations and ecological communities. Under the *Threatened Species Conservation Act 1995*, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for this species (Department of Environment and Conservation, Threatened Species Unit). The site provides only marginal foraging habitat and no active nests, perches or areas of suitable breeding habitats were recorded. The site is unlikely to be critical to the survival of this species.

Conclusion

The proposal is unlikely to have a significant impact on the Osprey. Important habitat resources for this species will not be affected.

15. Microchiropteran Bats

Eight microchiropteran bat species have been included in this assessment because they are likely to be affected similarly by the proposal. Threatened species assessed below include the following species:

- Hoary Wattled Bat
- Golden-tipped Bat
- Little Bent-wing Bat
- Common Bent-wing Bat
- Eastern Freetail-Bat
- Large-footed Myotis
- Greater Broad-nosed Bat
- Yellow-bellied Sheathtail Bat.

15.1 Hoary Wattled Bat (*Chalinolobus nigrogriseus*)

Status

The Hoary Wattled Bat is listed as Vulnerable under Schedule 2 of the *Threatened Species Conservation Act 1995*.

Description

The Hoary Wattled Bat is a small sooty-coloured bat with a light silvery-white frosting to the hairs. There are small lobes of skin or wattles between the ears and mouth; however, they are poorly developed compared to other wattled bats (Cronin 2000).

Habitat

In New South Wales the Hoary Wattled Bat occurs in dry open eucalypt forests, favouring forests dominated by Spotted Gum, boxes and ironbarks, and heathy coastal forests where Red Bloodwood and Scribbly Gum are common. Because it flies fast below the canopy level, forests with naturally sparse understorey layers may provide the best habitat (Churchill 1998).

Important habitat requirements in the Northern Rivers Catchment Management Region include dead or alive hollow-bearing trees for breeding, and hollow-bearing trees and rock crevasses for roosting (Department of Environment and Conservation 2005b).

Ecology

Hoary Wattled Bats are forest dwellers and roost in tree hollows in eucalypt trees. The bats are typically observed flying about at dusk, leaving its roost site before other bat species have emerged. They commonly forage along watercourses and swampy areas (Strahan 1995).

Hoary Wattled Bats prefer to eat moths and beetles, but will eat a wide variety of prey including spiders, mantids, earwigs, crickets, grasshoppers, cicadas, bugs, diving beetles, scarabs, click beetles, leaf beetles, weevils, flies, moths and ants. Females lactate in October and November and give birth in October and November, usually to twins (Churchill 1998).

Distribution

Widely distributed across northern Australia although absent from the arid centre. In north east New South Wales it reaches the lower Clarence and Richmond River areas, extending from near Murwillumbah in the north, south to between Grafton and Coffs Harbour (Department of Environment and Conservation 2005b).

In the study area:

The species was recorded in the current study at 4 km north of the Macleay River at Frederickton (Figure B12).

Threats

Specific threats to Hoary Wattled Bats identified by the Department of Environment and Conservation (2005b) include:

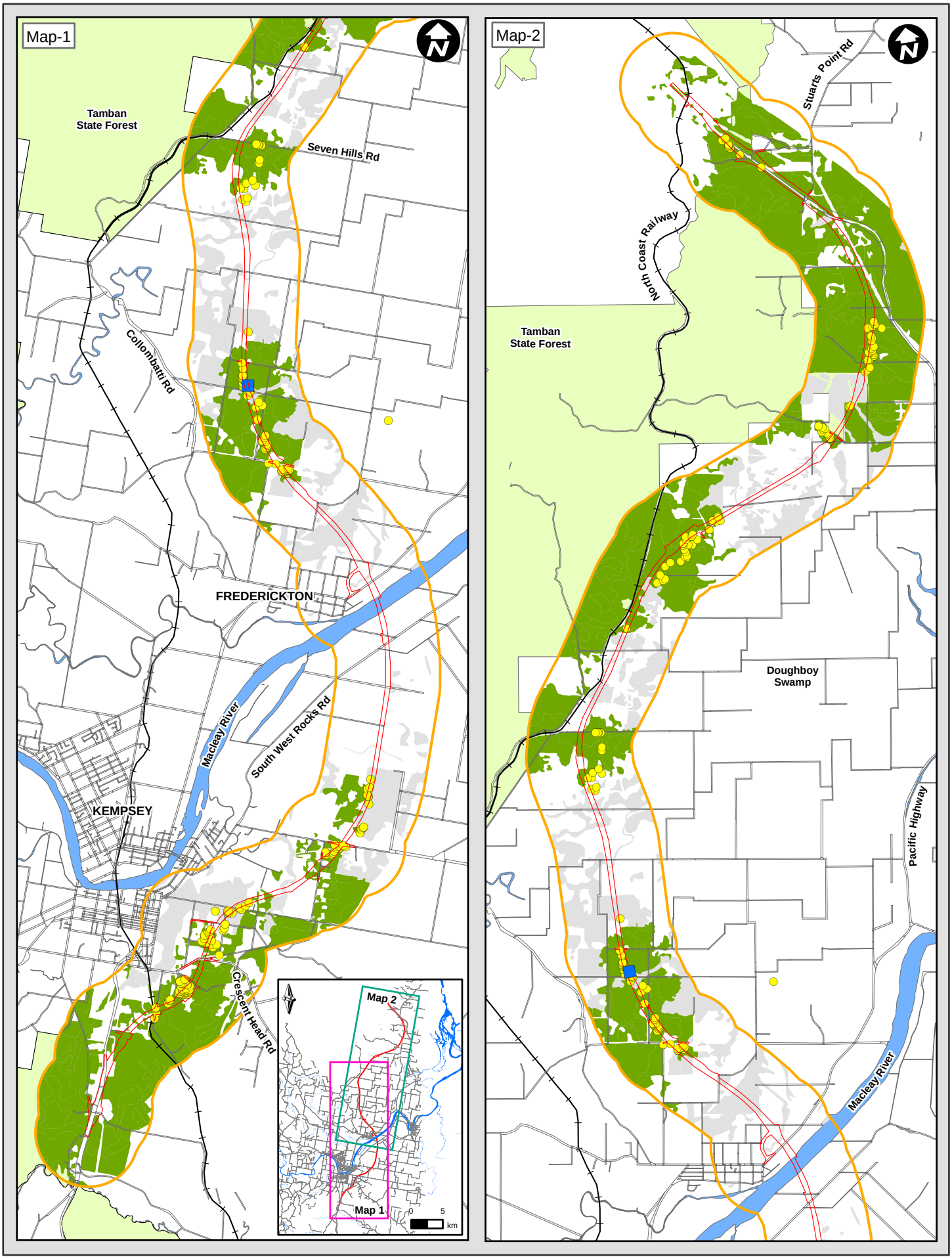
- clearing and fragmentation of dry forest and woodland habitat through clearing for agriculture and development
- loss of hollow-bearing trees used for roosting and maternity sites, usually as a result of too-frequent burning and forest management favouring younger stands
- use of pesticides.

Specific impacts

The proposed Upgrade involves the removal of a total of 272.8 ha of forest/woodland native vegetation, which provides foraging and roosting habitat for the Hoary Wattled Bat.

A total of 224 hollow-bearing trees suitable for microchiropteran bats were recorded along and immediately adjacent to the proposed Upgrade.

Roads are unlikely to create a barrier to movement for this highly mobile species. Microchiropteran bats are generally considered to be at low risk of colliding with moving vehicles.



2116519A_2067_Haory_Wattled_Bat.mxd SWD - Sep, 2005

0 1 2 3 4 Kilometres

Hoary Wattled Bat (Current Survey)

Habitat Tree

Potential Habitat

Note: Fauna may use other habitat types on an occasional basis.

Construction Footprint

Study Area

Existing Vegetation

Waterway

Existing Road

State Forest

Map B12 Habitat for Hoary Wattled Bat

15.2 Golden-tipped Bat (*Kerivoula papuensis*)

Status

The Golden-tipped Bat is listed as vulnerable under Schedule 2 of the *Threatened Species Conservation Act 1995*.

Description

Golden-tipped Bats have dark brown, curly fur with bright golden tips to each hair. The distinctively coloured fur extends along the wings, legs and tail. It has a short, pointed, over-hanging nose and pointy, funnel-shaped ears. Adults weigh about six grams and have a wingspan of about 25 cm. The woolly body fir helps them to camouflage with their background foraging environment (Cronin 2000).

Habitat

The Golden-tipped Bat is found predominantly in coastal forests, in the ecotones of wet and dry sclerophyll forests and often in the vicinity of creeks. It has been found to roost in a range of habitats from dead trees/foliage to the roofs of houses (Churchill 1998; Schulz 1997a). Riparian rainforest provides the key habitat for the species (Law & Chidel 2004).

Important habitat requirements in the Northern Rivers Catchment Management Region include tree hollows, bark, tree fissures and/or rock fissures and caves for breeding. Rainforest or other vegetation within 20 m of drainage lines is used for roosting (Department of Environment and Conservation 2005b).

Ecology

Golden-tipped Bats will fly up to 2 km from roost sites to forage in rainforest and sclerophyll forest on upper-slopes (Parnaby & Mills 1994). Stomach contents and scat analysis have revealed that these bats specialise in a diet of spiders, predominantly orb weaver spiders (Churchill 1998). Little is known about foraging movements especially regarding the extent that the bat forages in the rainforest or sclerophyll vegetation (Law & Chidel 2004).

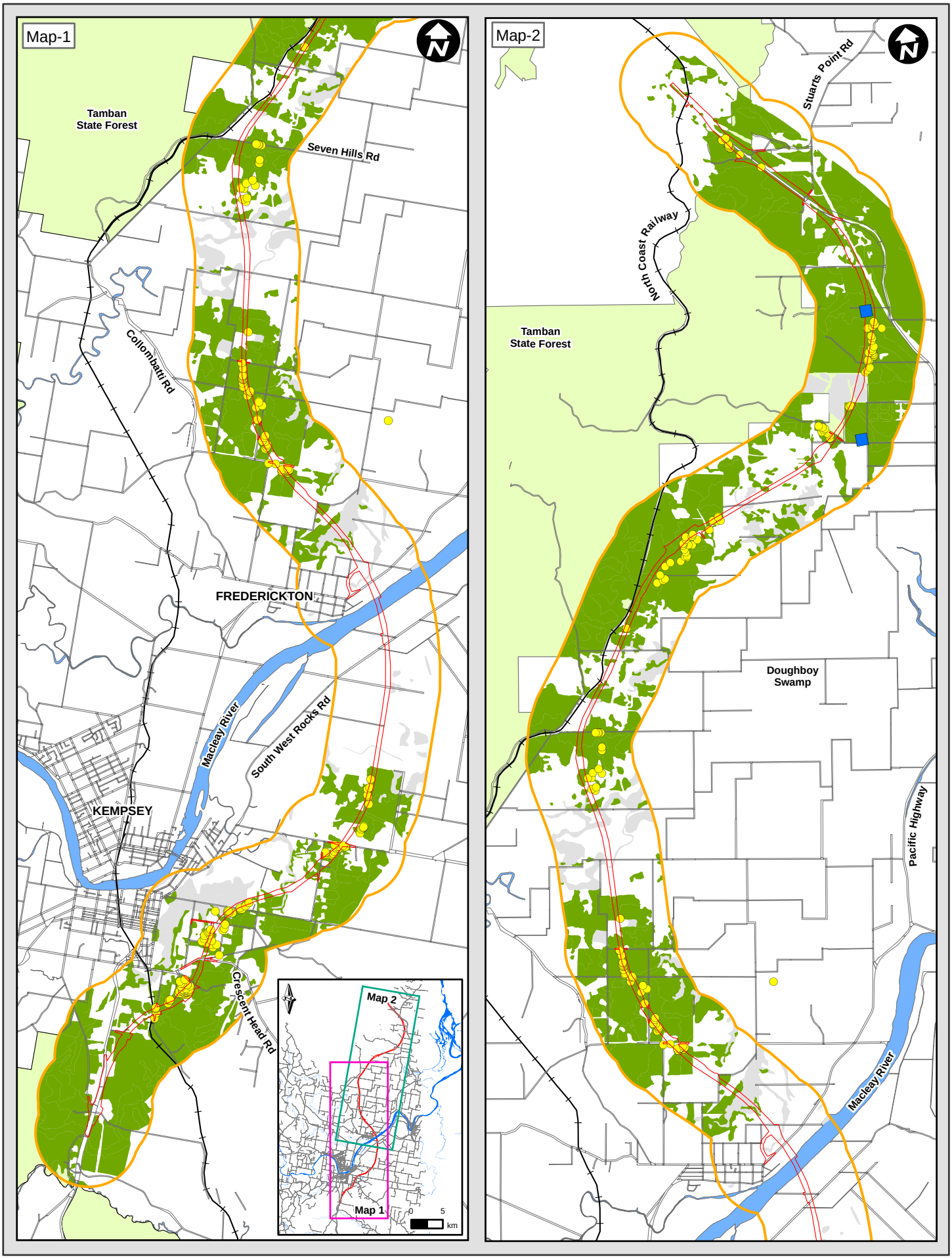
Very little is known about the biology the Golden-tipped Bat. Bioclimatic analyses of this species indicate that the golden-tipped bat is stenothermic (adapted to a limited range of temperatures) and requires reasonably high moisture levels. The most significant predictive variable of the distribution of the species is a narrow preferred temperature range between mean winter minima and mean summer maxima (Strahan 1995).

Distribution

The Golden-tipped Bat is confined to the coastal areas and escarpments from the Queensland border to approximately Bega on the south coast of New South Wales (Churchill 1998).

In the study area:

The species was recorded during the current study adjacent to the northern part of Tamban State Forest (Figure B13).



2116519A_2069_Golden_tipped_Bat.mxd SWD - Sep, 2005

0 1 2 3 4 Kilometres

Note: Fauna may use other habitat types on an occasional basis.

Golden Tipped Bat (Current Survey)

Golden-tipped Bat (Atlas of NSW Wildlife)

Habitat Tree

Construction Footprint

Study Area

Existing Vegetation

Potential Habitat

Waterway

Existing Road

State Forest

Map B13 Habitat for Golden- tipped Bat

Threats

Specific threats to Golden-tipped Bat identified by the Department of Environment and Conservation (2005b) include:

- loss of riparian rainforest for roosting
- loss of understorey habitat on upper-slopes for foraging.

Specific impacts

The proposed Upgrade involves the removal of a total of 272.8 ha, which provides foraging and roosting habitat for the Golden-tipped Bat.

A total of 224 hollow-bearing trees suitable for microchiropteran bats were recorded along and immediately adjacent the proposed upgrade.

Roads are unlikely to create a barrier to movement for this highly mobile species. Microchiropteran bats are generally considered to be at low risk of colliding with moving vehicles.

15.3 Little Bent-wing Bat (*Miniopterus australis*)

Status

The Little Bent-wing Bat is listed as Vulnerable under Schedule 2 of the *Threatened Species Conservation Act 1995.*

Description

Little Bent-wing Bats are small chocolate brown insectivorous bats with a body length of about 45 mm. The fur is long and thick, especially over the crown and around the neck (Cronin 2000).

Habitat

Little Bent-wing Bats inhabit sclerophyll forests and utilise a variety of roosts sites including hollows. Limestone caves utilised by the Little Bent-wing Bat are usually located close to large areas of dense vegetation, including wet sclerophyll forest, rainforest or dense Coast Banksia scrub (Churchill 1998). The species has also been infrequently recorded in tree hollows (Schulz 1997a).

Ecology

Males are sexually active during the winter (late July), with fertilisation taking place immediately. In spring, the females move to suitable nursery caves where a single young is born in December (Dwyer 1966). These maternity sites are usually located in limestone cave systems, which provide sufficient temperature and humidity to raise the young (Churchill 1998). The southern most breeding population of this species are in the Macleay River watershed (Brad Law, *personal communication*).

Distribution

The Little Bent-wing Bat is distributed from the tip of Cape York along the coast and tablelands to the Central Coast of New South Wales (Department of Environment and Conservation 2005b).

Both the capture and call analysis data suggest the Little Bent-wing Bat is among the most common species in the study area. It was recorded at all sites throughout the study area (Figure B14) and often during the dusk census. These data suggest it is likely to utilise tree hollow resources on or near the footprint.

In the study area the Little Bent-wing Bat is likely to use tree hollows on or near the development footprint as temporary roosting sites.

Maternity caves for both the Little Bent-wing Bat have been recorded at Riverton, Glen Lyon and Willi Willi bat cave in Yessabah Nature Reserve 15 km south-west of Kempsey (Bradley Law, Personal communication).

Threats

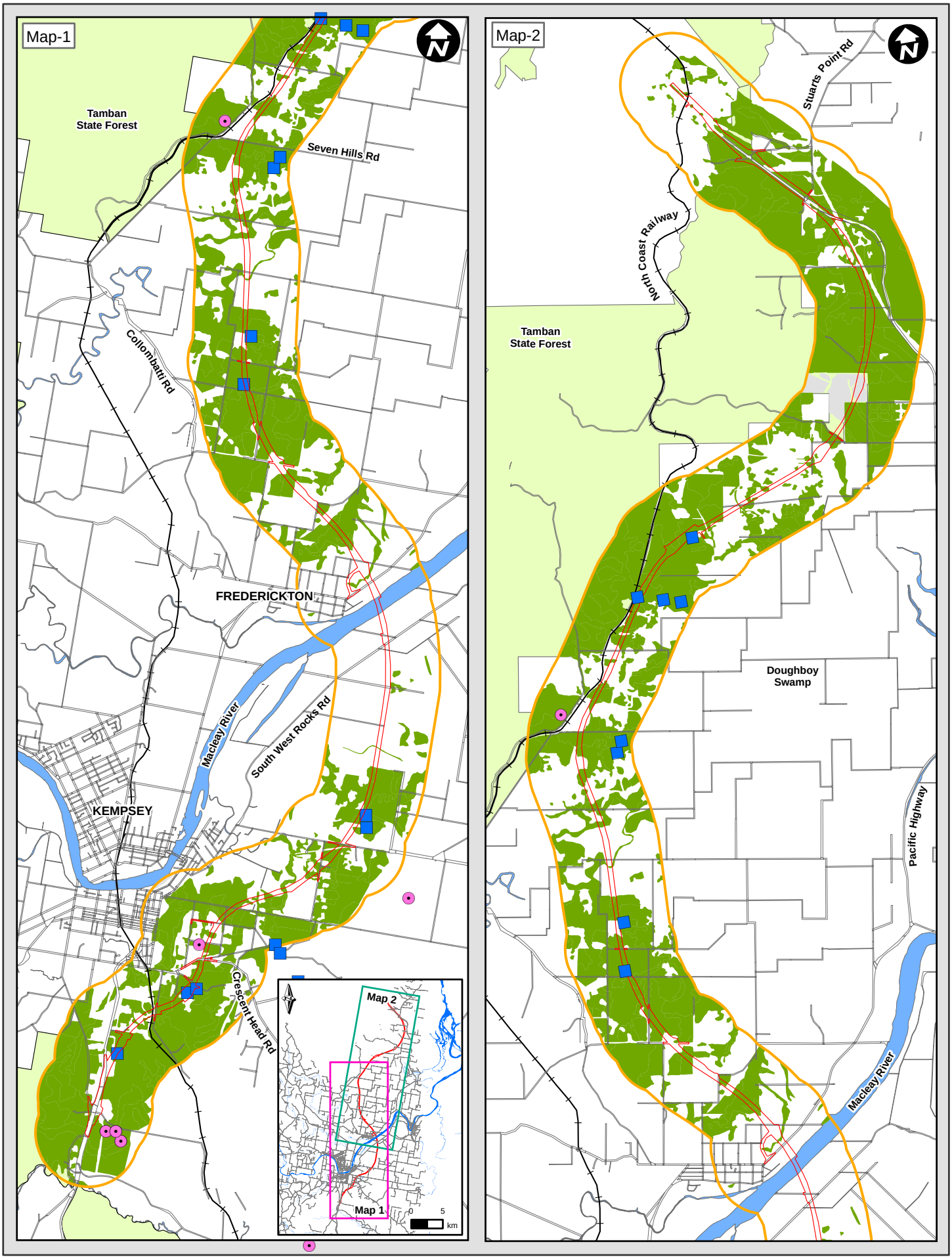
Specific threats to the Little Bent-wing Bat identified by the Department of Environment and Conservation (2005b) include:

- alteration and destruction of foraging habitat, especially that surrounding maternity caves
- clearing and fragmentation of dry forest and woodland habitat through clearing for agriculture and development
- disturbance to cave roosts and/or hibernating colonies during winter
- loss of hollow-bearing trees used for roosting and maternity sites, usually as a result of too-frequent burning and forest management favouring younger stands
- use of pesticides
- recreational caving.

Specific impacts

The proposed Upgrade involves the removal of a total of 272.8ha, which provide foraging habitat.

Roads are unlikely to create a barrier to movement for this highly mobile species. Microchiropteran bats are generally considered to be at low risk of colliding with moving vehicles.



0 1 2 3 4 Kilometres

Little Bent-wing Bat (Current Survey)

Little Bent-wing-Bat (Atlas of NSW Wildlife)

Potential Habitat

Note: Fauna may use other habitat types on an occasional basis.

Construction Footprint

Study Area

Existing Vegetation

Waterway

Existing Road

State Forest

Map B14 Habitat for Little Bent-wing Bat

2116519A_2070_Little_Bent-wing_Bat.mxd SWD - Sep, 2005

15.4 Common Bent-wing Bat (*Miniopterus schreibersii*)

Status

The Common Bent-wing Bat is listed as Vulnerable under Schedule 2 of the *Threatened Species Conservation Act 1995.*

Description

The Common Bent-wing Bat has chocolate to reddish-brown fur on its back and slightly lighter coloured fur on its belly. It has a short snout and a high 'domed' head with short round ears. The species has a longer body and forearm length than the Little Bent-wing Bat (Churchill 1998).

Habitat

Common Bent-wing Bats roost selection varies in response to seasonal and annual climatic variations (Dwyer 1966). Both species often share roosting sites with each other and, in winter, the two species may form mixed clusters. In New South Wales the largest maternity colony is in close association with a large maternity colony of Common Bent-wing Bats and appears to depend on the large colony to provide the high temperatures needed to rear its young (Baudinette et al. 1994).

Ecology

In spring, adult females converge in specific nursery caves in spring and summer to breed and which provide the high temperature and humidity required for the survival of their young. They give birth to a single young around December and juveniles disperse from the maternity caves during March (Churchill 1998). Maternity caves serve animals from a radius of several hundred kilometres (Baudinette et al. 1994; Dwyer 1966).

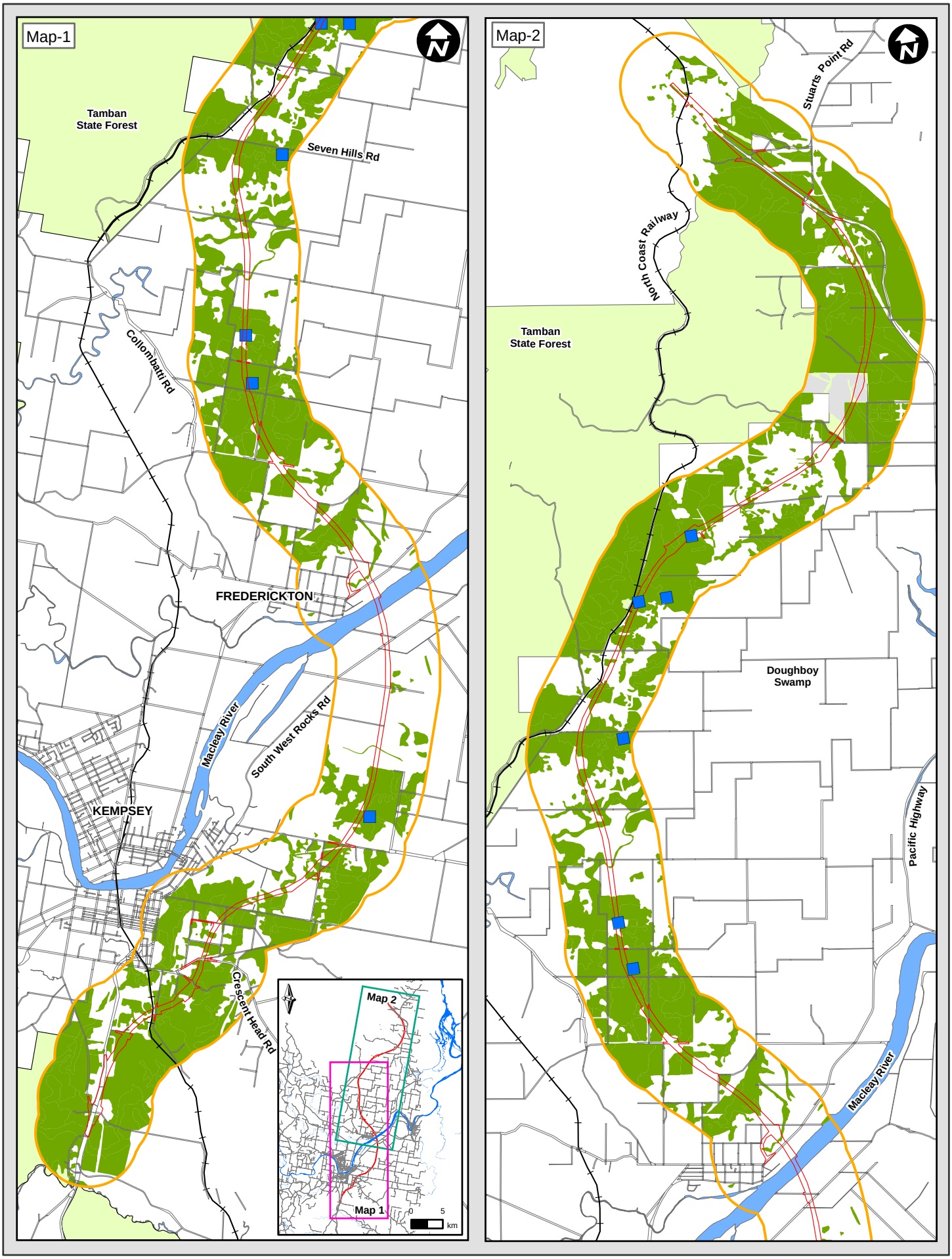
Distribution

The Common Bent-wing Bat is sparsely distributed along the entire eastern seaboard from the Great Dividing Range to the coast from Cape York Peninsula in Queensland, round to South Australia ((Department of Environment and Conservation 2005b).

In the study area:

The Common Bent-wing Bat was recorded at the eight sites north of the Macleay River after dusk (Figure B15). Four individuals were observed roosting in a subterranean roost site (rail culvert) although greater numbers are likely to inhabit this site in the vicinity of site six and at wet site four (adjacent to one another).

Maternity caves for Common Bent-wing Bat have been recorded at Riverton, Glen Lyon and Willi Willi bat cave in Yessabah Nature Reserve near Kempsey (Bradley Law, Personal communication).



2116519A_2072_Eastern_Bent-wing_Bat.mxd SWD - Sep, 2005

0 1 2 3 4 Kilometres

Eastern Bent-wing Bat (Current Survey)

Eastern Bent-wing Bat (Atlas of NSW Wildlife)

Potential Habitat

Note: Fauna may use other habitat types on an occasional basis.

Construction Footprint

Study Area

Existing Vegetation

Waterway

Existing Road

State Forest

Map B15 Habitat for Eastern Bent-wing Bat

Threats

Specific threats to the Common Bent-wing Bat identified by the Department of Environment and Conservation (2005b) include:

- alteration and destruction of foraging habitat, especially that surrounding maternity caves
- clearing and fragmentation of dry forest and woodland habitat through clearing for agriculture and development
- disturbance to cave roosts and/or hibernating colonies during winter
- loss of hollow-bearing trees used for roosting and maternity sites, usually as a result of too-frequent burning and forest management favouring younger stands
- use of pesticides
- recreational caving.

Specific impacts

The proposed Upgrade involves the removal of a total of 272.8 ha of native forest/woodland vegetation, which provides foraging habitat.

Roads are unlikely to create a barrier to movement for this highly mobile species. Microchiropteran bats are generally considered to be at low risk of colliding with moving vehicles.

15.5 Eastern Freetail-bat (*Mormopterus norfolkensis*)

Status

The Eastern Freetail-bat is listed as vulnerable under Schedule 2 of the *Threatened Species Conservation Act 1995*.

Description

The Eastern Freetail-bat has dark brown to reddish brown fur on the back and is slightly paler below. Like other species of freetail-bat, it has a long (3 - 4 cm) bare tail protruding from the tail membrane. The species has a hairless faces with wrinkled lips and triangular ears (Cronin 2000).

Habitat

Eastern Freetail-bats occur in rainforest, dry sclerophyll forest and woodland east of the Great Dividing Range. They roost mainly in tree hollows but will also roost under bark or in man-made structures (Churchill 1998).

Ecology

Eastern Freetail-bats are solitary and probably insectivorous, however little is known about the feeding requirements of the species (Strahan 1995). It is presumed to hunt above the canopy or in forest clearings for leafhoppers, chafers, weevils and other beetles. No information is available on the reproductive strategies or local and seasonal movements of the species (Churchill 1998).

Distribution

The Eastern Freetail-bat is found along the east coast from south Queensland to southern New South Wales. This species is sparsely distributed from Sydney in southern New South Wales to south-east Fraser Island in Queensland (Department of Environment and Conservation 2005b).

In the study area:

East Coast Freetail-bat was caught on one occasion at site nine whilst trip-lining and identified in the call analysis from 10 other sites (Figure B16). Based on the records obtained during the current survey this species appears widely distributed in the study area. Calls of this species were also identified during the dusk census which suggests it roosts nearby. The tree hollow surveys identified a number of potential refuge sites in these areas.

Threats

Specific threats to both species of Eastern Freetail-bat identified by the Department of Environment and Conservation (2005b) include:

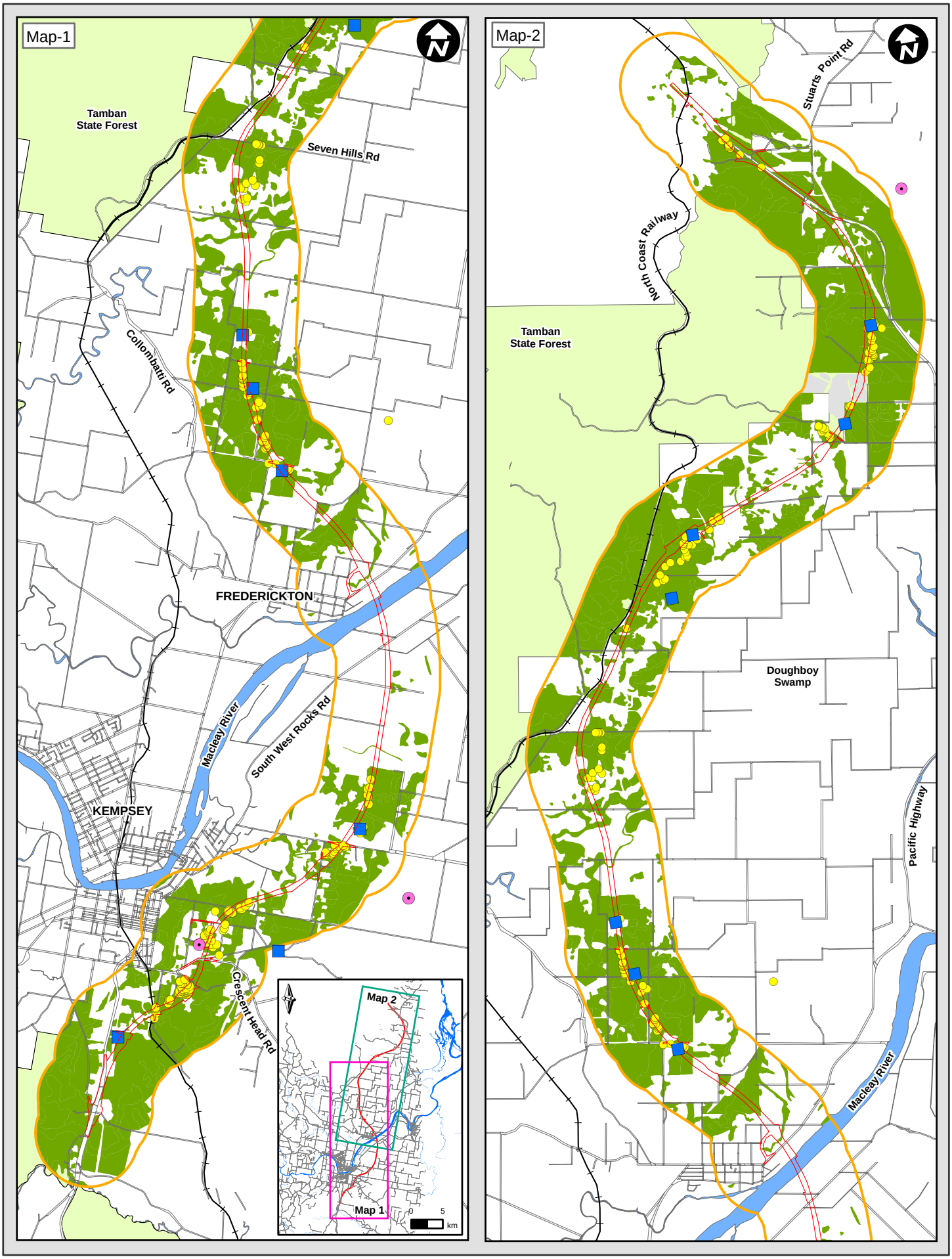
- loss of hollow-bearing trees
- loss of foraging habitat
- application of pesticides in or adjacent to foraging areas.

Specific impacts

The proposed Upgrade involves the removal of a total of 272.8 ha of native forest/woodland vegetation, which provides foraging habitat for Eastern Freetail-bat.

A total of 224 hollow-bearing trees suitable for microchiropteran bats were recorded along and immediately adjacent the proposed upgrade.

Roads are unlikely to create a barrier to movement for this highly mobile species. Microchiropteran bats are generally considered to be at low risk of colliding with moving vehicles.



2116519A_2072_Eastern_Freetail_Bat.mxd SWD - Sep, 2005

0 1 2 3 4 Kilometres

Note: Fauna may use other habitat types on an occasional basis.

Eastern Freetail Bat (Current Survey)

Eastern Freetail-bat (Atlas of NSW Wildlife)

Habitat Tree

Construction Footprint

Study Area

Existing Vegetation

Potential Habitat

Waterway

Existing Road

State Forest

Map B16 Habitat for Eastern Freetail Bat

15.6 Large-footed Myotis (*Myotis adversus*)

Status

The Large-footed Myotis is listed as vulnerable under Schedule 2 of the *Threatened Species Conservation Act 1995*.

Description

The Large-footed Myotis has disproportionately large feet; more than 8 mm long. The toes are widely-spaced and distinctly hairy, with long, curved claws. It has dark-grey to reddish brown fur above and is paler below. It weighs up to 15 g and has a wingspan of about 28 cm (Churchill 1998).

Habitat

The Large-footed Myotis is a cave dwelling bat that also roosts in mine shafts, stormwater tunnels, under bridges and in buildings. This species occasionally roosts in tree hollows amongst vegetation, often in clumps of pandanus palms. The species usually select roosts close to water, often choosing caves that overhang pools. They have been caught in mangroves, paperbark swamps, riverine monsoon forest, rainforest, wet and dry sclerophyll forest, open woodland and river red gum woodland (Richards 1998).

Large-footed Myotis have a preference for foraging over the surface of open, smooth flowing or still water (Churchill 1998).

Ecology

Large-footed Myotis forages most commonly over water, feeding on insects and small fish that they catch by raking their long feet across the water surface. The species may forage individually or in groups (Thompson & Brock Penton 1982). This species usually roosts in small colonies of 10 to 15 individuals, and occasionally in groups of up to several hundred. Large-footed Myotis form breeding groups with a single male and one to 12 females, while other males will roost alone or in small all-male clusters (Lloyd et al. 1999). In New South Wales females have one young each year usually in November or December (Churchill 1998).

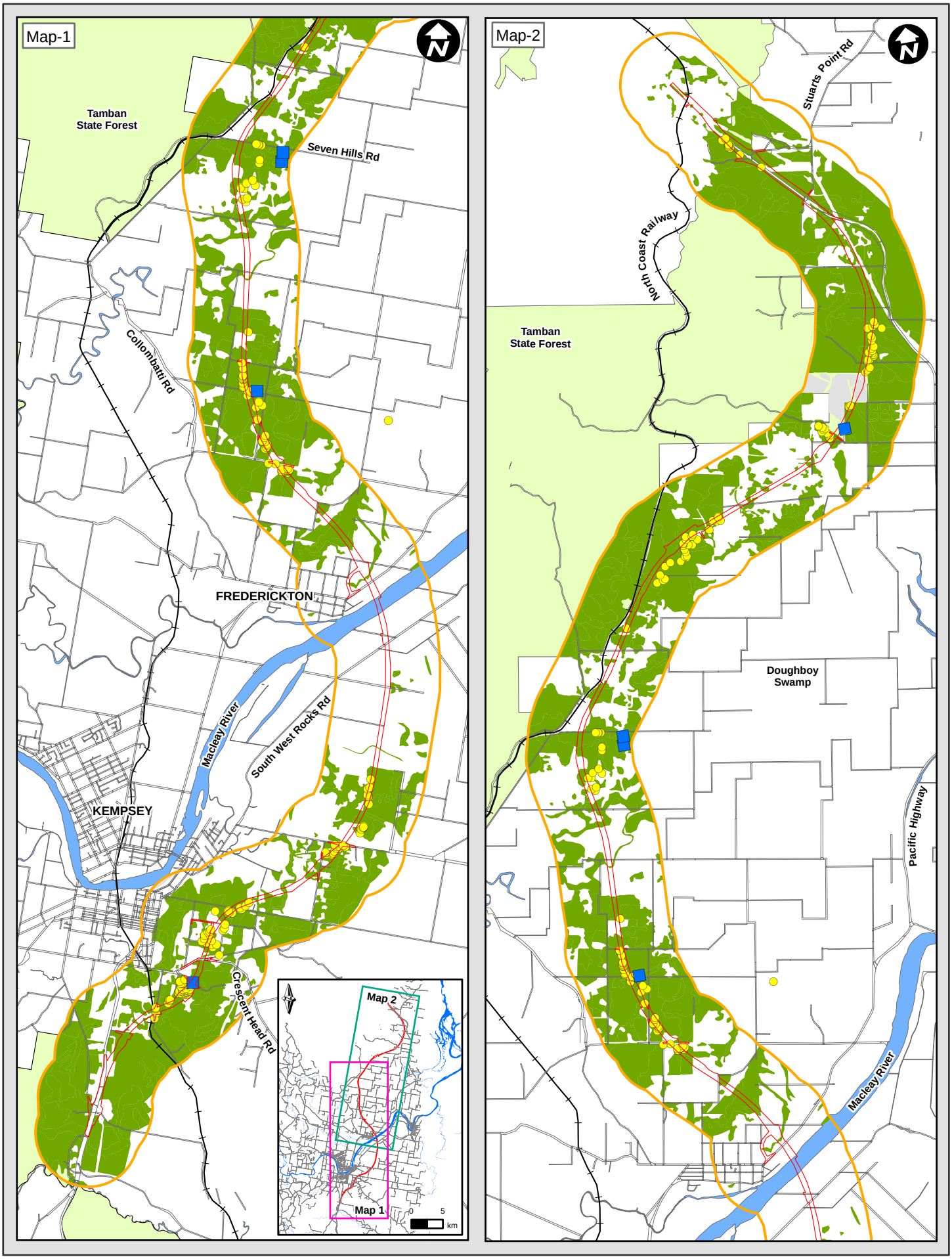
An accurate estimate of the Large-footed Myotis home range has not been determined. However, the species never occurs far from bodies of water, and close proximity to foraging and roosting opportunities are considered to be important to the species (Richards 1998).

Distribution

The Large-footed Myotis is found in the coastal band from the north-west of Australia, across the top-end and south to western Victoria. It is rarely found more than 100 km inland, except along major rivers. This species is widely distributed along rivers, estuaries and reservoirs on the New South Wales north coast (Department of Environment and Conservation 2005c).

In the study area:

Sporadic records of this species were obtained from the bat call analysis at five sites north and south of the Macleay River (Figure B17). No individuals were caught during the field survey although this species can be difficult to capture away from water. Calls were identified during a dusk census at site 10 which suggests at least some individuals roost in the immediate (<500 m) area.



2116519A_2073_Large-footed_Myotis.mxd SWD - Sep, 2005

0 1 2 3 4 Kilometres

Large-footed Myotis (Current Survey)

Large-footed Myotis (Atlas of NSW Wildlife)

Habitat Tree

Note: Fauna may use other habitat types on an occasional basis.

Construction Footprint

Study Area

Existing Vegetation

Potential Habitat

Waterway

Existing Road

State Forest

Map B17 Habitat for Large-footed Myotis

Threats

Specific threats to Large-footed Myotis identified by the Department of Environment and Conservation (2005b) include:

- loss or disturbance of roosting sites and maternity caves
- clearing adjacent to foraging areas
- application of pesticides in or adjacent to foraging areas
- reduction in stream water quality affecting food resources.

Specific impacts

The proposed Upgrade involves the removal of a total of 272.8 ha of native forest/woodland vegetation, which provide foraging habitat for Large-footed Myotis.

15.7 Greater Broad-nosed Bat (*Scoteanax rueppellii*)

Status

The Greater Broad-nosed Bat is listed as vulnerable under Schedule 2 of the *Threatened Species Conservation Act 1995*.

Description

The Greater Broad-nosed Bat is a large and robust microchiropteran bat, up to 95 mm long, with a broad head and a short square muzzle. It is dark reddish-brown to mid-brown above and slightly paler below (Cronin 2000). It is distinguished from other broad-nosed bats by its greater size (Churchill 1998).

Habitat

The Greater-broad-nosed Bat inhabits a variety of habitats from woodland through to moist and dry eucalypt forest and rainforest, though it is most commonly found in tall wet forest. Open woodland habitat and dry open forest suits the direct flight of this species during foraging activities. Greater-broad-nosed Bat utilises a variety of roost sites including hollows, and has also been found in buildings (Hoye & Dwyer 1998).

Ecology

The flight of Greater-broad-nosed Bat is noticeably slower and direct with poor manoeuvrability along creek and river corridors and the edges of patches of woodland in otherwise cleared paddocks at an altitude of 3-6 m. This species forages after sunset and has a highly varied diet of slow-flying prey such as large moths and a variety of beetles, including ground beetles, chafers and leaf beetles. It has been known prey on other bats in the wild (Hoye & Dwyer 1998).

Little is known of its reproductive cycle, however a single young is born in January; prior to birth, females congregate at maternity sites located in suitable trees, where they appear to exclude males during the birth and raising of the single young (Churchill 1998).

Distribution

The Greater Broad-nosed Bat is found mainly in the gullies and river systems that drain the Great Dividing Range, from north-eastern Victoria to the Atherton Tableland. It extends to the coast over much of its range. In New South Wales it is widespread on the New England Tablelands, however does not occur at altitudes above 500 m (Department of Environment and Conservation 2005b).

In the study area:

Greater Broad-nosed Bat were captured on one occasion at site nine (trip-lining) and was identified in call analysis from a further four sites north of the Macleay River (Figure B18). All sites comprise considerable tracts of vegetation and have extensive tree hollow resources in the immediate area (<500 m). Most of the records were obtained during the dusk census period which suggests the species roosts nearby.

Threats

Specific threats to Greater Broad-nosed Bat identified by the Department of Environment and Conservation (2005b) include:

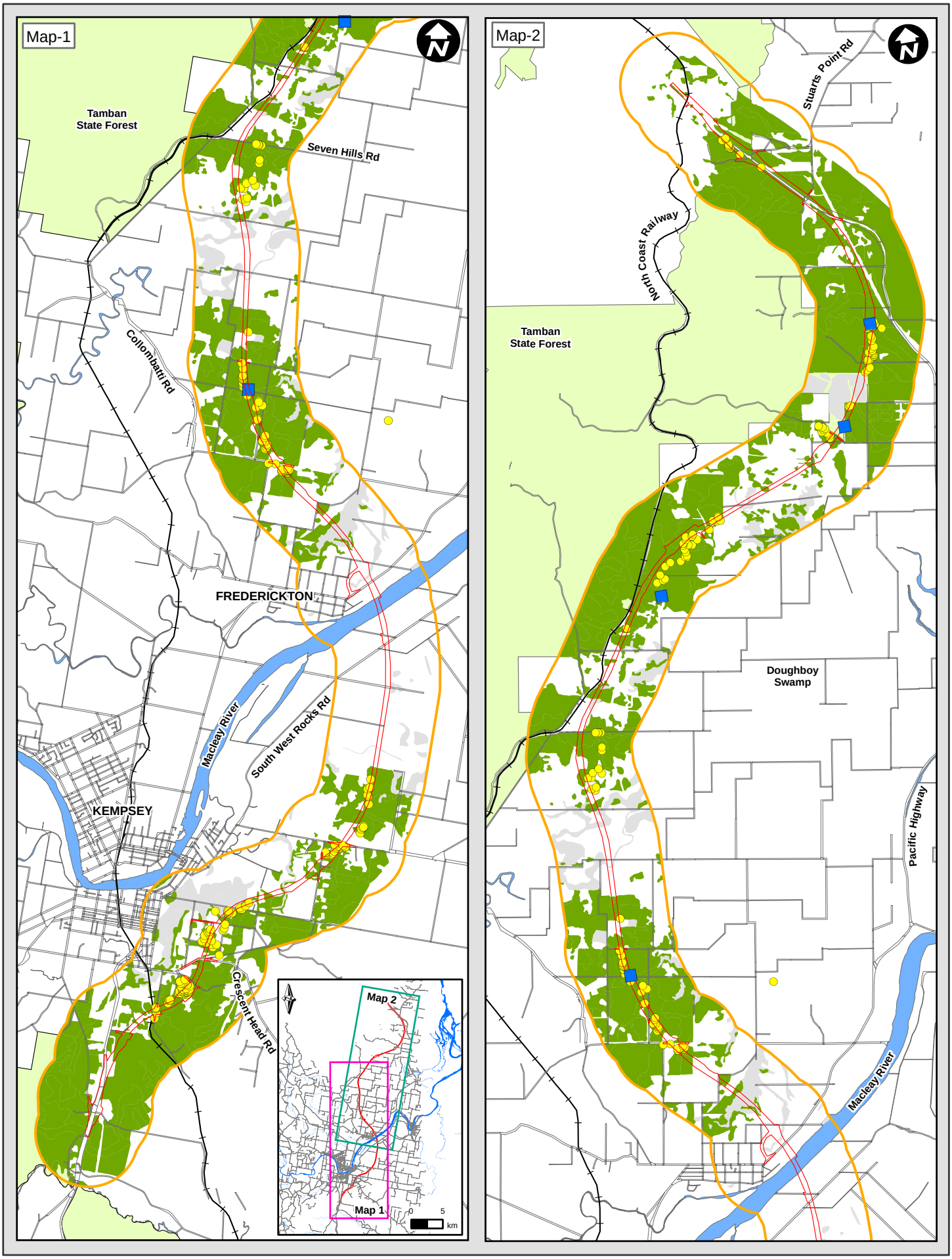
- disturbance to roosting and summer breeding sites
- foraging habitats are being cleared for residential and agricultural developments, including clearing by residents within rural subdivisions
- loss of hollow-bearing tree
- pesticides and herbicides may reduce the availability of insects, or result in the accumulation of toxic residues in individuals' fat stores
- changes to water regimes are likely to impact food resources, as is the use of pesticides and herbicides near waterways.

Specific impacts

The proposed Upgrade involves the removal of a total of 272.8 ha of native forest/woodland vegetation, which provides marginal foraging habitat for Greater Broad-nosed Bat.

A total of 224 hollow-bearing trees suitable for microchiropteran bats were recorded along and immediately adjacent the proposed upgrade.

The proposal will not isolate habitat for Greater Broad-nosed Bat. Roads are unlikely to create a barrier to movement for this highly mobile species, and it is at low risk of colliding with vehicles.



2116519A_2081_Greater_Broad-nosed_Bat.mxd SWD - Sep, 2005

0 1 2 3 4 Kilometres

Greater Broad-nosed Bat (Current Survey)

Greater Broad-nosed Bat (Atlas of NSW Wildlife)

Habitat Tree

Note: Fauna may use other habitat types on an occasional basis.

Construction Footprint

Study Area

Existing Vegetation

Potential Habitat

Waterway

Existing Road

State Forest

Map B18 Habitat for Greater Broad-nosed Bat

15.8 Yellow-bellied Sheathtail Bat (*Saccolaimus flaviventris*)

Status

The Yellow-bellied Sheathtail Bat is listed as vulnerable under Schedule 2 of the *Threatened Species Conservation Act 1995*.

Description

The Yellow-bellied Sheathtail Bat is a very distinctive, large, microchiropteran bat up to 87 mm long. This species has long, narrow wings, a glossy, jet-black back, and a white to yellow belly extending to the shoulders and just behind the ear. Characteristically, it has a flattened head and a sharply-pointed muzzle. The tail is covered with an extremely elastic sheath that allows variation in the tail-membrane area (Churchill 1998).

Habitat

Yellow-bellied Sheathtail Bats occur in almost all habitats including wet and dry sclerophyll forest, open woodland, *Acacia* shrubland and grasslands. This species roosts in hollows of live and dead trees, the outside walls of buildings, under exfoliating bark, or in burrows of terrestrial mammals in treeless areas. They have also been found in the abandoned nests of Sugar Glider (*Petaurus breviceps*) or birds (Richards 1998).

Ecology

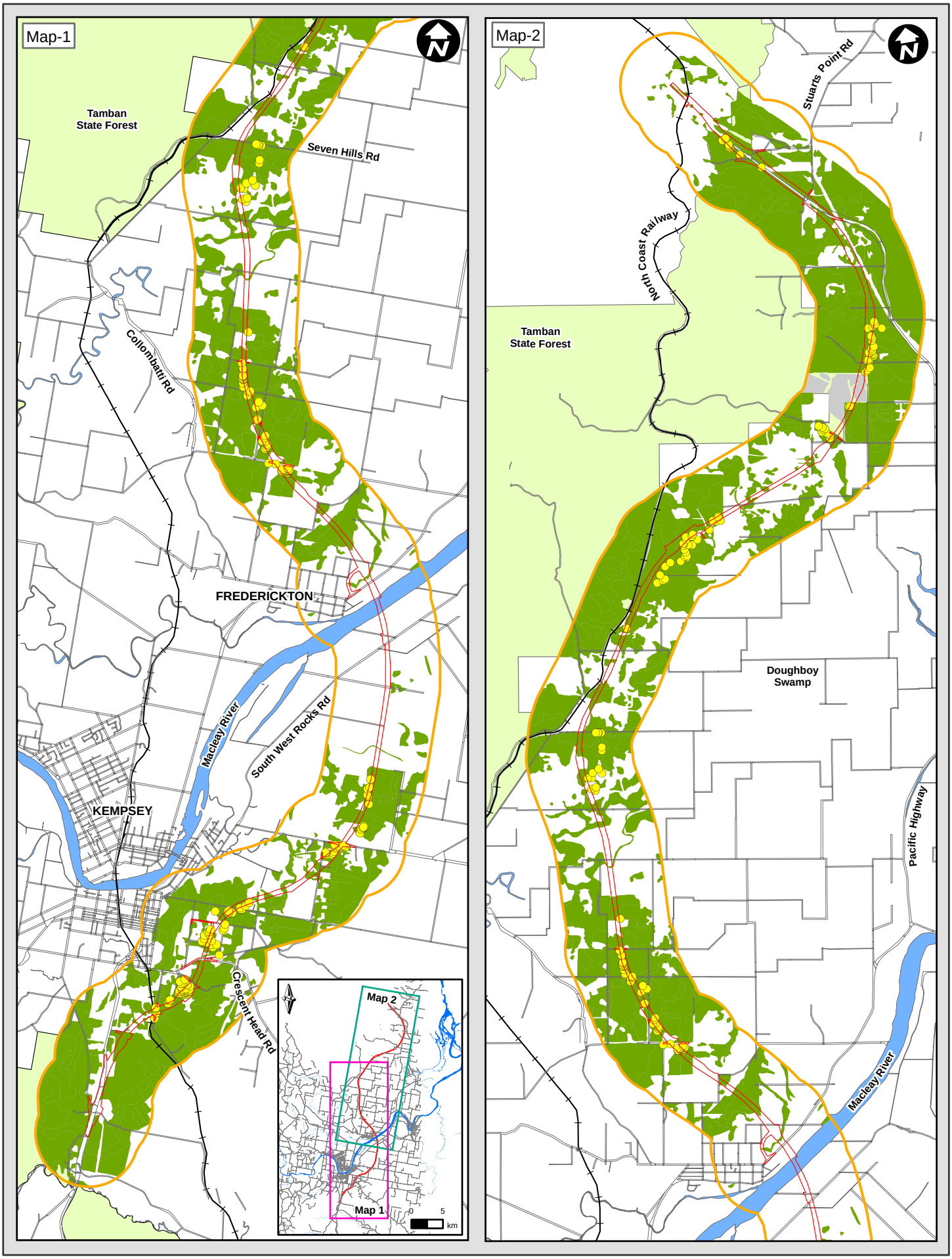
Yellow-bellied Sheathtail Bats forage above the tree canopy. Foraging height varies with the height of the canopy; they fly high and fast. In more open country they forage lower to the ground (Lumsden & Bennett 1995). This species eats a variety of prey mainly beetles (up to 90%) but also long-horned grasshoppers, shield bugs and few flying ants (Churchill 1998).

Yellow-bellied Sheathtail Bats tend to be solitary for most of the year but may form small groups of up to six. Breeding has been recorded from December to mid-March, when a single young is born. Seasonal movements are unknown and there is speculation about a migration to southern Australia in late summer and autumn (Richards 1998).

Distribution

The Yellow-bellied Sheathtail Bat is a wide-ranging species found across northern and eastern Australia. In the most southerly part of its range (most of Victoria, south-western New South Wales and adjacent South Australia) it is a rare visitor in late summer and autumn. There are scattered records of this species across the New England Tablelands and North West Slopes (Department of Environment and Conservation 2005b).

The distribution of Yellow-bellied Sheathtail Bat and its habitats in the study area is shown in Figure B19.



2116519A_2080_Yellow_bellied_Sheathtail_Bat.mxd SWD - Sep, 2005

0 1 2 3 4 Kilometres

Note: Fauna may use other habitat types on an occasional basis.

Map B19 Habitat for Yellow-bellied Sheathtail Bat

- Yellow-bellied Sheathtail-bat (Atlas of NSW Wildlife)
- Habitat Tree
- Potential Habitat
- Construction Footprint
- Study Area
- Existing Vegetation
- Waterway
- Existing Road
- State Forest

Threats

Specific threats to Yellow-bellied Sheathtail Bat identified by the Department of Environment and Conservation (2005b) include:

- disturbance to roosting and summer breeding sites
- foraging habitats are being cleared for residential and agricultural developments, including clearing by residents within rural subdivisions
- loss of hollow-bearing trees; clearing and fragmentation of forest and woodland habitat
- pesticides and herbicides may reduce the availability of insects, or result in the accumulation of toxic residues in individuals' fat stores.

Specific impacts

The proposed Upgrade involves the removal of a total of 272.8 ha of native forest/woodland vegetation, which provides marginal foraging habitat for Yellow-bellied Sheathtail Bat.

A total of 224 hollow-bearing trees suitable for microchiropteran bats were recorded along and immediately adjacent the proposed upgrade.

The proposal will not isolate habitat for Yellow-bellied Sheathtail Bat. Roads are unlikely to create a barrier to movement for this highly mobile species, and it is at low risk of colliding with vehicles.

15.9 Significance assessment - *Environmental Planning and Assessment Act 1979*

How is the proposal likely to affect the lifecycle of a threatened species and/or population?

The proposal involves the removal of foraging habitat for these eight species. However, it will not affect known roosting caves for Little and Common Bent-wing Bats, Large-footed Myotis and Golden-tipped Bats. Hollow-bearing trees that may provide potential roosting sites for Greater Broad-nosed Bats, Eastern Freetail-bats, Yellow-bellied Sheathtail, Hoary Wattled Bats will be removed as a result of the proposal. However similar resources are available and would be accessible in the study area and the wider region that will not be affected by the proposed Upgrade.

How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The proposal involves the removal of native vegetation and some cleared open country. Some tree hollows suitable for roosting will also be removed. However, in a regional context, similar foraging and roosting habitat is likely to be well-represented in several State Forests and National Parks in the area with 4,300 ha occurring within the study area. The proposal is therefore unlikely to remove a significant area of known foraging and potential roosting/breeding habitat.

Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Hoary Wattled Bat is widely distributed across north coasts of Western Australia, Northern Territory, Queensland and northern New South Wales. In north east New South Wales it reaches the lower Clarence and Richmond River areas, extending from near Murwillumbah in the north, south to between Grafton and Coffs Harbour. As a result, the study area is at the southern most limit of distribution for this species.

None of the other microchiropteran bat species considered in this assessment are at the limit of their distribution within the study area.

How is the proposal likely to affect current disturbance regimes?

Parts of the proposed Upgrade occur within already cleared or fragmented habitats that include a range of disturbances commonly found in agricultural landscapes. However the proposed Upgrade will require clearing of vegetation and habitats in relatively intact areas and as such will introduce new edge effects to these sites. In total, 148.2 ha of forest/woodland vegetation will be affected by new edge effects that may include weeds, increased levels of predation, increased noise and changed hydrological regimes.

How is the proposal likely to affect habitat connectivity?

The proposal will not isolate habitat for microchiropteran bats as the road will not create a barrier to movement for these highly mobile species.

How is the proposal likely to affect critical habitat?

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations and ecological communities. Under the *Threatened Species Conservation Act 1995*, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for this species. The site provides foraging habitat for these species. No maternity roosts occur within the site and further areas of habitat are found extensively within the study area and broader region. The site is unlikely to be critical to the survival of these species.

Conclusion

The proposal is unlikely to have a significant impact on microchiropteran species of bat. Although habitat will be removed, similar habitats are available in the local and regional area that would not be affected.

16. Yellow-bellied Glider (*Petaurus australis*)

Status

The Yellow-bellied Glider is listed as vulnerable under Schedule 2 of the *Threatened Species Conservation Act 1995*.

Description

The Yellow-bellied Glider is a large, active, sociable and vocal glider. Adults weigh 450 - 700 g have a head and body length of about 30 cm and a large bushy tail that is about 45 cm long. They have grey to brown fur above with a cream to yellow belly, which is paler in young animals. The dark stripe down the back is characteristic of the group. It has a large gliding membrane that extends from the wrist to the ankle. It has a loud, distinctive call, beginning with a high-pitched shriek and subsiding into a throaty rattle (NSW National Parks and Wildlife Service 1999c).

Habitat

Yellow-bellied Gliders occur in tall mature eucalypt forest generally in areas with high rainfall and nutrient rich soils (Strahan 1995). The forest type preferences for this species varies with latitude and elevation and includes mixed coastal forests to dry escarpment forests in the north and moist coastal gullies and creek flats to tall montane forests in the south of New South Wales. The Yellow-bellied Glider forages over a wide range of canopy heights, and in plant communities that have an open overstorey and understorey (Goldingay 1992).

The major determinant for potential habitat appears to be the presence of specific combinations of tree species and assemblages, in relation to the seasonal variability of sap, nectar and insects of the trees. Yellow-bellied Gliders favour tall, mature forest with a range of *Eucalyptus* species, especially smooth barked species such as E*. viminalis, E. fastigata, E. ovata* and *E. cypellocarpa*, which shed their bark annually and hence provide not only sap but insects which shelter in the loose bark. The preferred habitat is characterised by a mosaic of tree-species associations, including those which flower in winter (Kavanagh 1987).

The hollows of large trees are required for den sites. The species requires relatively large tree hollows because family groups share den sites (Gibbons & Lindenmayer 1997).

Ecology

Yellow-bellied Gliders are mainly nocturnal, sheltering in nests in tree hollows lined with leaves during the day (Goldingay & Kavanagh 1991). The foraging behaviour of Yellow-bellied Glider is diverse and responsive to changes in tree phenology such as periods of flowering and bark shedding. Yellow-bellied Gliders tend to show a pattern of seasonal use of their home range due to a dependence on certain food types that are only available from particular forest types at particular times of the year (Kavanagh 1987). They feed primarily on plant and insect exudates, including nectar, sap, honeydew and manna with pollen and insects providing protein (Goldingay 1992). Sap is extracted by biting into the trunks and branches of favoured food trees, often leaving a distinctive ‘V’-shaped scar (Triggs 1996).

Yellow-bellied Gliders have home ranges that appear to function as territories, with vocalisations serving to advertise and maintain their integrity. They are very mobile and occupy large home ranges between 20 to 85 ha to encompass dispersed and seasonally variable food resources (Goldingay & Kavanagh 1991).

Yellow-bellied Gliders form small family groups consisting of a dominant male and up to five females and their young all den together large hollows. The single young is born between November and May with the young become sexually mature at 18 to 24 months (Craig 1985).

Distribution

This species is restricted to eastern Australia and occurs along the entire eastern edge of New South Wales, although its occurrence within this area is extremely patchy (NSW National Parks and Wildlife Service 1999c).

Yellow-bellied Gliders and their preferred habitats have been recorded in numerous coastal conservation reserves in the North Coast bioregion (NSW National Parks and Wildlife Service 1999b). The species is also recorded frequently in State Forests (NSW National Parks and Wildlife Service 2003a). However, given the apparent rarity of this species and increased development pressure on the coastal fringe of New South Wales, it is unlikely that Yellow-bellied Gliders are adequately represented in the conservation reserve system in the region.

In the study area:

Yellow-bellied Glider was recorded east of Pacific Highway, between Tamban State Forest and Doughboy Swamp. A targeted survey of this site was completed in March 2007 (see Section 3 of this report) and confirmed the presence of at least two individuals, with habitat occurring mainly to the west of the proposed Upgrade.

Threats

Specific threats identified in the Yellow-bellied Glider Recovery Plan by the NSW National Parks and Wildlife (NSW National Parks and Wildlife Service 2003a) include:

- loss and fragmentation of habitat
- loss of hollow-bearing trees
- loss of feed trees.

Specific impacts

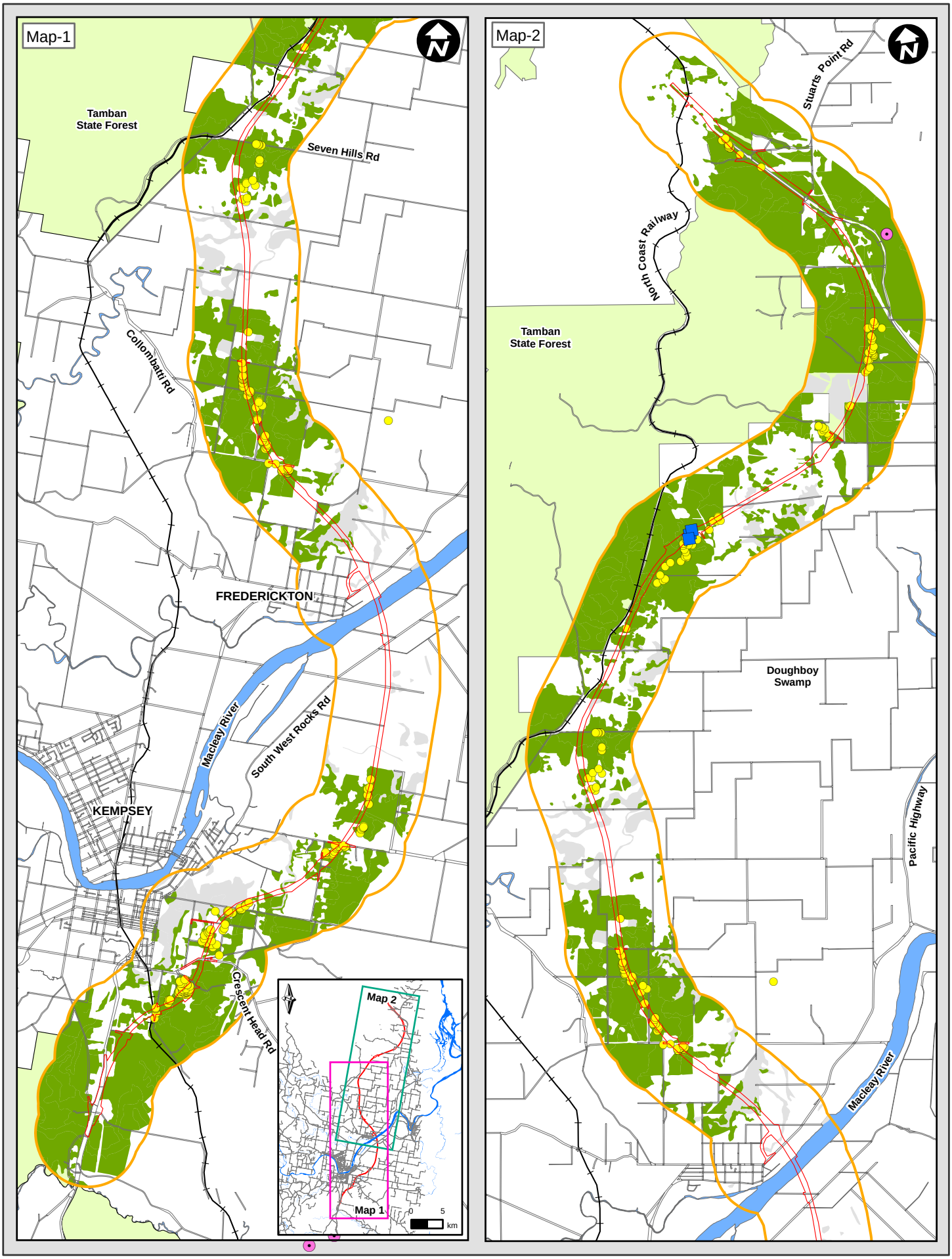
The proposed Upgrade involves the removal of a total of 272.8 ha of native forest/woodland vegetation, which provides potential foraging habitat for Yellow-bellied Glider. However, most areas of habitat used by this species are in the northern half of the study area and occur to the west of the proposed upgrade footprint.

The proposal will remove 163 hollow-bearing trees that have the potential to be used as denning sites for large gliders. Within the area with known individuals (see Section 3 of this report), the proposed Upgrade will remove 12 hollow-bearing trees suitable for use by Yellow-bellied Gliders and approximately 14 ha of suitable foraging habitat.

Yellow-bellied Gliders are regarded to be at risk from road mortality.

Mitigation

- Implementation of clearing protocols.



0 1 2 3 4 Kilometres

Yellow-bellied Glider (Current Survey)

Yellow-bellied Glider (Atlas of NSW Wildlife)

Habitat Tree

Note: Fauna may use other habitat types on an occasional basis.

Construction Footprint

Study Area

Existing Vegetation

Potential Habitat

Waterway

Existing Road

State Forest

Map B20 Habitat for Yellow-bellied Glider

2116519A_2074_Yellow_bellied_Glider.mxd SWD - Sep, 2005

16.1 Significance assessment - *Environmental Planning and Assessment Act 1979*

How is the proposal likely to affect the lifecycle of a threatened species and/or population?

The proposed Upgrade involves the removal of a total of 272.8 ha of native forest, which provides potential foraging habitat for Yellow-bellied Glider. However, most areas of habitat used by this species are in the northern half of the study area. The proposal involves the removal of 163 hollow-bearing trees that have the potential to be used as denning sites for large gliders. Within the area with known individuals (see Section 3 of this report), the proposed Upgrade will remove 12 hollow-bearing trees suitable for use by Yellow-bellied Gliders and approximately 14 ha of suitable foraging habitat.

Similar habitat will be retained in adjacent areas within the study area (4,300 ha) and would continue to provide Yellow-bellied Glider with sufficient foraging and breeding resources in order to maintain a viable population. Clearing protocols will be put in place to avoid direct mortality as a result of the proposed Upgrade.

The proposal is considered unlikely to disrupt the lifecycle of the Yellow-bellied Glider such that it is at risk of extinction.

How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

Construction of the proposed Upgrade will not remove or modify a significant area of known habitat for Yellow-bellied Glider in a regional context. Similar habitat will be retained in adjacent areas within the study area, continuing to provide Yellow-bellied Glider with sufficient foraging and breeding resources in order to maintain a viable population. The removal of this habitat is not considered to be significant in a regional context.

The proposal involves the removal of native vegetation which is used for foraging as well as hollow-bearing dead trees that have the potential to be used as denning sites. Within the area with known individuals (see Section 3 of this report), the proposed Upgrade will remove 12 hollow-bearing trees suitable for use by Yellow-bellied Gliders and approximately 14 ha of suitable foraging habitat.

Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Yellow-bellied Glider is found along the eastern coast to the western slopes of the Great Dividing Range, from southern Queensland to Victoria. The study area is not at the distributional limit for the species.

How is the proposal likely to affect current disturbance regimes?

Parts of the proposed Upgrade occur within already cleared or fragmented habitats that include a range of disturbances commonly found in agricultural landscapes. However the proposed Upgrade will require clearing of vegetation and habitats in relatively intact areas and as such will introduce new edge effects to these sites. In total, 148.2 ha of forest/woodland vegetation will be affected by new edge effects that may include weeds, increased levels of predation, increased noise and changed hydrological regimes.

How is the proposal likely to affect habitat connectivity?

The home range for the species has been estimated up to 85 ha (Russell 1995). Yellow-bellied Gliders tend to show a pattern of seasonal use of its home range due to a dependence on certain food types that are only available from particular forest types at particular times of the year (Goldingay 1992; Kavanagh 1984).

Only small areas of habitat will be fragmented. The species is mobile and similar habitats that are adjacent to the areas proposed for clearing will be retained. The species can glide distance of up to 140 m, which is greater than the width of the proposed Upgrade.

Within the area with known individuals (see Section 3 of this report), the proposed Upgrade will remove 12 hollow-bearing trees suitable for use by Yellow-bellied Gliders and approximately 14 ha of suitable foraging habitat. A further five hollow-bearing trees are likely to be come isolated on the eastern side of the highway. However there is no evidence that the resident gliders use this habitat to the east of the proposed Upgrade.

Therefore, it is unlikely that important habitats of Yellow-bellied Glider in the study area will become fragmented and interconnectivity between other habitats will remain.

How is the proposal likely to affect critical habitat?

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations and ecological communities. Under the *Threatened Species Conservation Act 1995*, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for this species.

Conclusion

The proposal is unlikely to have a significant impact on the Yellow-bellied Glider. Although the proposed Upgrade will remove known habitat for this species, similar habitat is available in the wider region to the west of the alignment. The proposed Upgrade is unlikely to fragment the population in the local area to any great extent.

17. Brush-tailed Phascogale (*Phascogale tapoatafa*)

Status

The Brush-tailed Phascogale is listed as vulnerable under Schedule 2 of the *Threatened Species Conservation Act 1995*.

Description

The Brush-tailed Phascogale is an arboreal marsupial carnivore that has a characteristic, black, bushy 'bottlebrush' tail, with hairs up to 4 cm long. Its fur is grey above and pale cream below and it has conspicuous black eyes and large naked ears. Adults have a head and body length of about 20 cm, a tail length of about 20 cm and weigh 110 - 235 g (Cronin 2000).

Habitat

The Brush-tailed Phascogale is largely arboreal, occupying a variety of habitats, however its preferred habitat is open dry sclerophyll forest with little groundcover (herbs, grasses, shrubs, or leaf litter) on ridges up to 600 m altitude. It also inhabits heath, swamps, rainforest and wet sclerophyll forest (Department of Environment and Conservation 2005c; Strahan 1995).

Specific habitat requirements of the species in the Northern Rivers Catchment Management Area include hollow trees, logs or stumps with entrances greater than 2.5 cm wide for breeding and globular nests or possum drays for shelter (Department of Environment and Conservation 2005c). It uses many different hollows over a short time span and prefers to forage in rough barked trees of 25 cm in diameter at breast height (Scarff et al. 1998).

Ecology

The diet of Brush-tailed Phascogales consists mainly of arthropods, such as spiders, centipedes, cockroaches, beetles and bull ants collected in trees (Scarff et al. 1998). The species will also forage on the ground and eucalypt nectar is extensively utilised when trees are flowering (Traill & Coates 1993).

The home range of Brush-tailed Phascogales is exclusive and densities are correspondingly low. Females occupy a home range of 37 ha, and males occupy up to 100 ha with their home ranges overlapping the female home range (Soderquist & Ealey 1994; Traill & Coates 1993).

The Brush-tailed Phascogale has a three week mating season which occurs mid May to early July. The female is attracted by the scent from the male chest gland. Following mating, the pair nest in tree hollows with narrow entrances. After forming the nest, the male will soon die through what is believed to be stress related illness induced by excessive copulative behaviour. Gestation normally takes 30 days and for the first five weeks the young will stay in the pouch. After seven weeks the young will be placed in the nest and within 20 weeks young are completely weaned. Females only produce one litter per lifetime (Soderquist 1993; Soderquist & Ealey 1994).

Distribution

The Brush-tailed Phascogale has a patchy distribution around the coast of Australia. In New South Wales is more frequently found in forest on the Great Dividing Range in the north-east and south-east of the State.

The Brush-tailed Phascogale has been recorded in National Parks, Nature Reserves and State Recreation Areas on the south, mid-north and north coast and adjacent inland areas of NSW.

The species has been recorded in a number of State Forests in the region including, as well as Dorrigo and Yuraygir National Parks. The extent to which the regional reserves conserve the Brush-tailed Phascogale is insufficiently known (Department of Environment and Conservation 2005b).

In the study area:

Brush-tailed Phascogale was recorded at four dry sites north of the Macleay River. A single male was recorded on the fifth night of arboreal trapping at site two (Figure B21). The capture occurred in an area characterised by numerous hollow bearing trees which appear to be a limited resource in the immediate area (<500 m). Two individuals were caught at site seven. In contrast, seven individuals were captured at site five and five individuals were caught at site six (PB 2006). The density of Brush-tailed Phascogale at the latter two sites supports the notion of high habitat quality for this species and should be regarded as local and regionally significant.

Refuge habitat for Brush-tailed Phascogale was identified at 164 trees and stags along the proposed footprint. This species was considered likely to use a range of tree hollow resources including large fissures and hollows with small openings. Studies undertaken by Forest NSW on the NSW mid north coast found this species readily used a wide range of hollows which left them vulnerable to predation (B. Cann, *personal communication*). In some cases, radio-collared animals used large hollows (greater than 20 cm) which led to predation by Lace Monitors (B. Cann, *personal communication*).

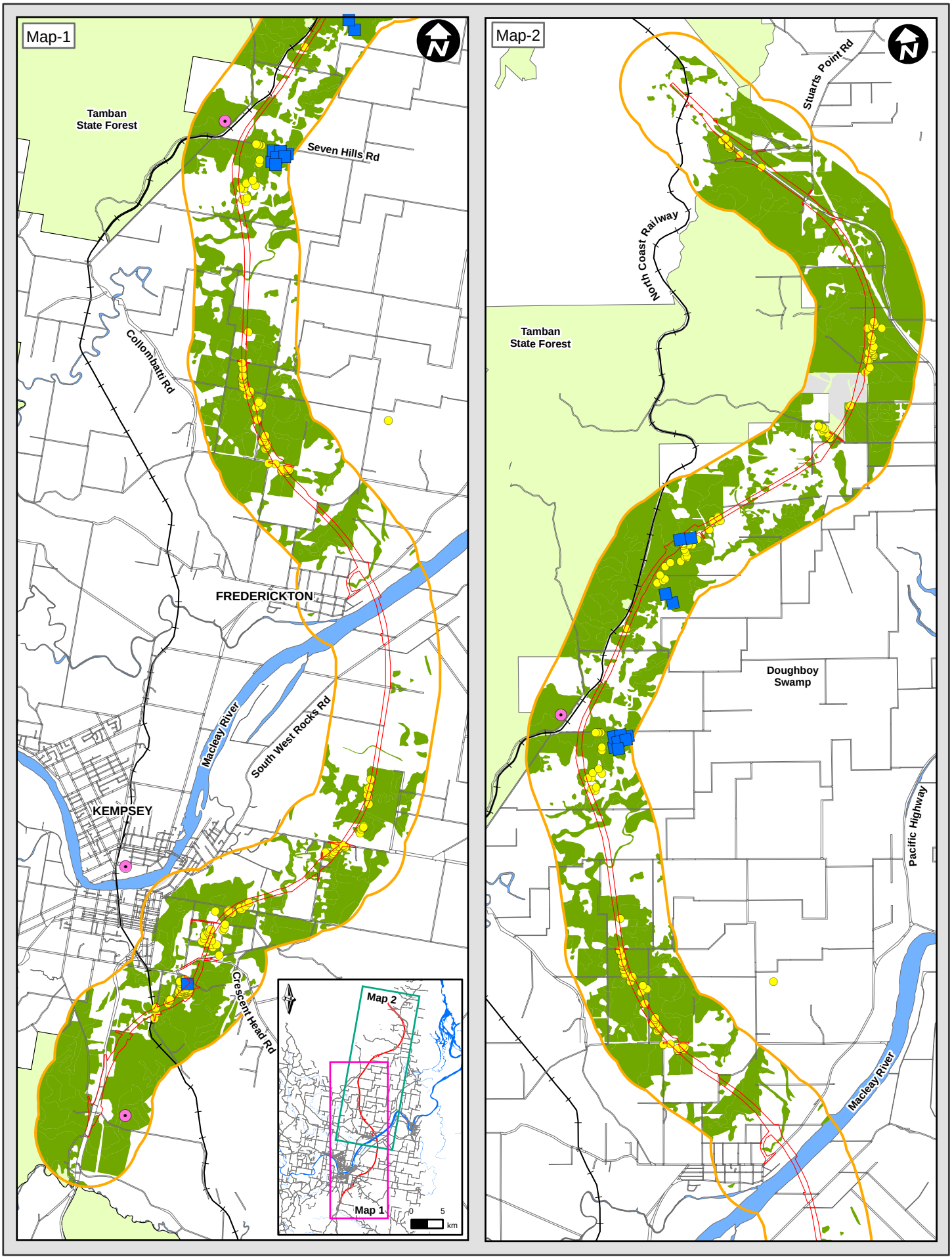
Threats

Specific threats to Brush-tailed Phascogale identified by the Department of Environment and Conservation (2005b) include:

- loss and fragmentation of habitat
- loss of hollow-bearing trees
- predation by foxes and cats
- competition for nesting hollows with the introduced honeybee.

Specific impacts

The proposed Upgrade involves the removal of a total of 272.8 ha of native forest/woodland vegetation. The vegetation clearing includes 121 ha of key habitat as defined by Scotts (2003) (note that this definition is different from that used by the Roads and Traffic Authority under their Compensatory Habitat Guidelines) mainly in the area of Tamban State Forest in the north of the proposed Upgrade, which contains significant foraging resources for Brush-tailed Phascogale.



2116519A_2076_Brush_Tailed_Phascogale.mxd SWD - Sep, 2005

0 1 2 3 4 Kilometres

Brush-tailed Phascogale (Current Survey)

Brush-tailed Phascogale (Atlas of NSW Wildlife)

Habitat Tree

Note: Fauna may use other habitat types on an occasional basis.

Construction Footprint

Study Area

Existing Vegetation

Potential Habitat

Waterway

Existing Road

State Forest

Map B21 Habitat for Brush-tailed Phascogale

A total of 164 hollow-bearing trees suitable for Brush-tailed Phascogale were identified along and immediately adjacent to the proposed Upgrade. The removal of groundcover habitats includes logs and stumps that are used as refuge sites for breeding.

Mitigation measures

- Use of nest boxes
- Including phascogale-proof fauna fencing in key area
- Including fauna underpasses in key areas.

17.1 Significance assessment - *Environmental Planning and Assessment Act 1979*

How is the proposal likely to affect the lifecycle of a threatened species and/or population?

The proposed Upgrade involves the removal of a total of 272.8 ha of native forest. The vegetation clearing includes 121 ha of key habitat as defined by Scotts (2003), mainly in the area of Tamban State Forest in the north of the proposed Upgrade which contains significant habitat resources for Brush-tailed Phascogale. A total of 164 hollow-bearing trees suitable for this species were identified along and immediately adjacent to the proposed Upgrade.

The proposal will remove habitat that is of high quality for the Brush-tailed Phascogale, including a range of tree hollow resources including large fissures and hollows. The habitats proposed for removal are regarded as local and regionally significant. While similar habitats are available in the local area and wider region, notably high numbers of Phascogales were recorded in the study area.

The proposal is considered likely to disrupt the lifecycle of this species and could place the local population at risk of extinction.

How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The proposal will remove habitat that is of high quality for the Brush-tailed Phascogale, including a range of tree hollow resources including large fissures and hollows with large openings.

The removal of this habitat is considered to be significant in a regional context.

Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Brush-tailed Phascogale has a patchy distribution around the coast of Australia. In New South Wales it is more frequently found in forest on the Great Dividing Range in the north-east and south-east of the State (Strahan 1995). The study area is not at the distributional limit for the species.

How is the proposal likely to affect current disturbance regimes?

Parts of the proposed Upgrade occur within already cleared or fragmented habitats that include a range of disturbances commonly found in agricultural landscapes. However the proposed Upgrade will require clearing of vegetation and habitats in relatively intact areas and as such will introduce new edge effects to these sites. In total, 148.2 ha of forest/woodland vegetation will be affected by new edge effects that may include weeds, increased levels of predation, increased noise and changed hydrological regimes.

How is the proposal likely to affect habitat connectivity?

The proposal will remove habitat that is if high quality for the Brush-tailed Phascogale, including a range of tree hollow resources including large fissures and hollows, which occur on both sides of the proposed Upgrade. Brush-tailed Phascogale have been recorded using underpasses (Australian Museum Business Services 2001c, 2001b, 2001a, 2001d), but the road is still likely to present a barrier to movement in this species.

How is the proposal likely to affect critical habitat?

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations and ecological communities. Under the Threatened Species Conservation Act 1995, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for this species (Department of Environment and Conservation, Threatened Species Unit). The site provides high quality habitat and includes a range of tree hollows, but is unlikely to be critical.

Conclusion

The proposal is likely to have a significant impact on the local population of Brush-tailed Phascogale, by removing significant habitat for the species and by increasing barrier effects and fragmentation of habitat in the local area.

18. Koala (*Phascolarctos cinereus*)

Status

The Koala is listed as vulnerable under Schedule 2 of the *Threatened Species Conservation Act 1995*.

Two population of Koala are currently listed as Endangered under Part 2 of Schedule 1 of the *Threatened Species Conservation Act 1995* (Hawks Nest and Tea Gardens area population and the Pittwater Local Government Area population). Koalas in the study area do not form part of these populations.

Description

The Koala is an arboreal marsupial with fur ranging from grey to brown above, and is white below. It has large furry ears, a prominent black nose and no tail. It spends most of its time in trees and has long, sharp claws, adapted for climbing. Adult males weigh 6-12 kg and adult females weigh 5–8 kg (NSW National Parks and Wildlife Service 2002a).

Habitat

Koalas are found in areas where there are suitable feed trees, ranging from open eucalypt woodlands to dense forests. Like other folivores, this species tends to be associated with forests growing on high-nutrient soils along river flats and drainage lines, most of which have been cleared for farmland (NSW National Parks and Wildlife Service 1999a). The suitability of forest and woodland communities as habitat for Koalas is influenced by the size and species of trees present, soil nutrients, climate, rainfall and the size and disturbance history of the habitat patches. Koalas feed on the foliage of more than 70 eucalypt species and 30 non-eucalypt species, but in any one area will select preferred browse species (Moore & Foley 2000).

Ecology

Koalas are generally Inactive for most of the day, feeding and moving mostly at night. They spend most of their time in trees, but will descend and traverse open ground to move between trees. They are generally solitary, but have complex social hierarchies based on a dominant male with a territory overlapping several females and sub-ordinate males on the periphery. Home range size varies with quality of habitat, ranging from less than two to several hundred hectares in size (Lunney et al. 2000).

Young males reach sexual maturity at approximately two years, although they are generally excluded from mating by the dominant male. Females reach sexual maturity at approximately two years and can produce one offspring each year, generally in summer (Ellis et al. 2000).

Following birth, the young lives in the pouch for 6 months and on leaving the pouch it remains dependent on its mother, riding on her back. Young reach independence at about 12 months, although they can remain in the mother's home range for a further 2 - 3 years. After this period, young animals disperse to establish their own home range (Logan & Sanson 2003). Dispersal distances generally range from 1-11 km, although movements in excess of 50 km have been recorded (NSW National Parks and Wildlife Service 2002a).

In coastal northern New South Wales, populations have been estimated to range from one animal every 45 ha to one every 4.5 ha (average one every 20-25 ha) (Melzer et al. 2000). Most young disperse at two to three years of age and females remain in their natal area. If no suitable habitat is found by young individuals then they become nomadic (Lunney et al. 2000).

Distribution

The Koala has a fragmented distribution throughout eastern Australia from north-east Queensland to the Eyre Peninsula in South Australia. In New South Wales it mainly occurs on the central and north coasts with some populations in the western region. It was historically abundant on the south coast of New South Wales, but now occurs in sparse and possibly disjunct populations (NSW National Parks and Wildlife Service 2003b).

Koalas are abundant on the north coast of New South Wales with concentrations around Port Stephens, from Bulahdelah to Taree, Port Macquarie and Coffs Harbour and between Lismore and Tweed Heads (Reed et al. 1990).

Although Koalas have been recorded in numerous conservation reserves and State Forests along the east coast and the slopes and tablelands of the Great Dividing Range, the species has poor representation in conservation reserves and is reliant predominantly upon freehold land and public outside the conservation reserve system (NSW National Parks and Wildlife Service 2003b).

In the study area:

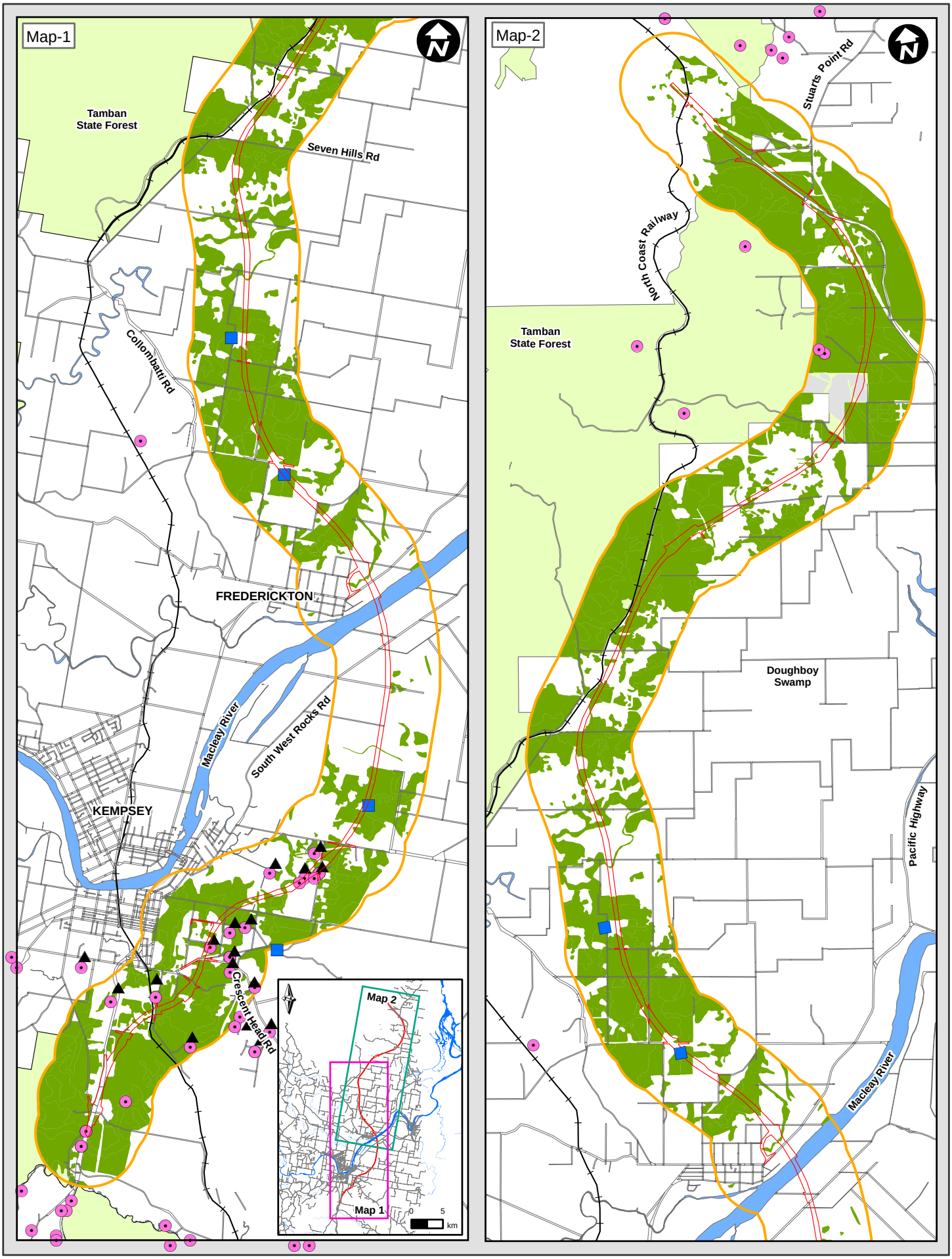
Koala was recorded at four sites all of which are associated with drainage lines (Figure B22). Three records were obtained from the Koala scat surveys which generally yielded low activity levels consistent with transient habitat. A fourth record was obtained from a calling male koala during a spotlight traverse at a wet site. The data suggests Koala is sparsely distributed on both the north and south sides of the Macleay River.

The results of the Koala survey and habitat analysis suggest that Koalas are resident in the area, but they are likely to use much of the area as only transient habitat. The low numbers recorded and lack of breeding females suggests that the study area would not be considered core Koala habitat within the definition of State Environmental Planning Policy 44 – Koala Habitat Protection.

Threats

Specific threats identified in the Koala Draft Recovery Plan by the NSW National Parks and Wildlife Service (2003b)includes:

- destruction of habitat by clearing for urban development, agriculture and mining, particularly on high nutrient content soils
- fragmentation of habitat by roads, urban development and agriculture, which creates barriers to movement, isolates individuals and populations, alters population dynamics and prevents gene flow and the ability to maintain recruitment levels
- mortality from attacks by dogs, road fatalities, fires, drought or other natural disasters, particularly in fragmented landscapes without suitable refuge areas
- degradation of habitat by fire, weed invasion, removal of important habitat trees and climate change
- in stressed populations, infection by Chlamydia, causing cystitis, keratoconjunctivitis, infertility and other symptoms.



0 1 2 3 4 Kilometres

Koala (Current Survey)

Koala (Vanessa Standing)

Koala (Atlas of NSW Wildlife)

Note: Fauna may use other habitat types on an occasional basis.

Construction Footprint

Study Area

Existing Vegetation

Potential Habitat

Waterway

Existing Road

State Forest

Map B22 Habitat for Koala

2116519A_2077_Koala.mxd SWD - Sep, 2005

Specific impacts

The proposed Upgrade involves the removal of a total of 272.8 ha of native forest/woodland vegetation, which provides potential foraging habitat for Koalas.

The proposal is also likely to isolate habitat for Koala. Indirect impacts of the proposal may include habitat degradation and predation by introduced predators.

Mitigation measures

Crossing structures have been recommended both north and south of the Macleay River in order to reduce the impacts of habitat fragmentation and road kills to Koala. These include culverts and bridges including fauna-proof fencing.

18.1 Significance assessment - *Environmental Planning and Assessment Act 1979*

How is the proposal likely to affect the lifecycle of a threatened species and/or population?

The proposed Upgrade involves the removal of a total of 272.8 ha of native forest/vegetation, which provides potential foraging habitat for Koala.

The results of the Koala survey and habitat analysis suggest that Koalas are resident in the area, but they are likely to use much of the area as only transient habitat. The low numbers recorded and lack of breeding females suggests that the study area would not be considered core Koala habitat.

It is unlikely that the removal of this extent of habitat would disrupt the lifecycle of this species or place the local population at risk of extinction.

How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

Construction of the proposal will not remove or modify a significant area of known habitat for Koalas in a regional context. Similar habitat will be retained in adjacent areas, continuing to provide Koalas with sufficient foraging and breeding resources. The removal of this habitat is not considered to be significant in a regional context.

Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Koala has a fragmented distribution throughout eastern Australia from north-east Queensland to the Eyre Peninsula in South Australia. The study area is not at the distributional limit for this species.

How is the proposal likely to affect current disturbance regimes?

Parts of the proposed Upgrade occur within already cleared or fragmented habitats that include a range of disturbances commonly found in agricultural landscapes. However the proposed Upgrade will require clearing of vegetation and habitats in relatively intact areas and as such will introduce new edge effects to these sites. In total, 148.2 ha of forest/woodland vegetation will be affected by new edge effects that may include weeds, increased levels of predation, increased noise and changed hydrological regimes.

How is the proposal likely to affect habitat connectivity?

There will be some fragmentation of habitat occurring to the south of the Macleay River, although habitats and vegetation remnants in this area are already highly fragmented. North of the Macleay River the proposed Upgrade will increase fragmentation in the Collombatti and Tamban State Forest areas.

The proposal is likely to isolate habitat for Koala by creating barriers for movement, but mitigation measures in the form of underpasses have been included in the proposal.

How is the proposal likely to affect critical habitat?

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations and ecological communities. Under the *Threatened Species Conservation Act 1995*, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for this species (Department of Environment and Conservation, Threatened Species Unit). Suitable habitat will be retained in adjacent areas (5,090 ha in the study area) and continue to provide Koala with sufficient foraging and breeding resources.

Conclusion

The proposal is unlikely to have a significant impact on Koala in the study area. Although habitat will be removed, this is not considered core Koala habitat and similar habitat features are available in the wider local and regional area.

19. Common Planigale (*Planigale maculata*)

Status

The Common Planigale is listed as vulnerable under Schedule 2 of the *Threatened Species Conservation Act 1995*.

Description

Common Planigales are tiny marsupials with a body length of about 8 cm and with a tail as long as its body. The head has a flattened appearance and their fur is grey-brown above, sometimes with tiny white spots, and paler below (Cronin 2000).

Habitat

Habitat of the Common Planigale ranges from rainforest to sclerophyll forest, and including grasslands, marshlands, heathland and rocky areas. It is also known from pine plantations, woodland savannah and wattle scrub. Habitat selection is primarily influenced by the surface cover. Preferred areas appear to have dense to rank groundcover associated with deep litter and log/bark debris and is usually close to water (Redhead 1998).

Specific habitat requirements of Common Planigale in the Northern Rivers Catchment Management Area include hollow logs, under bark, rocks, cracks in soil, grass tussocks or building debris for breeding, dense leaf-litter or ground cover close to water for foraging and Hollow logs, under bark, rocks, cracks in soil, grass tussocks or building debris for refuge and shelter (Department of Environment and Conservation 2005c).

Ecology

Common Planigales are active at night and during the day shelter in saucer-shaped nests built in crevices, hollow logs, beneath bark or under rocks (Cronin 2000). They are fierce carnivorous hunters and agile climbers, preying on insects and small vertebrates, some nearly their own size (Redhead 1998).

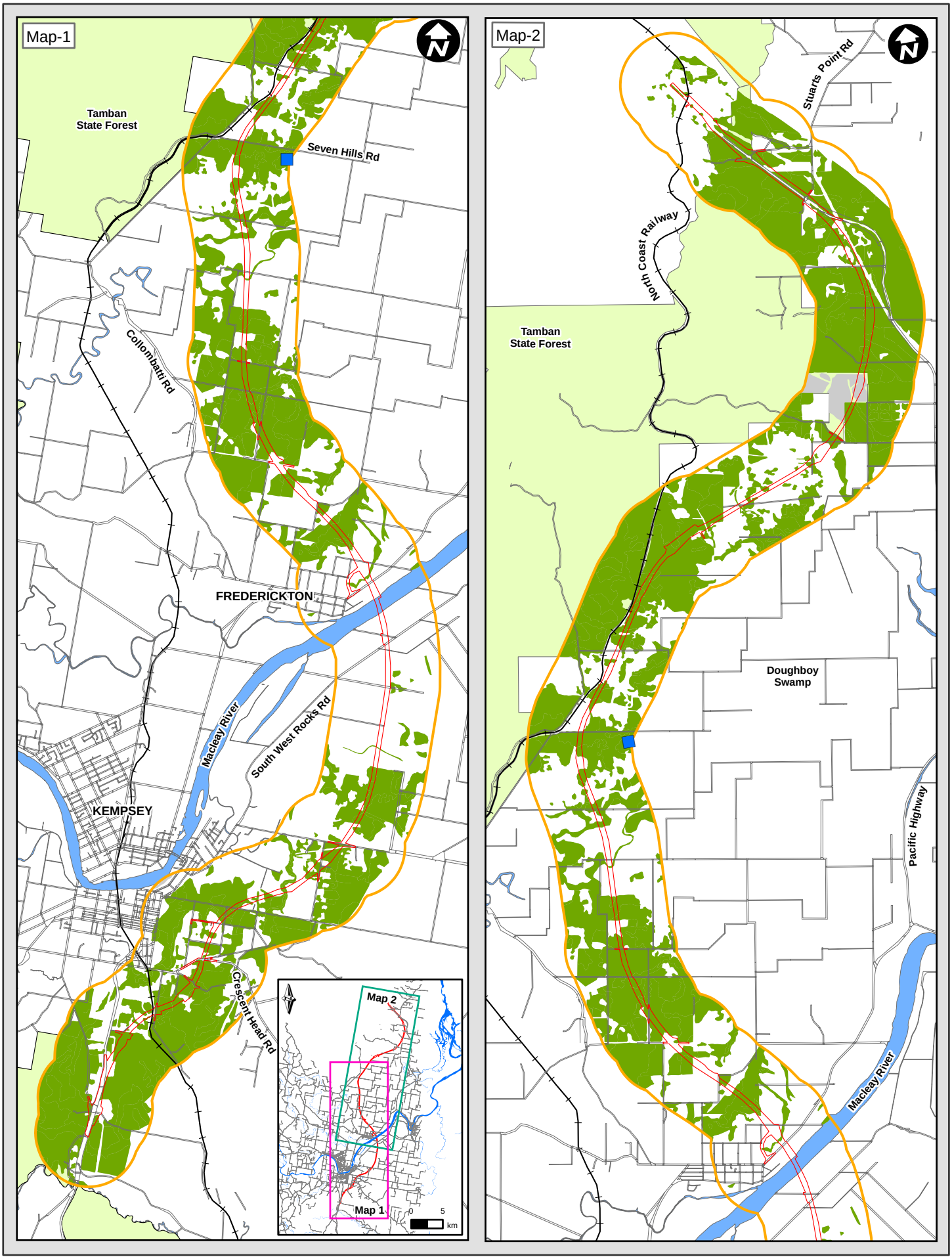
Breeding occurs from October to January. The female builds a nest lined with grass, eucalypt leaves or shredded bark (Redhead 1998). Very little is known of the home range of the Common Planigale (Department of Environment and Conservation 2005c).

Distribution

The Common Planigale occurs in northern coastal Northern Australia and from the Cape York Peninsula along the east coast south as far as about Newcastle in New South Wales (Department of Environment and Conservation 2005c).

In the study area:

A single Common Planigale was tentatively identified on the eastern side of the Pacific Highway near Doughboy Swamp (Figure B23). The individual escaped from its holding bag and could not be recaptured to provide a definitive identification. Two principal reasons are given for its identification. Firstly, its overall appearance and size is consistent with other planigales caught in the current study and secondly, no juvenile brown antechinus (analogous species) were caught during this survey period nor were any adults caught at this site. Subsequent surveys at nearby sites in January recorded numerous juvenile Brown Antechinus.



2116519A_2078_Common_Planigale.mxd SWD - Sep, 2005

0 1 2 3 4 Kilometres

Common Planigale (Current Survey)

Common Planigale (Atlas of NSW Wildlife)

Potential Habitat

Note: Fauna may use other habitat types on an occasional basis.

Construction Footprint

Study Area

Existing Vegetation

Waterway

Existing Road

State Forest

Map B23 Habitat for Common Planigale

Threats

Specific threats to Common Planigale identified by the Department of Environment and Conservation (2005b) include:

- predation by foxes, cats and cane toads
- loss and fragmentation of habitat through clearing for agriculture and development in coastal areas
- frequent burning and grazing that reduces ground cover such as hollow logs and bark
- disturbance of vegetation surrounding water bodies.

Specific impacts

The proposed Upgrade involves the removal of a total of 272.8 ha of native forest/woodland vegetation, which may provide habitat for the Common Planigale.

The proposal is also likely to isolate habitat for this species.

Indirect impacts may include habitat degradation due to edge effects and weed infestation.

19.1 Significance assessment - *Environmental Planning and Assessment Act 1979*

How is the proposal likely to affect the lifecycle of a threatened species and/or population?

The proposed Upgrade involves the removal of a total of 272.8 ha of native forest/woodland vegetation, which may provide potential foraging habitat for the Common Planigale. Similar habitats in adjacent areas will remain unaffected by the proposal.

The species was tentatively recorded at only one location in the study area, despite intensive targeted surveys.

Given the amount of potential habitat and records the species in the area proposed for development it is unlikely that the proposed Upgrade would disrupt the lifecycle of a viable population such that it would be placed at risk of extinction.

How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

Construction of the proposal will not remove or modify a significant area of known habitat for Common Planigale in a regional context. Similar habitat will be retained in adjacent areas (4,300 ha in the study area) and continue to provide the regional population of Coastal Planigale with foraging and breeding resources. The removal of this habitat is not considered to be significant in a regional context.

Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Coastal Planigale occurs in northern coastal Northern Australia and from the Cape York Peninsula along the east coast south as far as about Newcastle in New South Wales. The study area is not at the distributional limit for this species.

How is the proposal likely to affect current disturbance regimes?

Parts of the proposed Upgrade occur within already cleared or fragmented habitats that include a range of disturbances commonly found in agricultural landscapes. However the proposed Upgrade will require clearing of vegetation and habitats in relatively intact areas and as such will introduce new edge effects to these sites. In total, 148.2 ha of vegetation will be affected by new edge effects that may include weeds, increased levels of predation, increased noise and changed hydrological regimes.

How is the proposal likely to affect habitat connectivity?

There will be some fragmentation of habitat to the south of the Macleay River, although habitats and vegetation remnants in this area are already highly fragmented. North of the Macleay River the proposed Upgrade will increase fragmentation in the Collombatti and Tamban State Forest areas.

The proposal is likely to isolate habitat for Common Planigale by creating barriers for movement. This species has not been recorded in monitoring of underpasses in other sections of the Pacific Highway (Australian Museum Business Services 2001c, 2001b, 2001a, 2001d).

How is the proposal likely to affect critical habitat?

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations and ecological communities. Under the *Threatened Species Conservation Act 1995*, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for this species. Suitable habitat will be retained in adjacent areas (4,300 ha) and continue to provide Common Planigales with sufficient foraging and breeding resources.

Conclusion

The proposal is unlikely to have a significant impact on Common Planigale given the extent of habitat available in the local and regional area and the likely low numbers of animals.

20. Grey-headed Flying-Fox (*Pteropus poliocephalus*)

Status

The Grey-headed Flying-Fox is listed as vulnerable under Schedule 2 of the *Threatened Species Conservation Act 1995* and also under the *Environment Protection and Biodiversity Conservation Act 1999.*

Description

The Grey-headed Flying-fox is the largest Australian bat, with a head and body length of 23 - 29 cm (Cronin 2000). It has dark grey fur on the body, lighter grey fur on the head and a russet collar encircling the neck. The wing membranes are black and the wingspan can be up to 1 m. It can be distinguished from other flying-foxes by the leg fur, which extends to the ankle (Churchill 1998).

Habitat

The Grey-headed Flying Fox is found in a variety of habitats including subtropical and temperate rainforest, mangroves, paper bark swamps, heathland, sclerophyll forests, urban gardens and cultivated areas. It forages on blossoms and fruits of over 80 species of plants (Parry-Jones & Augee 1991).

The major foraging resource for Grey-headed Flying Fox includes the nectar and pollen of a variety of native plants including eucalyptus, melaleuca and banksia, and fruits of rainforest trees and vines, and native figs (*Ficus* spp.). They have also been found to chew leaves and appear to eat the salt glands from mangroves (Parry-Jones & Augee 1991).

Specific habitat requirements of the species in the Northern Rivers Catchment Management Area include canopy trees associated with rainforest, or coastal scrub or riparian or estuarine communities and with sufficient forage resources available within 40 km for breeding (Department of Environment and Conservation 2005c).

Ecology

Grey-headed Flying Foxes congregate in camps of up to 200,000 individuals with camp size influenced by the availability of the local blossom, with the camps being located close to water, in vegetation within a dense canopy. These bats have nightly feeding range of up top 50 km from their daytime camp (Eby 1991).

Individual camps may have tens of thousands of animals and are used for mating, birth and the rearing of young. Annual mating commences in January and a single young is born each October or November. For the first three weeks females carry their young when they forage, after this, the young are left together in the camp when they forage (Churchill 1998).

Site fidelity to camps is high with some camps being used for over a century. Individuals are highly mobile and regularly move between camp sites in response to local food availability (Parry-Jones & Augee 1992; Spencer et al. 1991).

Distribution

Grey-headed Flying-foxes are found within 200 km of the eastern coast of Australia, from Bundaberg in Queensland to Melbourne in Victoria.

The Grey-headed Flying-Fox is a widespread and highly mobile species that occurs throughout the region. It is known from 36 camp sites occurring in National Parks in New South Wales, including 22 (60%) located in the North Coast bioregion. A further 24 camp localities are known from environmental protection zones in the region (Eby 1991).

In the study area:

Grey-headed Flying-fox was recorded at most of the survey sites in the study area (Figure B24). A roost was located at Kempsey swamp and was subject to a count in two seasons (summer and autumn.) The census identified approximately 4,560 individuals in mid December but the camp was deserted by mid April.

Additional Grey-headed Flying-fox colonies/camps within the foraging of the species in the Kempsey local government area include:

- Aldavilla colony is occupied irregularly (zoned rural residential)
- Arakoon colony is occupied annually (zoned rural residential)
- Clybucca colony is occupied annually (rural zoned for agriculture)
- Crescent Head Road is occupied irregularly (zoned recreation reserve)
- Crescent Head colony's occupation is unknown (zoned environmental protection)
- Deep Creek colony is occupied rarely (rural zoned for agriculture)
- Jocks Crossing colony is occupied rarely (rural zoned for agriculture)
- Bellingen River Island colony.

The above information is based on occupation patterns of the species at camps from the last five years of data from Grey-headed Flying Fox colony database maintained by the Department of Environment and Conservation Threatened Species Unit (Kylie McCelland, DEC Threatened Species Officer*, personal communication*).

Threats

Specific threats to Grey-headed Flying-foxes identified by the Department of Environment and Conservation (2005b) include:

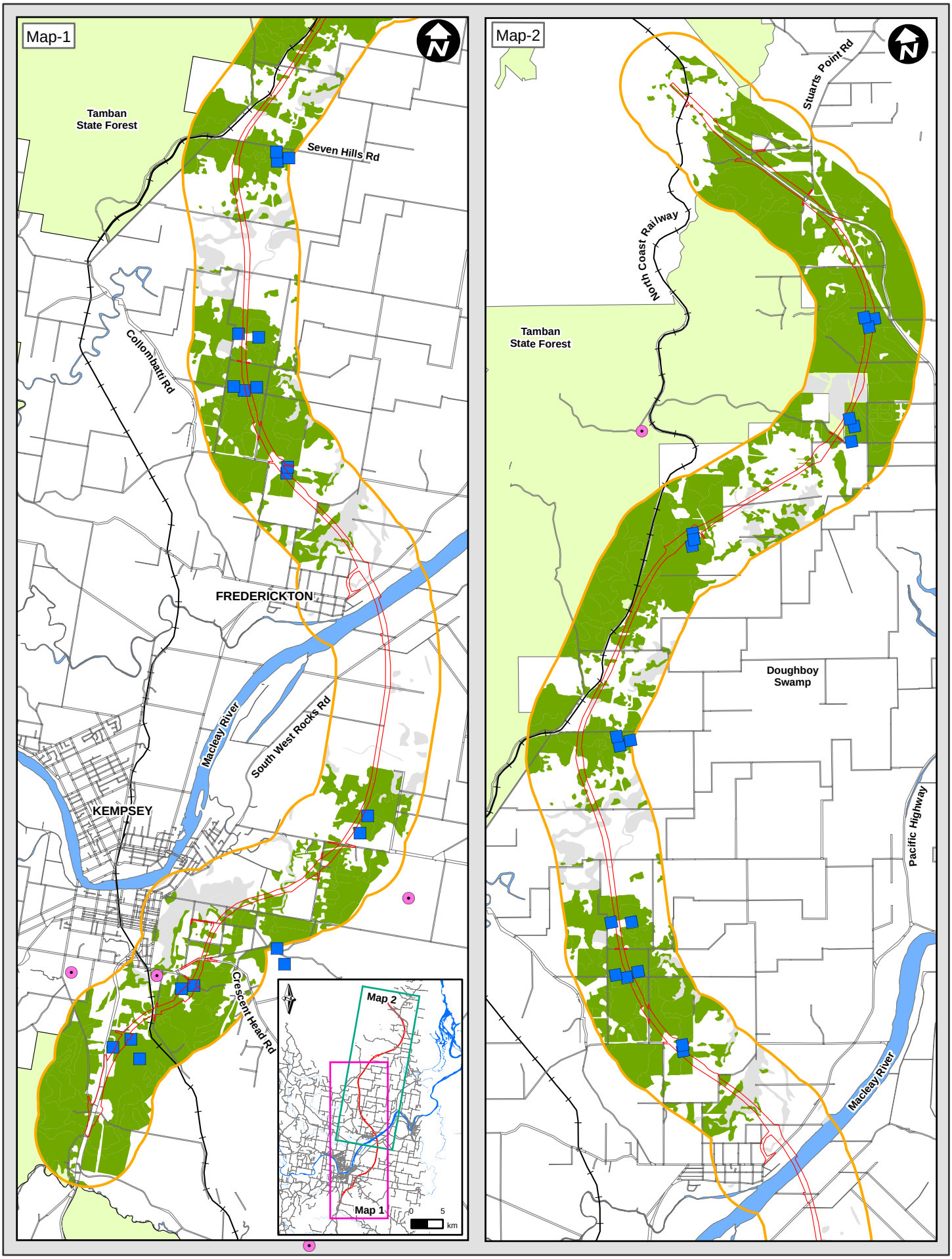
- loss of foraging habitat
- disturbance of roosting sites
- unregulated shooting
- electrocution on powerlines.

Specific impacts

The proposed Upgrade involves the removal of a total of 272.8 ha of native forest, consisting of dry sclerophyll forest (82%), forested wetland (147%) and wet sclerophyll forest (3%) that provide variable foraging habitat for Grey-headed Flying-fox.

Similar foraging habitats in adjacent areas will remain unaffected and no important roosting camps have been recorded in the habitat proposed for removal. The alignment of the proposed Upgrade was moved during the design phase so as to avoid a camp at east Kempsey Wetlands.

Grey-headed Flying-foxes are not at high risk of colliding with moving vehicles.



2116519A_2079_Grey_headed_Flying_Fox.mxd SWD - Sep, 2005

0 1 2 3 4 Kilometres

Grey-headed Flying Fox (Current Survey)

Grey-headed Flying-fox (Atlas of NSW Wildlife)

Potential Habitat

Note: Fauna may use other habitat types on an occasional basis.

Construction Footprint

Study Area

Existing Vegetation

Waterway

Existing Road

State Forest

Map B24 Habitat for Grey-headed Flying-fox

20.1 Significance assessment - *Environmental Planning and Assessment Act 1979*

How is the proposal likely to affect the lifecycle of a threatened species and/or population?

The proposed Upgrade involves the removal of a total of 242.8 ha of native forest, consisting of dry sclerophyll forest (79%), forested wetland (17%) and wet sclerophyll forest (4%) that provide variable foraging habitat for Grey-headed Flying-fox.

Similar foraging habitats in adjacent areas will remain unaffected and no important roosting camps have been recorded in the habitat proposed for removal. Additionally, the camp at Kempsey Wetlands has been avoided through the route selection process. Therefore, the proposal is considered unlikely to disrupt the lifecycle of this species or place it at risk of extinction.

How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The proposed Upgrade involves the removal of a total of 272.8 ha of native forest. Clearing of native vegetation is listed as a Key Threatening Processes are listed on Schedule 3 of the *Threatened Species Conservation Act 1995*.

Similar foraging habitats in adjacent areas will remain unaffected (4,300 ha in the study area) and no important roosting camps have been recorded in the habitat proposed for removal. The removal of foraging habitat for the Grey-headed Flying-fox is not considered significant in a regional context.

Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

Grey-headed Flying-fox occurs from Rockhampton in central Queensland to western Victoria (Churchill 1998). Therefore, the study area is not at the distributional limit for this species.

How is the proposal likely to affect current disturbance regimes?

Parts of the proposed Upgrade occur within already cleared or fragmented habitats that include a range of disturbances commonly found in agricultural landscapes. However the proposed Upgrade will require clearing of vegetation and habitats in relatively intact areas and as such will introduce new edge effects to these sites. In total, 148.2 ha of vegetation will be affected by new edge effects that may include weeds, increased levels of predation, increased noise and changed hydrological regimes.

How is the proposal likely to affect habitat connectivity?

The Grey-headed Flying-fox is a highly mobile species that undertakes seasonal movements and often travels 30 km and occasionally up to 70 km between roost sites and feeding habitat (Churchill 1998). Therefore, the proposal will not create a barrier to movement and will not isolate areas of remaining foraging habitat.

How is the proposal likely to affect critical habitat?

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations and ecological communities. Under the *Threatened Species Conservation Act 1995*, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for this species (Department of Environment and Conservation, Threatened Species Unit).

Conclusion

The proposal is unlikely to have a significant impact on Grey-headed Flying-fox in the study area. Although foraging habitat will be removed, similar habitat is available in both the local and regional area and significant habitat features such as camps have been avoided.

20.2 Significance assessment – *Environment Protection and Biodiversity Conservation Act 1999*

The Grey-headed Flying-foxes that forage in the site are not considered an 'important population' because:

- there is no established breeding population that relies on maternity resources within the site for breeding or dispersal
- the populations of the species that forage in the area are not restricted to the habitat within the site due to the species large home range therefore the genetic diversity of the species can still be maintained by interbreeding with other populations throughout the wider area
- the population of the species that forage in the site are not at limit of the species range.

Although the camp at East Kempsey Wetlands would be considered an important population, the alignment of the proposed Upgrade has been moved to avoid impacts to this site.

Will the action lead to a long-term decrease in the size of an important population of a species?

Although the proposed Upgrade involves the removal of 272.8 ha of native forest, 4,300 ha of similar foraging areas adjacent to the Upgrade in the study area would remain unaffected. Furthermore, no important roosting camps have been recorded in the habitat proposed for removal, with the camp located in the East Kempsey Wetlands avoided due to the route selection process, and the removal of foraging habitat for the Grey-headed Flying-fox is not considered significant in a regional context. Therefore the proposal is considered unlikely to disrupt the lifecycle of this species, nor is it likely to reduce population size/numbers in the long-term.

Will the action reduce the area of occupancy of an important population?

The proposed Upgrade involves the removal of a total of 272.8 ha of native forest, consisting of dry sclerophyll forest (82%), forested wetland (14%) and wet sclerophyll forest (3%) that provide variable foraging habitat for Grey-headed Flying-fox. However, due to the high mobility of the species, the proposal is unlikely to create a barrier to movement and would not isolate adjacent areas of remaining foraging habitat. In addition, one potentially affected population was found to exist within the Kempsey Wetlands, but this population was successfully avoided during the route selection phase.

Will the action fragment an existing important population into two or more populations?

As discussed above, the only important population existing within the area of the proposed upgrade resulted in an alternate preferred alignment. In addition, parts of the proposed Upgrade occur within already cleared or fragmented habitats that include a range of disturbances commonly found in agricultural landscapes. As such, no important existing populations would be directly impacted or fragmented due to the proposed Upgrade.

Will the action adversely affect habitat critical to the survival of a species?

No critical habitat has been listed for the Grey-headed Flying-fox.

Habitat critical to the survival of threatened species may, however, also include areas that are not listed on the Register of Critical Habitat if they are necessary:

- for activities such as foraging, breeding, roosting, or dispersal
- for the long-term maintenance of the species or ecological community (including the maintenance of species essential to the survival of the species or ecological community, such as pollinators)
- to maintain genetic diversity and long term evolutionary development
- for the reintroduction of populations or recovery of the species or ecological community (Department of the Environment and Heritage 2006).

The extent of the habitat that would be cleared as a result of the proposal does not represent habitat critical to the survival of Grey-headed Flying-fox.

Will the action disrupt the breeding cycle of an important population?

Although the proposed Upgrade requires the removal of 272.8 ha of forest that provides variable foraging habitat for the Grey-headed Flying-fox, similar foraging habitat is provided in adjacent, unaffected areas. Also, no important roosting camps have been recorded in the habitat proposed for removal and the camp at Kempsey Wetlands was successfully avoided during the route selection process. Therefore, the proposal is considered unlikely to disrupt the breeding and life cycle of this species.

Will the action modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?

The proposed Upgrade involves the removal of a total of 272.8 ha of native forest, consisting of dry sclerophyll forest (82%), forested wetland (14%) and wet sclerophyll forest (3%) that provide variable foraging habitat for Grey-headed Flying-fox. Although parts of the proposed Upgrade reside within already cleared or fragmented habitats, the proposed Upgrade would require the clearing of vegetation and habitats in relatively intact areas, and therefore may introduce new edge effects to these areas. In total, 245 ha of vegetation would be affected by new edge effects such as weeds, increased levels of predation, increased noise and changed hydrological regimes. However, due to the proposed alignment of the Upgrade and the high mobility of the species, such changes to the availability or quality of available habitat would not be significant to such an extent that the species is likely to decline.

Will the action result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species´ habitat?

The proposed Upgrade is unlikely to introduce any new invasive species to the area.

Will the action interferes substantially with the recovery of the species?

As the proposed Upgrade has avoided existing Grey-headed Flying-fox camps, does not present as a significant barrier to species' movement, and would not result in the fragmentation of existing populations or the disruption of species' life-cycles, the proposal would not substantially interfere with the recovery of the species. In addition, no critical habitat has been declared within the proposal corridor and the availability of adjacent foraging habitat combined with the high mobility of the species further suggests that the recovery of the Grey-headed Flying-fox would not be substantially affected.

Conclusion

The proposal is unlikely to have a significant impact on Grey-headed Flying-fox in the study area. Although foraging habitat will be removed, similar habitat is available in both the local and regional area and significant habitat features such as camps have been avoided.

21. Squirrel Glider (*Petaurus norfolcensis*)

Status

The Squirrel Glider is listed as vulnerable under Schedule 2 of the *Threatened Species Conservation Act 1995*.

Endangered populations are listed under Part 2 of Schedule 1 of the *Threatened Species Conservation Act 1995*. Two endangered populations of Squirrel Glider are listed under the Act including the Barrenjoey Peninsula and Wagga Wagga Local Government Area populations. The population of Squirrel Glider at the study area does is not considered be endangered.

Description

Adult Squirrel Gliders have a head and body length of about 20 cm. They have blue-grey to brown-grey fur above and white on the belly. The prehensile tail is broad, long and bushy and soft with a dark tip. There is a dark stripe from between the eyes to the mid-back and the tail is soft and bushy averaging about 27 cm in length (Strahan 1995).

Habitat

Squirrel Gliders inhabit mature or old growth Box, Box-Ironbark woodlands and River Red Gum forest west of the Great Dividing Range and Blackbutt, Forest Redgum and Bloodwood forest with banksia heath understorey in coastal areas. They also occurs in Grey Gum/Spotted Gum/Grey Ironbark dry hardwood forest of the central NSW Coast(Department of Environment and Conservation 2005c). Squirrel Gliders generally prefers mixed species stands with a shrub or gum-producing *Acacia* midstorey. On the Central Coast this species also forages on *Banksia* and *Xanthorrhea* nectar (Smith & Murray 2003). In northern New South Wales this species occurs in coastal forest and in some wet forest areas bordering on rainforest (Goldingay & Sharpe 1998). Suitable vegetation communities include at least one flora species that would flower heavily in winter and one or more of the eucalypts should be smooth-barked (Department of Environment and Conservation 2005c).

Tree hollows greater than 5 cm diameter in both living and dead trees as well as hollow stumps are used as den sites for refuge and nesting (Gibbons & Lindenmayer 1997). Studies in Queensland showed that Squirrel Gliders used ironbark eucalypts and stags more than the hollows of smooth barked eucalypts and non-eucalypt tree species (Rowston 1998).

The abundance of Squirrel Gliders increases significantly with canopy height, canopy cover, the number of mature and old-growth trees and the number of tree hollows (Smith & Murray 2003).

Ecology

The nocturnal Squirrel Glider displays seasonal trends in feeding behaviour that are in accordance with phenological patterns consists of trees and shrubs (Goldingay & Sharpe 1998). The diet includes *Acacia* gum, eucalypt sap, nectar, honeydew and manna, lichens with invertebrates and pollen providing protein (NSW National Parks and Wildlife Service 1999e).

Squirrel Gliders utilise tree hollows for diurnal shelter either alone or in family groups of up to six individuals and offspring that occupy the same hollow simultaneously. The size and composition of groups of gliders occupying a particular hollow varies from day to day because gliders regularly swap den trees (Van de Ree 2002). The nests are bowl-shaped and lined with leaf within tree hollows (Triggs 1996). The maximum age of a Squirrel Glider is 5-6 years and predation by owls are a common natural cause of mortality (NSW National Parks and Wildlife Service 1999e).

Squirrel Gliders are agile climbers and can glide for more than 50 m in one movement. Nightly movements are estimated as between 300 and 500 m. Home-ranges have been estimated as between 0.65 and 8.55 ha and movements tend to be greater for males than females. The home-range of a family group is likely to vary according to habitat quality and availability of resources, with more productive forests attributed to smaller home ranges (Quin 1995).

Distribution

Squirrel Gliders are widely though sparsely distributed in eastern Australia, from northern Queensland to western Victoria (Department of Environment and Conservation 2005c).

The species has been recorded in Brisbane Water National Park, Tooloom National Park, Border Ranges National Park, Mount Warning National Park (NSW National Parks and Wildlife Service 1999e), Bungalwalbin Nature Reserve (Goldingay & Sharpe 1998) and Limeburners Creek Nature Reserve (Quin 1995).

The majority of State Forests and National Parks in the region would provide suitable habitat for the Squirrel Glider including Tamban State Forest, Mount Boss State Forest and Werrikimbe National Park where the species has been recorded. Large areas of preferred and critical habitat are available in the Kempsey-Wauchope Management area (Truyard Pty Ltd 1993).

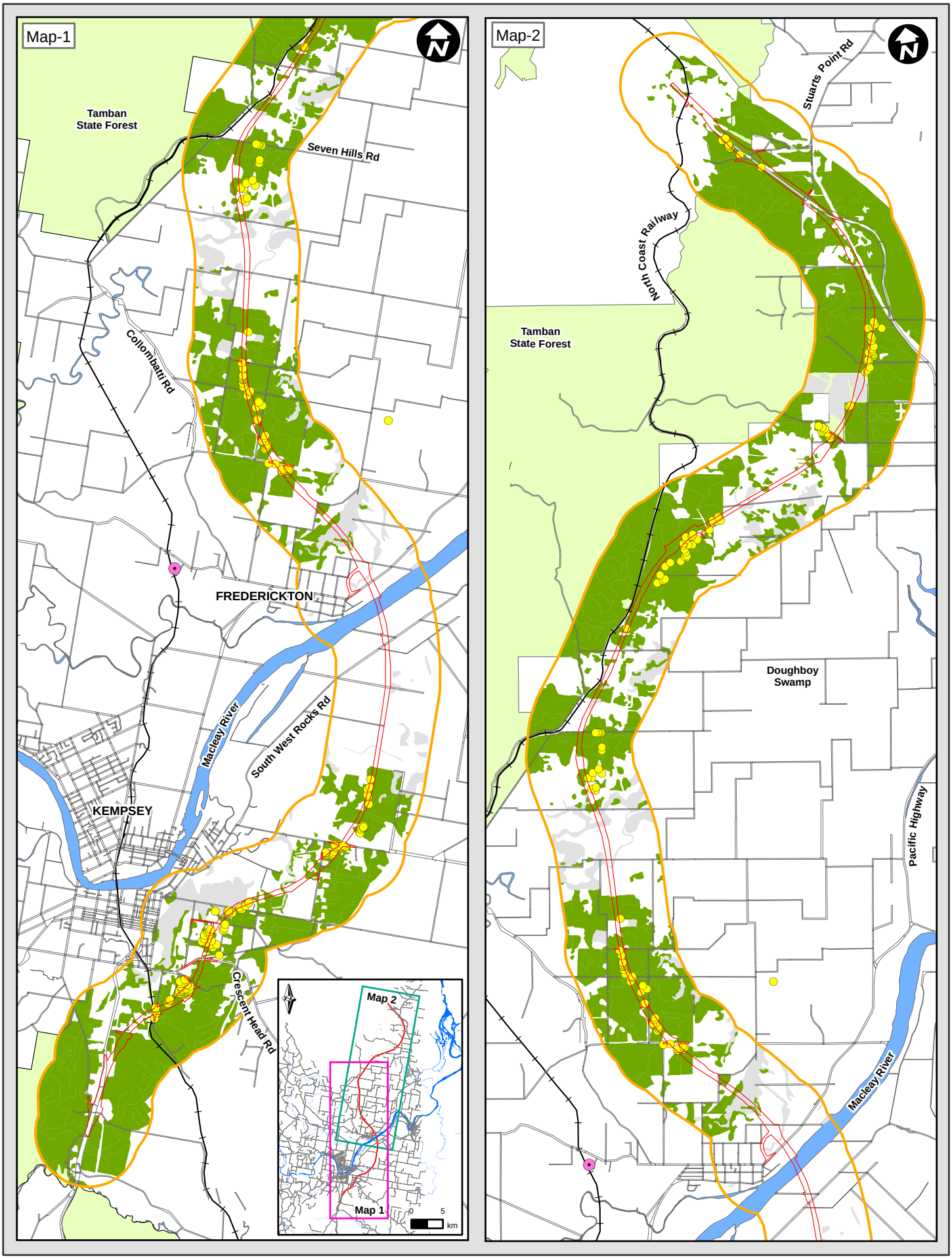
In the study area:

Squirrel Glider was not recorded in the current field surveys; however it has been recorded previously 4 km west of the study area at Frederickton (Department of Environment and Conservation 2005d) and suitable habitat exists (Figure B25).

Threats

Specific threats to Squirrel Gliders identified by the Department of Environment and Conservation (2005b)include:

- loss and fragmentation of habitat
- removal of hollow-bearing trees
- loss of flowering understorey and mid-storey shrubs in forests
- individuals can get caught in barbed wire fences while gliding
- predation by foxes and cats
- inappropriate fire regimes may deplete food resources and isolate populations making them susceptible to regional.



2116519A_2075_Squirrel_Glider.mxd SWD - Sep, 2005

0 1 2 3 4 Kilometres

Note: Fauna may use other habitat types on an occasional basis.

Squirrel Glider (Atlas of NSW Wildlife)

Habitat Tree

Potential Habitat

Construction Footprint

Study Area

Existing Vegetation

Waterway

Existing Road

State Forest

Map B25 Habitat for Squirrel Glider

Specific impacts

The proposed Upgrade involves the removal of a total of 272.8 ha of native forest, consisting of dry sclerophyll forest (82%), forested wetland (14%) and wet sclerophyll forest (3%) that offer marginal foraging and potential breeding habitat for Squirrel Glider. A total of 167 hollow-bearing trees suitable for small gliders occur along and immediately adjacent to the proposed Upgrade.

Indirect impacts include weed invasion and increased abundance of feral predators as result of edge effects.

21.1 Significance assessment - *Environmental Planning and Assessment Act 1979*

How is the proposal likely to affect the lifecycle of a threatened species and/or population?

The species was not recorded during the current survey and only few previous records of Squirrel Glider exist in the local area.

The proposed Upgrade involves the removal of a total of 272.8 ha of native forest, consisting of dry sclerophyll forest (82%), forested wetland (14%) and wet sclerophyll forest (3%) that offer marginal foraging habitat for Squirrel Glider. A total of 167 hollow-bearing trees suitable for small gliders occur along and immediately adjacent to the proposed Upgrade.

Significantly large areas of similar habitat in adjacent areas would remain unaffected by the proposal (4,300 ha within the study area).

The proposal is considered unlikely to disrupt the lifecycle of this species or place it at risk of extinction.

How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The proposed Upgrade involves the removal of a total of 272.8 ha of native forest, consisting of dry sclerophyll forest (82%), forested wetland (16%) and wet sclerophyll forest (3%) that offer habitat for the Squirrel Glider. A total of 167 hollow-bearing trees suitable for small gliders occur along and immediately adjacent to the proposed Upgrade.

Significantly large areas of similar habitat in adjacent areas would remain unaffected by the proposal (4,300 ha within the study area). The removal of habitat for the Squirrel Glider is not considered significant in a regional context.

Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

Squirrel Gliders are widely though sparsely distributed in eastern Australia, from northern Queensland to western Victoria. Therefore, the study area is not at the distributional limit for this species.

How is the proposal likely to affect current disturbance regimes?

Parts of the proposed Upgrade occur within already cleared or fragmented habitats that include a range of disturbances commonly found in agricultural landscapes. However the proposed Upgrade will require clearing of vegetation and habitats in relatively intact areas and as such will introduce new edge effects to these sites. In total, 148.2 ha of vegetation will be affected by new edge effects that may include weeds, increased levels of predation, increased noise and changed hydrological regimes.

How is the proposal likely to affect habitat connectivity?

Squirrel Gliders are agile climbers and can glide for more than 50 m in one movement. Nightly movements are estimated as between 300 and 500 m. Home-ranges have been estimated as between 0.65 and 8.55 ha and movements tend to be greater for males than females. The home-range of a family group is likely to vary according to habitat quality and availability of resources (Quin 1995).

A recent pilot study comparing movements of Squirrel Gliders across a section of single carriageway highway in Victoria with a section of dual carriageway highway nearby, suggests that individuals are far less likely to cross the wider road (Van de Ree 2006). This work suggests that the difference is likely due to a combination of the width of the road, the volume of traffic and the speed of the traffic.

How is the proposal likely to affect critical habitat?

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations and ecological communities. Under the *Threatened Species Conservation Act 1995*, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for this species (Department of Environment and Conservation, Threatened Species Unit). Suitable habitat will be retained in adjacent areas (5090 ha) and continue to provide foraging and breeding resources. The site is unlikely to be critical to the survival of this species.

Conclusion

The proposal is unlikely to have a significant impact on Squirrel Glider in the study area. No individuals were recorded despite targeted survey and similar habitats to those likely to be affected by the proposed Upgrade are available in both the local area and the wider region.

22. Grey Nurse Shark (*Carcharias taurus*)

Status

The Grey Nurse Shark is listed as Endangered under the *Fisheries Management Act 1994* and as Critically Endangered under the *Environment Protection and Biodiversity Conservation Act 1999*.

Description

Grey nurse sharks have large, stout bodies tapered at both ends, a pointed snout and small eyes. Unlike many other sharks, grey nurses do not have a transparent, moveable membrane inside the eyelid known as a nictitating membrane. They have two large top (or dorsal) fins of similar size. The mouth extends beyond the front of the eyes and contains long, slender, spear-shaped teeth with one small point on either side. The tail (or caudal) fin is distinctive with the top lobe being larger than the bottom. The upper surface of grey nurse sharks is bronze coloured and the underside is paler. Juveniles often have dark spots on the lower half of the body and the caudal fin. These spots fade as the shark becomes larger, but are sometimes still seen on adults. Grey nurse sharks can grow to at least 3.2 m in length (Department of Environment and Conservation 2007).

Habitat and ecology

Grey nurse sharks are active mainly at night and feed on a wide range of bony fishes, sharks, rays, squids and crustaceans (Department of Environment and Conservation 2007).

Sexual maturity is reached in about 4-6 years for males and 6-8 years for females, at lengths of around 1.9 m and 2.2 m for males and females respectively. Mating probably occurs in autumn and females are likely to give birth in winter at the sites where they aggregate.

As a result of this two-yearly reproductive cycle, females produce one pup per year or less on average, which gives this species the lowest reproductive rate of any shark and makes them extremely vulnerable to human-induced pressures (Department of Environment and Conservation 2007).

Distribution

Grey nurse sharks are native to subtropical to cool temperate waters in the Mediterranean Sea and the Atlantic, Indian and western Pacific Oceans. Once widely distributed, they are now mainly restricted to Australia and the east coasts of the USA, Uruguay, Argentina and South Africa. In Australia there is an east coast and a west coast population. The east coast population is found predominantly in inshore coastal waters along the coast of NSW and southern Queensland. There are a number of key habitat sites along the coast of NSW and southern Queensland where grey nurse sharks are regularly found in groups. These sites generally have sandy-bottomed gutters or rocky caves and are in the vicinity of inshore rocky reefs or islands (Department of Environment and Conservation 2007).

Threats

Specific threats to the grey nurse shark identified by the Department of Environment and Conservation (2007) include:

- illegal fishing and injury due to accidental capture by commercial and recreational fishers
- capture in beach safety mesh nets (shark nets)

- collection for aquaria (although there is currently a moratorium on capturing grey nurse sharks for aquaria from NSW waters)
- loss of genetic diversity resulting from the declining population numbers.

22.1 Significance assessment - *Environmental Planning and Assessment Act 1979*

How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Grey Nurse Sharks typically occur on shallow rocky reefs along the New South Wales coast (Last & Stevens 1994). They would be most common on rocky headlands and islands (such as Fish Rock) north and south of South West Rocks where the Macleay River meets the sea. In addition, there have been reports in the past that Grey Nurses occasionally occur in embayments (such as Botany Bay, Sydney). It is likely that Grey Nurse Sharks migrate along the NSW coast. Young are born live which also occur on shallow rocky reefs, often segregated from adults. Given that the life cycle of the species is generally confined to the coastline, particularly rocky reefs, it is unlikely that the proposed Upgrade would disrupt the life cycle of Grey Nurse Sharks.

How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The major habitat that would be affected by the proposed highway Upgrade would be waterway (rivers and streams) foreshore and sediments, some of which supports the growth of seagrasses. The major habitat utilised by grey nurse sharks comprises rocky reefs, with small sandy gutters within the reef matrix being often the preferred microhabitat. There is some likelihood that the species ranges away from reefs to feed at night, but the extent of this range is unknown. On this basis, the reef habitat of Grey Nurse Sharks would not be affected by the proposal. Moreover, the area that would be affected by the highway Upgrade would be unlikely to constitute a significant area of habitat used for feeding or other purposes by the Grey Nurse Shark.

Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

Grey Nurse Sharks occur along the NSW coast and extend into southern Queensland and northern Victoria. They also occur in Western Australia and several other parts of the world (eg. South Africa). The species is therefore not at the limit of its known distribution within the vicinity of Kempsey or the nearby South West Rocks.

How is the proposal likely to affect current disturbance regimes?

The proposed highway Upgrade will not affect current disturbance regimes for the Grey Nurse Shark. Waterway crossings would be designed following NSW Fisheries Guidelines (Fairfull & Witheridge 2003).

How is the proposal likely to affect habitat connectivity?

Since the area of the proposed highway Upgrade is not known habitat, nor likely to be significant habitat for Grey Nurse Sharks, it would not become isolated from other habitats used by the species. Waterway crossings would be designed following NSW Fisheries Guidelines (Fairfull & Witheridge 2003).

How is the proposal likely to affect critical habitat?

No critical habitat used by Grey Nurse Sharks would be affected by the proposed development.

Conclusion

The proposed Upgrade is most unlikely to have any effect on Grey Nurse Sharks

22.2 Significance assessment – *Environment Protection and Biodiversity Conservation Act 1999*

Will the action lead to a long-term decrease in the size of a population?

The life-cycle of the Grey Nurse Shark is generally confined to the coastline, particularly rocky reefs, which would not be affected by the proposed Upgrade. Furthermore, the area likely to be affected by the proposal would not constitute a significant area of habitat that would be used for feeding or other purposes by the Grey Nurse shark. As a result, the proposed Upgrade would not lead to the long-term decrease in population numbers/sizes of this species.

Will the action reduce the area of occupancy of the species?

The major habitat that would be affected by the proposed highway Upgrade would be rivers and streams. The major habitat utilised by grey nurse sharks comprises rocky reefs, with small sandy gutters within the reef matrix being often the preferred microhabitat. There is some likelihood that the species ranges away from reefs to feed at night, but the extent of this range is unknown. On this basis, the reef habitat and other areas of occupancy of Grey Nurse Sharks would not be affected by the proposal.

Will the action fragment an existing population into two or more populations?

Since the area of the proposed highway Upgrade is not known habitat, nor likely to be significant habitat for Grey Nurse Sharks, it would not become isolated from other habitats used by the species. In addition, any waterway crossings would be designed following NSW Fisheries Guidelines (Fairfull & Witheridge 2003).

Will the action adversely affect habitat critical to the survival of a species?

No critical habitat has been declared for this species. Habitat critical to the survival of threatened species includes areas that are not listed on the Register of Critical Habitat if they are necessary:

- for activities such as foraging, breeding, roosting, or dispersal
- for the long-term maintenance of the species or ecological community (including the maintenance of species essential to the survival of the species or ecological community, such as pollinators)
- to maintain genetic diversity and long term evolutionary development
- for the reintroduction of populations or recovery of the species or ecological community (Department of the Environment and Heritage 2006).

No critical habitat used by Grey Nurse Sharks would be affected by the proposed development.

Will the action disrupt the breeding cycle of a population?

The young of the Grey Nurse Shark are born live on shallow rocky reefs, often segregated from adults. Given that the life cycle of the species is generally confined to the coastline, particularly rocky reefs, it is unlikely that the proposed Upgrade would disrupt the breeding and life cycle of Grey Nurse Sharks.

Will the action modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?

The major habitats that would be affected by the proposed highway Upgrade would be rivers and stream. The major habitat utilised by grey nurse sharks comprises rocky reefs, with small sandy gutters within the reef matrix being often the preferred microhabitat. There is some likelihood that the species ranges away from reefs to feed at night, but the extent of this range is unknown. On this basis, the reef habitat of Grey Nurse Sharks would not be affected by the proposal. Moreover, the area that would be affected by the highway Upgrade would be unlikely to constitute a significant area of habitat used for feeding or other purposes by the Grey Nurse Shark. Since the area of the proposed highway Upgrade is not known habitat, nor likely to be significant habitat for Grey Nurse Sharks, it would not become isolated from other habitats used by the species. Therefore it is unlikely that the proposed Upgrade would modify, destroy, remove, isolate or decrease the availability/quality of habitat to the extent that this species is likely to decline.

Will the action result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat?

No invasive species would be introduced to the area as a result of the proposed Upgrade.

Will the action introduce disease that may cause the species to decline?

The proposed Upgrade is unlikely to introduce any disease that would affect the Grey Nurse Shark.

Will the action interfere with the recovery of the species?

No recovery plan has been prepared for the Grey Nurse Shark.

Since the area of the proposed highway Upgrade is not known habitat (nor likely to be significant habitat) for Grey Nurse Sharks and that no long-term reductions in population numbers/sizes, no reduction in areas of occupancy, no fragmentation effects or disruptions to lifecycles, and the absence of critical habitat, the proposal is not expected to interfere with the recovery of the Grey Nurse Shark.

Conclusion

The proposed Upgrade is most unlikely to have any effect on Grey Nurse Sharks

23. Great White Shark (*Carcharodon carcharias*)

Status

The great White Shark is listed as Vulnerable under both the *Fisheries Management Act 1994* and the *Environment Protection and Biodiversity Conservation Act 1999*.

Description

Great White Sharks have a torpedo-shaped body, coloured grey to grey-brown on the upper surface and white below. They have large, serrated triangular teeth, very small second dorsal and anal fins, and a distinct keel before the broad crescent-shaped tail.. Great white sharks measure around 120-150 cm at birth and can grow to at least 6 m in length, although there are unconfirmed reports of individuals up to 7 m (Department of Environment and Conservation 2007).

Habitat and ecology

Relatively little is known about the biology of Great White Sharks. They are normally found in inshore waters around rocky reefs and islands, and often near seal colonies. They have been recorded at varying depths down to 1,200m and may travel large distances in a relatively short time but can remain in the same area for weeks or even months (Department of Environment and Conservation 2007).

Juveniles feed mainly on fish and adults mainly on other sharks, rays and marine mammals.

Great White Sharks reach sexual maturity at around 10 years of age. They probably do not breed every year. Females give birth to relatively few pups (between 4 and 10). They are fully developed and independent at birth, and measure around 120-150 cm in length (Department of Environment and Conservation 2007).

Distribution

Great White Sharks are found throughout the world in temperate and subtropical oceans, including the coastal waters of NSW, with a preference for cooler waters. Scientific evidence suggests that their numbers and average size have declined over the last few decades. Their natural rarity, low natural mortality, low reproductive rate and other life history characteristics make their populations highly vulnerable to the impacts of fishing (DEC website).

Threats

Specific threats to the Great White Shark identified by the Department of Environment and Conservation (2007) include:

- by-catch (i.e. as non-target species taken incidentally during commercial fishing activities)
- capture in beach safety mesh nets (shark nets).

23.1 Significance assessment - *Environmental Planning and Assessment Act 1979*

How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Great White Sharks (*Carcharodon carcharias*) are listed as endangered on the threatened species schedules of the *Fisheries Management Act 1994*. They are large, highly predatory animals whose life cycle is poorly understood. They occur from cold temperate to tropical waters worldwide and generally frequent coastal waters, often close to shore. They also swim into bays and estuaries, hence may occur, albeit rarely, in the Macleay River system.

Great White Sharks are live bearers that do not generally appear to be attached to specific habitats. The exception is when they take up residence adjacent to rocky shores, particularly where seals or sea lions are present. Emerging evidence suggests that both juveniles and adults can be wide ranging, with one tagged individual moving from Tasmania along the New South Wales coast into southern Queensland. There is also anecdotal evidence that the species follows large schools of migrating fish (e.g. Sea Mullet, Australian Salmon) and migrating whales, particularly with calves. The proposed highway Upgrade is unlikely to affect the lifecycle of the Great White Shark.

How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

If Great White Sharks do prefer a particular habitat, it is likely to be rocky shores with seals or sea lions and this type of habitat would not be affected by the proposed Upgrade. They may also follow schools of fish along the coast, therefore it is possible that if the development affected fish behaviour in the Macleay River system, it may affect “temporary” habitat of Great White Sharks. In that case, the area of the proposal would not be considered significant known habitat, as the sharks are likely to simply follow the schools elsewhere.

Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

As this species ranges all along the New South Wales coast and throughout all the oceans of the world, it is not at the limit of its distribution when near the proposed Upgrade.

How is the proposal likely to affect current disturbance regimes?

The proposed highway Upgrade will not affect current disturbance regimes for the Great White Shark. Mitigation measures would be included to avoid and minimise impacts to aquatic habitats.

How is the proposal likely to affect habitat connectivity?

Since the area of the proposed Upgrade is not known habitat, or likely to be significant habitat for Great White Sharks, it would not become isolated from other habitats used by the species. Waterway crossings would be designed following NSW Fisheries Guidelines (Fairfull & Witheridge 2003).

How is the proposal likely to affect critical habitat?

No critical habitat would be affected for Great White Sharks.

Conclusion

The proposed highway Upgrade is most unlikely to affect Great White Sharks.

23.2 Significance assessment - *Environment Protection and Biodiversity Conservation Act 1999*

Under the *Environment Protection and Biodiversity Conservation Act 1999*, important populations are:

- likely to be key source populations either for breeding or dispersal
- likely to be necessary for maintaining genetic diversity
- at or near the limit of the species range (Department of the Environment and Heritage 2005)
- If ever present in the Macleay Estuary, the Great White Shark would not be considered an important population.

Will the action lead to a long-term decrease in the size of an important population of a species?

The Great White Shark is a live bearer that does not generally appear to be attached to specific habitats, with the exception being when they take up residence adjacent to rocky shores, particularly where seals or sea lions are present. As such, the area likely to be affected by the proposal would not constitute a significant area of habitat that would be used for feeding or other purposes by the Great White Shark. As a result, the proposed Upgrade would not lead to the long-term decrease in population numbers/sizes of this species.

Will the action reduce the area of occupancy of an important population?

If Great White Sharks do prefer a particular habitat, it is likely to be rocky shores with seals or sea lions, and this type of habitat would not be affected by the proposed Upgrade. On this basis, the reef habitat and other areas of occupancy of Grey Nurse Sharks would not be affected by the proposal.

Will the action fragment an existing important population into two or more populations?

Since the area of the proposed Upgrade is not preferred habitat, or likely to be significant habitat for Great White Sharks, it would not become isolated from other habitats used by the species, nor would an existing population become fragmented due to the proposed Upgrade. In addition, waterway crossings would be designed following NSW Fisheries Guidelines (Fairfull & Witheridge 2003).

Will the action adversely affect habitat critical to the survival of a species?

No critical habitat would be affected for Great White Sharks.

Will the action disrupt the breeding cycle of an important population?

Great White Sharks are live bearers that do not generally appear to be attached to specific habitats. The exception is when they take up residence adjacent to rocky shores, particularly where seals or sea lions are present. Emerging evidence suggests that both juveniles and adults can be wide ranging, with one tagged individual moving from Tasmania along the New South Wales coast into southern Queensland. There is also anecdotal evidence that the species follows large schools of migrating fish (e.g. Sea Mullet, Australian Salmon) and migrating whales, particularly with calves. The proposed highway Upgrade is unlikely to affect the breeding and lifecycle of the Great White Shark.

Will the action modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?

The area of the proposed Upgrade is not known habitat, or likely to be significant habitat for Great White Sharks. In addition, the proposed highway Upgrade would not affect current disturbance regimes for the Great White Shark (although mitigation measures would be included to avoid and minimise impacts to aquatic habitats). Therefore the proposed Upgrade would not modify, destroy, remove, isolate or decrease the availability/quality of habitat to the extent that the species is likely to decline.

Will the action result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species´ habitat?

No invasive species will be introduced into the area as a result of the proposed Upgrade.

Will the action interfere substantially with the recovery of the species?

Since the area of the proposed highway Upgrade is not known habitat (nor likely to be significant habitat for Grey Nurse Sharks) and that no long-term reductions in population numbers/sizes, no reduction in areas of occupancy, no fragmentation effects or disruptions to lifecycles, and in the absence of critical habitat, the proposal is not expected to interfere with the recovery of the Great White Shark.

Conclusion

The proposed highway Upgrade is most unlikely to affect Great White Sharks.

24. Green Sawfish (*Pristis zijsron*)

Status

The Green Sawfish is listed as Endangered under the *Fisheries Management Act 1994*

Description

Green sawfish have a shark-like body and a flattened head with a narrow blade-like snout studded with 24-28 pairs of 'rostral teeth'. They are greenish brown or olive in colour on the upper surfaces and pale whitish below. Green sawfish can grow to at least 5 metres in Australian waters (Department of Environment and Conservation 2007).

Habitat and ecology

Green sawfish live on muddy or sandy-mud soft bottom habitats in inshore areas. They also enter estuaries, where they have been found in very shallow water.

They feed on slow-moving, shoaling fish such as mullet, which they stun with sideswipes of the snout. They also use their saw to sweep other prey, such as molluscs and small crustaceans, out of the sand and mud.

Green sawfish probably don't reach sexual maturity until they are at least 2-3 m in length. Like all sharks and rays, they have internal fertilisation and give birth to a limited number of live young (Department of Environment and Conservation 2007).

Distribution

Green sawfish were once widely distributed in the northern Indian Ocean, around South and South-East Asia and around northern Australia. However, their numbers have been greatly reduced by fishing and accidental capture in prawn trawl and gill nets. Their large size and saw mean that they easily become entangled in nets and are difficult to remove, and so rarely survive capture. The natural distribution of green sawfish originally extended from the Queensland border to the NSW south coast (Shoalhaven River) (Department of Environment and Conservation 2007).

Threats

Specific threats to the green sawfish identified by the Department of Environment and Conservation (2007) include:

- by-catch (accidental capture) from prawn trawling, fish trawling, gillnetting and other commercial fisheries, particularly in inshore and estuarine areas
- deliberate capture for sale of the fins (for the shark-fin soup trade), flesh and saws
- land reclamation and degradation of the soft bottom areas that they use for feeding and breeding.

24.1 Significance assessment - *Environmental Planning and Assessment Act 1979*

How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Green Sawfish (*Pristis zijsron*) are listed as vulnerable on the threatened species schedules of the *Fisheries Management Act 1994*. They occur in shallow, sedimentary habitats common to those of embayments and estuaries. The species occurs from the northern Indian Ocean and South-east Africa, through Indonesia and tropical Australia (Stevens 1994). It occurs as far south as Sydney on the East Coast, with one record from South Australia. As far as is known, there is no local population of green sawfish occurring in the Macleay River system. If there were such a population, the proposed development may displace individuals, but it unlikely that it would cause local extinction, as suitable requirements are available in numerous other parts of the Macleay River system.

How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

No population of Green Sawfish has been identified in the Macleay River system and there is unlikely to be such a population. Hence, it is most unlikely that population of this species would be affected by the proposal.

Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The core distribution of Green Sawfish is within tropical and sub-tropical waters, extending into the warm temperate. Any green sawfish occurring in the Macleay River system would be at the limit of their distribution.

How is the proposal likely to affect current disturbance regimes?

The proposed highway Upgrade will not affect current disturbance regimes for the Green Sawfish. Mitigation measures would be included to avoid and minimise impacts to aquatic habitats.

How is the proposal likely to affect habitat connectivity?

The habitat at the proposed development site is an extensive waterway system of rivers and streams that open to the sea near South-West Rocks. Under the proposed development, any ‘corridor’ from the Macleay River system would be retained. In the event that Green Sawfish did occur within the study area, there would remain access to other parts of the Macleay River system and beyond. Waterway crossings would be designed following NSW Fisheries Guidelines (Fairfull & Witheridge 2003).

How is the proposal likely to affect critical habitat?

It is most unlikely the proposed highway upgrade will affect critical habitat for the Green Sawfish.

Conclusion

The proposed highway Upgrade may cause some minor localised disturbance to Green Sawfish if present. No population of this species is however recognised in the area, hence it is highly unlikely that the species would be affected and no specific management action is warranted.

25. Black Cod (*Epinephalus daemelii*)

Status

The Black Cod is listed as Vulnerable under the *Fisheries Management Act 1994.*

Description

Adult Black Cod can grow to 2 m in length and at least 80 kg in weight, but it is more common to see smaller fish (up to 1 m/30 kg). Juveniles have a distinct black 'saddle' shaped spot just in front of the tail, plus five irregular grey or black stripes. These markings tend to fade as the fish grows and may be only faintly visible in adults. Some fish also have small black spots or occasional whitish markings on the body and/or fins. The black cod has large canine teeth in both jaws (Department of Environment and Conservation 2007).

Habitat and ecology

Adult Black Cod are usually found in caves, gutters and beneath bomboras on rocky reefs. They are territorial and often occupy a particular cave for life. Small juveniles are often found in coastal rock pools, and larger juveniles around rocky shores in estuaries (Department of Environment and Conservation 2007).

Black Cod are opportunistic carnivores, eating mainly other fish and crustaceans.

Black Cod are apparently slow growing. Smaller fish are mostly females, but they generally change sex to become males at around 100-110 cm in length (Department of Environment and Conservation 2007).

Distribution

Black Cod are found in warm temperate and subtropical parts of the south-western Pacific, and naturally occurred along the entire NSW coast including Lord Howe Island (Department of Environment and Conservation 2007).

Threats

Specific threats to the black cod identified by the Department of Environment and Conservation (2007) include:

- line and spearfishing, due to their slow-moving, territorial and curious behaviours. As a result their populations have been greatly reduced over the last two centuries
- over-harvesting by line, net and spear fishing
- illegal fishing (and possibly hooking injuries in accidentally caught fish)
- impacts on juvenile black cod may occur due to the loss or degradation of estuarine nursery habitats.
- iack of research – more information is required regarding black cod biology and diet

25.1 Significance assessment - *Environmental Planning and Assessment Act 1979*

How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Black Cod (*Epinephalus daemelii*) are listed as vulnerable on the threatened species schedules of the *Fisheries Management Act 1994*. Black Cod, also known as Black Rock Cod and Saddled Rock Cod, occur from southern Queensland to Kangaroo Island (South Australia). They are also found at Lord Howe Island, Norfolk Island, Kermadec islands and the North Island of New Zealand (Heemstra & Randall 1993). They are protogynous hermaphrodites (i.e. change sex from female to male) and occur on relatively shallow coastal and estuarine rocky reefs. Juveniles may recruit to rock pools where the adults are territorial, usually adopting a cave as a core territory. The life cycle of the species revolves around rocky reefs and possibly rock pools with pelagic dispersal of eggs and larvae (Pogonoski 2000; Pollard 1999). Apart from rocky reefs and artificial breakwalls that occur at the mouths of estuaries, there is no reference in the literature that suggests Black Cod use estuaries beyond this to complete their life cycle.

There is no rocky reef habitat at the proposed crossing over the Macleay River that may be disturbed. Most environmental disturbance would occur to soft sediments, which are not favoured habitat for Black Cod. Therefore, it is most unlikely that the Black Cod would be negatively affected in terms of its life cycle or other population parameters by the proposed Upgrade.

How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

No extensive areas of natural rocky reef occur within the study area, while artificial rock walls would be added, not removed or otherwise modified in terms of habitat suitability.

Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Macleay River system is between the geographical mid to upper point of the distribution of black cod along the New South Wales coast, and therefore not at the limit of its range.

How is the proposal likely to affect current disturbance regimes?

The proposed Upgrade will not affect current disturbance regimes for the Black Cod. Mitigation measures would be included to avoid and minimise impacts to aquatic habitats.

How is the proposal likely to affect habitat connectivity?

The habitat at the proposed development site is an extensive waterway system of rivers and streams that open to the sea near South-West Rocks. Under the proposed development, any ‘corridors’ between habitats would be retained. In the event that Black Cod did occur within the study area, there would remain access to other parts of the Macleay River system and beyond. Waterway crossings would be designed following NSW Fisheries Guidelines (Fairfull & Witheridge 2003).

How is the proposal likely to affect critical habitat?

No critical habitat for Black Cod would be affected by the proposed development.

Conclusion

The proposed highway Upgrade does not represent any significant threat to Black Cod.

26. References

Anstis, M 2002, *Tadpoles of South-eastern Australia: a Guide with Keys*, New Holland Publishers, Sydney.

Arnett, AE & Pepper, JW 1997, 'Evidence of mate guarding in the Glossy Black-Cockatoo *Calyptorhynchus lathami*', *Emu*, vol. 97, pp. 177-80.

Australian Museum Business Services 2001a, *Fauna Underpass Monitoring Stage One – Final Report – Herons Creek*, Report prepared for the Roads and Traffic Authority, Sydney.

——— 2001b, *Fauna Underpass Monitoring Stage One – Final Report – Brunswick heads*, Report prepared for the Roads and Traffic Authority, Sydney.

——— 2001c, *Fauna Underpass Monitoring Stage One - Final Report – Bulahdelah to Coolongolook*, Report prepared for the Roads and Traffic Authority, Sydney.

——— 2001d, *Fauna Underpass Monitoring Stage One – Final Report – Taree*, Report prepared for the Roads and Traffic Authority, Sydney.

Barker, J, Grigg, G & Tyler, M 1995, *A field guide to Australian Frogs*, Surrey Beatty and Sons, Sydney.

Baudinette, RK, Wells, RT, Sanderson, KJ & Lark, BA 1994, 'Microclimatic conditions in maternity caves of the Bent-wing Bat, *Miniopterus schreibersii*:an attempted restoration of a former maternity site', *Wildlife Research*, vol. 21, no. 2, pp. 607-19.

Benson, D & McDougall, L 1999, 'Ecology of Sydney plant species Part 7a: Dicotyledon families Nyctaginaceae to Primulaceae', *Cunninghamia*, vol. 6, no. 2, pp. 403-509.

——— 2002, 'Ecology of Sydney plant species Part 9. Monocotyledon families: Agavaceae to Juncaginaceae', *Cunninghamia*, vol. 7, no. 4, pp. 695-930.

Briggs, JD & Leigh, JH 1996, *Rare or Threatened Australian Plants*, CSIRO, Canberra.

Churchill, S 1998, *Australian Bats*, Reed New Holland, Sydney.

Clancy, GP 2005, 'The diet of the Osprey (*Pandion haliaetus*) on the north coast of New South Wales', *Emu*, vol. 105, no. 1, pp. 87-91

Cogger, HG 2000, *Reptiles and Amphibians of Australia*, Reed Books, Sydney.

Craig, SA 1985, 'Social organization, reproduction and feeding behaviour of a population of Yellow-Bellied Gliders, *Petaurus australis*', *Wildlife Research*, vol. 12, no. 1, pp. 1-18.

Cronin, L 2000, *Key guide to Australian mammals*, Envirobooks, Annandale, NSW.

Crowley, GM & Garnett, ST 2001, 'Food value and tree selection by Glossy Black-Cockatoos *Calyptorhynchus lathami*', *Emu*, vol. 26, pp. 116-26.

Debus, SJS 1994, 'The Sooty Owl *Tyto tenebricosa* in NSW', *Australian Birds*, vol. 28, S4-S19.

——— 1995, 'Surveys of large forest owls in Northern New South Wales: methodology, calling behaviour and owls responses', *Corella*, vol. 19, no. 2, pp. 38-50.

Debus, SJS & Chafer, CJ 1994, 'The Powerful Owl *Ninox strenua* in NSW.' *Australian Birds*, vol. 28, pp. 41-57.

Debus, SJS & Rose, AB 1994, 'The Masked Owl *Tyto novaehollandiae* in NSW', *Australian Birds*, vol. 28, pp. 21-39.

Debus, SJS, McAllan, IAW & Morris, AK 1993, 'The Square-tailed Kite *Lophoictinia isura* in NSW', *Australian Birds*, vol. 26, pp. 104- 17.

Department of Environment and Conservation 2004, *Raptor and waterbird nest trees*, Department of Environment and Conservation, Coffs Harbour.

——— 2005a, *Atlas of NSW Wildlife*, Department of Environment and Conservation, Hurstville, <http://wildlifeatlas.nationalparks.nsw.gov.au/wildlifeatlas/watlas.jsp>.

——— 2005b, *Threatened species, populations and ecological communities*, NSW Department of Environment and Conservation, 2006, <http://www.threatenedspecies.environment.nsw.gov.au/index.aspx>.

——— 2005c, *Bionet*, Department of Environment and Conservation, <http://www.bionet.nsw.gov.au/BioNet.cfm?is_ie5up>.

——— 2005d, *Draft recovery plan for the large forest owls: Powerful Owl, Sooty Owl and Masked Owl.*, Department of Environment and Conservation, Sydney South.

——— 2005e, *Register of critical habitat in New South Wales*, NSW Department of Environment and Conservation, 2005, <http://www.nationalparks.nsw.gov.au/npws.nsf/Content/Critical+habitat+protection+by+doctype>.

——— 2007, *Threatened species, populations and ecological communities*, NSW Department of Environment and Conservation, 2006, <http://www.threatenedspecies.environment.nsw.gov.au/index.aspx>.

Department of the Environment and Heritage 2005, *EPBC Act - Principal Significant Impact Guidelines 1.1. Matters of National Environmental Significance*, Department of the Environment and Heritage, Canberra.

Dorfman, EY, Lamont, A & Dickman, CR 2001, 'Foraging behaviour and succes of Black-necked Storks (*Ephippiorhynchus asiaticus*) in Australia: implications for management', *Emu*, vol. 101, pp. 145-9.

Dostine, PL & Morton, SR 2000, 'Seasonal abundance and diet of the Comb-crested Jacana *Irediparra gallinacea* in the tropical Northern Territory', *Emu*, vol. 100, pp. 299-311.

Dwyer, PD 1966, 'The population pattern of *Miniopterus schreibersii* in north-eastern New South Wales', *Australian Journal of Zoology*, vol. 14, no. 2, pp. 1073-137.

Eby, P 1991, 'Seasonal movements of Grey-headed Flying-foxes, *Pteropus poliocephalus* (Chiroptera : Pteropodidae), from two maternity camps in northern New South Wales', *Wildlife Research*, vol. 18, no. 5, pp. 547 - 59.

Ellis, WA, Hale, PT & Carrick, BF 2000, 'Breeding dynamics of koalas in open woodlands', *Australian Journal of Zoology*, vol. 48, no. 1, pp. 317-33.

Fairfull, S & Witheridge, G 2003, *Why do fish need to cross the road? Fish passage requirements for waterway crossings*, NSW Fisheries, Cronulla.

Garnett, ST & Crowley, GM 2000, *The Action Plan for Australian Birds*, Environment Australia, Canberra.

Garnett, ST, Peddler, LP & Crowley, GM 1999, 'The breeding biology of the Glossy Black Cockatoo *Calyptorhynchus lathami* on Kangaroo Island, South Australia', *Emu*, vol. 99, pp. 262-79.

Gibbons, P & Lindenmayer, DB 1997, *Conserving hollow-dependent fauna in timber-production forests*, NSW National Parks and Wildlife Service, Hurstville.

Goldingay, RL 1992, 'Socioecology of the Yellow-bellied Glider (*Petaurus australis*) in a coastal forest', *Australian Journal of Zoology*, no. 40, pp. 267-78.

Goldingay, RL & Kavanagh, RP 1991, *The Yellow-bellied Glider: a review of its ecology, and management considerations*, Royal Zoological Society of NSW.

Goldingay, RL & Sharpe, DJ 1998, 'Feeding behaviour of the Squirrel Glider at Bungawalbin Nature Reserve, north-eastern New South Wales', *Wildlife Research*, vol. 25, no. 1, pp. 243-54.

Harden, G 1993, *Flora of New South Wales Volume 4*, University of New South Wales Press Ltd., Kensington.

——— 2000, *Flora of New South Wales Volume 1 (Revised Edition)*, University of New South Wales Press Ltd., Kensington.

Heemstra, PC & Randall, JE 1993, *Groupers of the World (Family Serranidae, Subfamily Epinephelinae). An Annotated and Illustrated Catalogue of the Grouper, Rockcod, Hind, Coral Grouper and Lyretail Species, FAO Fisheries Synopsis, No. 125, Vol. 16.* , FAO, Rome.

Higgins, PJ (ed.) 1999, *Handbook of Australian, New Zealand and Antarctic Birds Volume 4: Parrots to Dollarbirds*, Volume 4: Parrots to Dollarbird, Oxford University Press, Melbourne.

Hoye, GA & Dwyer, PD 1998, 'Large-eared Pied Bat', in R Strahan (ed.), *The Mammals of Australia*, New Holland Publishers, Sydney.

Kavanagh, RP 1984, 'Seasonal Changes in habitat use by gliders and possums in southeastern New South Wales.' in APSID Hume (ed.), *Possums and Gliders*, Australian Mammal Society, Sydney, pp. 527-43.

——— 1987, 'Forest phenology and its effect on foraging behavior and selection of habitat by the Yellow-Bellied Glider, *Petaurus australis* ', *Wildlife Research*, no. 14, pp. 371-84.

——— 1992, 'The impact of predation by the Powerful Owl *Ninox strenua* on a population of the Greater Glider *Petauroides volans*', *Australian Journal of Ecology*, vol. 17, no. 3, pp. 469-72.

——— 1996, 'The breeding biology and diet of the Masked Owl *Tyto novaehollandiae* near Eden, New South Wales', *Emu*, vol. 96, no. 1, pp. 158-65.

Kavanagh, RP & Debus, SJS 1994, 'The Powerful Owl *Ninox strenua* in New South Wales', *Australian Birds*, vol. 28, supplement 21-38.

Kavanagh, RP, Debus, S, Tweedie, T & Webster, R 1995, 'Distribution of nocturnal forest birds and mammals in north-eastern New South Wales: relationships with environmental variables and management history', *Wildlife Research*, vol. 22, no. 1, pp. 359-77.

Kingsford, RT 2000, 'Ecological impacts of dams, water diversions and river management on flooplain wetlands in Australia', *Austral Ecology*, vol. 25, pp. 109-27.

Kingsford, RT & Norman, FI 2002, 'Australian Waterbirds- a product of the continent's ecology', *Emu*, vol. 102, pp. 47-69.

Last, PR & Stevens, JD (eds) 1994, *Sharks and Rays of Australia*, CSIRO.

Law, BS & Chidel, M 2004, 'Roosting and foraging ecology of the Golden-tipped Bat (*Kerivoula papuensis*) on the south coast of New South Wales ', *Wildlife Research*, vol. 31, no. 1, pp. 73-8.

Lloyd, S, Hall, LS & Bradley, AJ 1999, 'Reproductive strategies of a warm temperate vespertilionid, the Large-footed myotis, *Myotis moluccarum*', *Australian Journal of Zoology*, vol. 47, no. 1, pp. 261-74.

Logan, M & Sanson, GD 2003, 'The effects of lactation on the feeding behaviour on the activity patterns of free-ranging Koala', *Australian Zoology*, vol. 51, no. 2, pp. 415-8.

Lumsden, LF & Bennett, AF 1995, 'Bats of a semi-arid environment in south-eastern Australia: biogeography, ecology and conservation', *Wildlife Research*, vol. 22, pp. 217-40.

Lunney, D, Mattews, A, Moon, C & Ferrier, S 2000, 'Incorporating habitat mapping into practical Koala conservation on private lands', *Conservation Biology*, vol. 14, no. 3, pp. 669-80.

Marchant, S & Higgins, PJ (eds) 1990, *Handbook of Australian New Zealand and Antarctic Birds. Volume 1: Ratites to Ducks*, Oxford University Press, Melbourne, Victoria.

——— (eds) 1993, *Handbook of Australian, New Zealand and Antarctic Birds Volume 2: Raptors to Lapwings*, vol. 2, Volume 2: Raptors to Lapwings, Oxford University Press, Melbourne.

Melzer, A, Carrick, F, Menkhorst, P & Lunney, D 2000, 'Overview, critical assesment and conservation implications of Koala distribution and abundance', *Conservation Biology*, vol. 14, no. 3, pp. 619-28.

Moore, BD & Foley, WJ 2000, 'A review of feeding and diet selection in Koalas (*Phascolarctos cinereus*)', *Australian Journal of Zoology*, vol. 48, no. 1, pp. 317-33.

NSW National Parks and Wildlife Service 1996, *Threatened Species Assessment under the EP&A Act: The '8 Part test' of Significance*, Information Circular No 2: NSW National Parks and Wildlife Service, Hurstville.

——— 1998, *Large forest owls northern regional recovery plan.*, Coffs Harbour.

——— 1999a, *Koala threatened species information*, NSW National Parks and Wildlife Service, Hurstville.

——— 1999b, *Spotted-tailed Quoll threatened species information*, NSW National Parks and Wildlife Service, Hurstville.

——— 1999c, *Yellow-bellied Glider threatened species information*, NSW National Parks and Wildlife Service, Hurstville.

——— 1999d, *Glossy Black-cockatoo threatened species information*, NSW National Parks and Wildlife Service, Hurstville.

——— 1999e, *Squirrel Glider threatened species information*, NSW National Parks and Wildlife Service, Hurstville.

——— 1999f, *Square-tailed Kite Threatened Species Information*, NSW National Parks and Wildlife Service,, Hurstville.

——— 2002a, *Koala Draft Recovery Plan*, NSW National Parks and Wildlife Service, Hurstville.

——— 2002b, *Threatened species of the upper north coast of New South Wales - Flora*, NSW National Parks and Wildlife Service, Northern Directorate, Coffs Harbour.

——— 2003a, *Recovery Plan for the Yellow-bellied Glider (Petaurus australis)*, NSW National Parks and Wildlife Service, Hurstville.

——— 2003b, *Draft Recovery Plan for the Koala*, NSW National Parks and Wildlife Service, Hurstville.

NSW Scientific Committee 2004a, *Final determination to list Swamp Sclerophyll Forest on Coastal Floodplains as an Endangered Ecological Community* NSW Department of Environment and Conservation, Hurstville.

——— 2004b, *Final determination to list freshwater wetlands on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions as an endangered ecological community*, NSW National Parks and Wildlife Service, Hurstville.

——— 2004c, *Final determination to list Swamp Oak Floodplain Forest as an Endangered Ecological Community*, NSW Department of Environment and Conservation, Hurstville.

——— 2005, *Final determination to list River-flat Eucalypt Forest on coastal floodplains as an Endangered Ecoological Community.*, NSW Department of Environment and Conservation, Hurstville.

Parnaby, H & Mills, D 1994, 'A record of Golden-tipped Bat from the escarpment forests of southern New South Wales', *Australian Zoologist*, vol. 29, no. 3-4, pp. 245-8.

Parry-Jones, KA & Augee, ML 1991, 'Food selection by Grey-headed Flying Foxes (*Pteropus poliocephalus*) occupying a summer colony site near Gosford, New South Wales', *Wildlife Research*, vol. 18, no. 1, pp. 111 - 24

——— 1992, 'Movements of Grey-headed Flying-foxes (*Pteropus poliocephalus*) to and from colony site on the Central Coast of New South Wales', *Wildlife Research*, vol. 19, no. 3, pp. 331 - 9

Pizzey, G & Knight, F 1997, *Field Guide to the Birds of Australia*, Angus and Robertson, Sydney.

Pogonoski, J 2000, *Threatened Fish Profile. Black Rockcod Epinephelus daemelii*.

Pollard, D 1999, 'Black Cod- Species Notes', *The Newsletter of the Marine Parks Authority Summer 1999/Autumn 2000. Volume Issue No. 1*.

Quin, DG 1995, 'Population ecology of the Squirrel Glider (*Petaurus norfolcensis*) and the Sugar Glider (*P. breviceps*) (Maruspialia : Petauridae) at Limeburners Creek, on the central north coast of New South Wales ', *Wildlife Research*, vol. 22, no. 4, pp. 471 - 505

Redhead, TD (ed.) 1998, *Common Planigale*, The Mammals of Australia, New Holland Publishers, Sydney.

Reed, PC, Lunney, D & Walker, P 1990, 'A 1986-1987 survey of the koala *Phascolarctos cinereus* (Goldfuss) in New South Wales and an ecological interpretation of its distribution.'

in AK Lee, K Handasyde & GD Sanson (eds), *Biology of the koala*, Surrey Beatty and Sons, Sydney.

Richards, GC 1998, 'Large-footed Myotis', in R Strahan (ed.), *Mammals of Australia*, New Holland Publishers, Sydney.

Rowston, C 1998, 'Nest and refuge-tree usage by Squirrel Gliders, *Petaurus norfolcensis*, in south-east Queensland', *Wildlife Research*, vol. 25, no. 2, pp. 157 - 64.

Royal Botanic Gardens 2005, *PlantNet - The Plant Information Network System of Botanic Gardens Trust (version 2.0)*, Royal Botanic Gardens, Sydney, <http://plantnet.rbgsyd.gov.au >.

Russell, R 1995, 'Yellow-bellied Glider', in R Strahan (ed.), *The Mammals of Australia. Second edition*, Reed Books, Sydney, pp. 226-8.

Sainty, GR & Jacobs, SWL 2003, *Waterplants in Australia*, 4th edn, Sainty and Associates Pty Ltd, Potts Point.

Scarff, FR, Rhind, SG & Bradley, JS 1998, 'Diet and foraging behaviour of Brush-tailed Phascogales (*Phascogale tapoatafa*) in the jarrah forest of south-western Australia', *Wildlife Research*, vol. 25, no. 5, pp. 511 - 26.

Schulz, M 1997a, 'Bats in bird nests in Australia: a review', *Mammal Review*, vol. 28, pp. 69-76.

——— 1997b, 'The diet of the Powerful Owl *Ninox strenua* in the Rockhampton area', *Emu*, vol. 97, no. 326-329.

Scotts, D 2003, *Key habitat corridors for forest fauna. A landscape framework for conservation in north-east New South Wales. Occasional Paper 32*, NSW National Parks and Wildlife Service, Sydney.

Simpson, K & Day, N 1996, *Field Guide to the Birds of Australia*, 5th edn, Viking. Penguin Books Australia Ltd., Ringwood.

Smith, A & Murray, M 2003, 'Habitat requirements of the Squirrel Glider and associated possums and gliders on the NSW Central Coast', *Wildlife Research*, vol. 30, pp. 291-301.

Soderquist, TR 1993, 'Maternal strategies of Brush-tailed Phascogale-Tapoatafa (Marsupialia, Dasyuridae) .1. Breeding Seasonality and Maternal Investment', *Australian Journal of Zoology*, vol. 41
no. 6, pp. 549 - 66.

Soderquist, TR & Ealey, L 1994, 'Social interactions and mating strategies of a solitary carnivorous marsupial, *Phascogale tapoatafa*, in the wild', *Wildlife Research*, vol. 21, no. 5, pp. 527-41.

Spencer, HJ, Palmer, C, Carol, A, Parry, K & Tones, B 1991, 'Movements of fruit-bats in eastern Australia determined by using radio-tracking', *Wildlife Research*, vol. 18, no. 1, pp. 463-8.

Strahan, R 1995, *The Mammals of Australia*, Reed New Holland, Sydney.

Thompson, D & Brock Penton, M 1982, 'Echolocation and feeding behaviour of *Myotis adversus*', *Australian Journal of Zoology*, vol. 30, no. 2, pp. 543-6.

Traill, BJ & Coates, TD 1993, 'Field observations on the Brush-tailed Phascogale *Phascogale tapotafa*', *Australian Mammology*, vol. 16, no. 1, pp. 61-5.

Triggs, B 1996, *Tracks, scats and other traces: a field guide to Australian mammals*, Oxford University Press, Melbourne.

Truyard Pty Ltd 1993, *Kempsey/ Wauchope Management Areas, Environmental Impact Statement, Volume 2- Fauna Impact Statement* Forestry Commission of New South Wales, Pennant Hills.

Van de Ree, R 2002, 'The population ecology of the Squirrel Glider (*Petaurus norfolcensis*) within a network of remnant linear habitats', *Wildlife Research*, vol. 29, no. 4, pp. 329 - 40.

——— 2006, 'Road upgrade in Victoria a filter to the movement of the endangered Squirrel Glider (Petaurus norfolcensis): Results of a pilot study', *Ecological Management & Restoration*, vol. 7, no. 3, pp. 226-8.