C.2.2 Large-eared Pied Bat (Chalinolobus dwyeri)

i. Conservation Status

The Large-eared Pied Bat is listed as Vulnerable under the EPBC Act and the TSC Act as well as the *Nature Conservation Act 1992* (NC Act) in Queensland.

ii. Species Habitat

The Large-eared Pied Bat roosts in caves (near their entrances), crevices in cliffs, old mine workings and in the disused, bottle-shaped mud nests of the Fairy Martin (*Petrochelidon ariel*), frequenting low to mid-elevation dry open forest and woodland close to these features (OEH 2012e). It also possibly roosts in the hollows of trees.

Sandstone cliffs in close proximity to fertile woodland valleys form important habitat for the Large-eared Pied Bat. Records from south-east Queensland suggest that rainforest and moist eucalypt forest habitats on other geological substrates (rhyolite, trachyte and basalt) at high elevation are of similar importance to the species (Queensland Department of Environment and Resource Management (Qld DERM) 2011). Therefore it is likely that the presence of suitable caves or overhangs may be more important than the precise geology(Queensland Department of Environment and Resource Management (Qld DERM) 2011).

Available roosts are not evenly distributed throughout the landscape. The species requires a combination of sandstone cliff/escarpment to provide roosting habitat that is adjacent to higher fertility sites, particularly box gum woodlands or river/rainforest corridors which are used for foraging (Pennay 2010 pers. comm. cited in TSSC 2010az). Almost all records have been found within several kilometres of cliff lines or rocky terrain (Queensland Department of Environment and Resource Management (Qld DERM) 2011).

The structure of primary nursery roosts appears to be very specific, i.e. arch caves with dome roofs (that need to be deep enough to allow juvenile bats to learn to fly safely inside) and with indentations in the roof (presumably to allow the capture of heat). These physical characteristics are not very common in the landscape and therefore are likely to be a limiting factor in their distribution (SEWPaC 2011b).

iii. Species Distribution

The species' current distribution is poorly known. Records exist from Shoalwater Bay, north of Rockhampton, Queensland, through to the vicinity of Ulladulla, NSW in the south (Queensland Department of Environment and Resource Management (Qld DERM) 2011). Despite the large range, it has been suggested that the species is far more restricted within its range than previously understood.

Much of the known distribution is within NSW. Available records suggest that the largest concentrations of populations appear to be in the sandstone escarpments of the Sydney basin and the north-west slopes (Coolah Tops, Mt Kaputar, Warrumbungle National Park (NP) and Pilliga Nature Reserve (NR)). Although the species is widely distributed, it is

uncommon and patchy within this area. Sightings of note include Tottenham, west of Narromine (NSW), which is the furthest west record; Swansea Open Cut Mine area of the Wallarah Peninsula, north coast NSW; a disused gold mine near Barraba (NSW) that included lactating females and dependent young; and Moreton NP (NSW) at the southern end of the species' range (Queensland Department of Environment and Resource Management (Qld DERM) 2011).

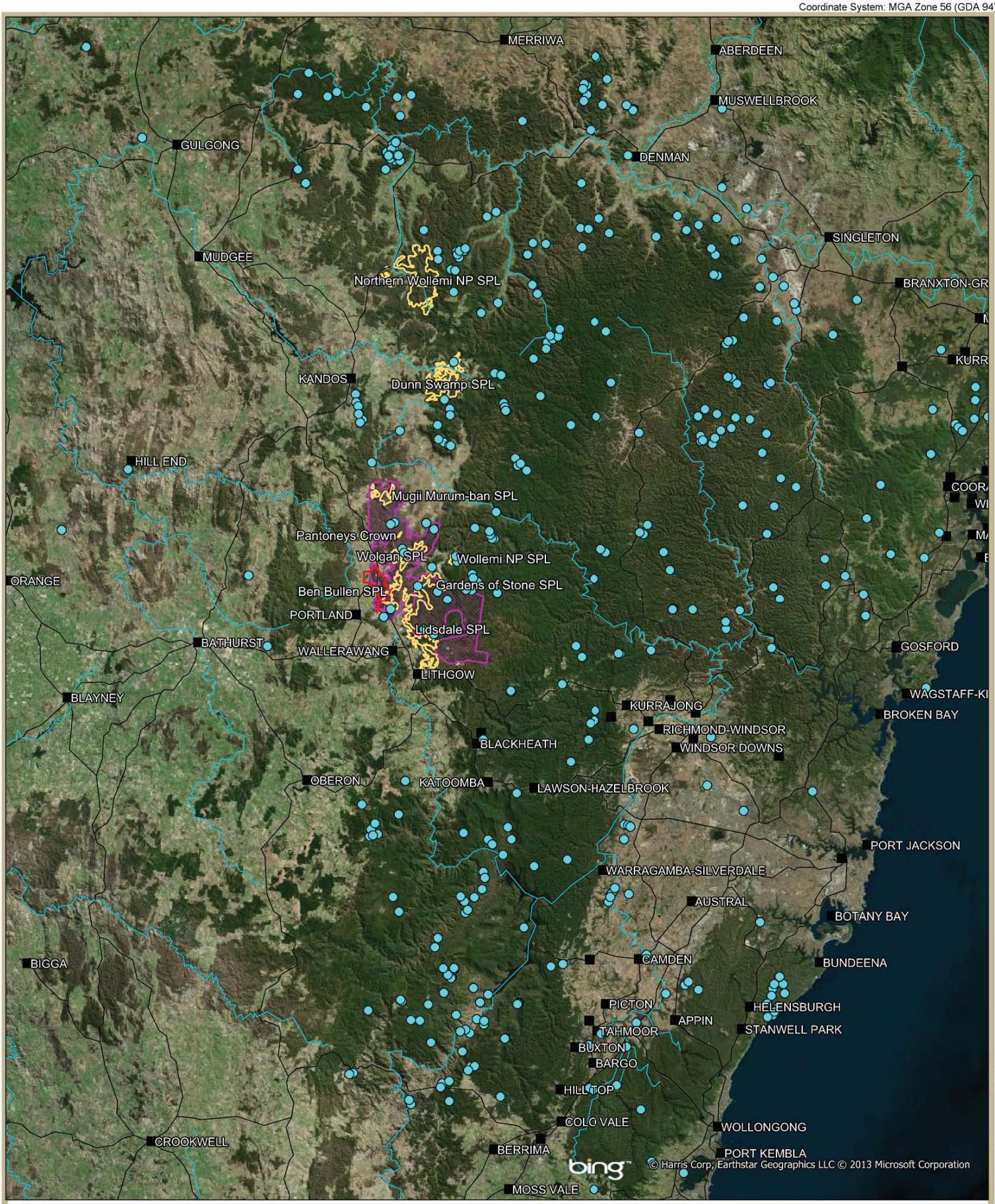
In Queensland, further records are known from sandstone escarpments in the Carnarvon, Expedition Ranges and Blackdown Tablelands. It is likely that these areas support a high proportion of the Queensland populations of the Large-eared Pied Bat, although estimates of the number of individuals present and their distribution in these areas has not been established. Additional records exist in the Scenic Rim near the NSW/Queensland border. The populations in this area appear to be reliant on the presence of roosts in volcanic rock types (Queensland Department of Environment and Resource Management (Qld DERM) 2011).

iv. Assessment of Dependency on Pagoda Landforms:

Although this species is highly likely to find suitable habitat in pagoda landforms, its requirements are not limited to these habitats. As discussed above, it has been recorded from a large range of habitats, most of which do not comprise pagodas.

It has a large range, and is known to occur in many different geology types including volcanic rock, rhyolite, trachyte and basalt, which do not form pagodas. It has been suggested in the Recovery Plan for this species that the precise geology is less important than the presence of suitable caves.

This species is commonly found in sandstone escarpment areas including pagoda habitat, however it is not specifically limited to areas containing pagodas. It is therefore considered that although pagodas provide suitable habitat this species, it is not dependent on pagoda landforms.



Legend

- Project Boundary
- Pagoda Country (as mapped by Washington and Wray 2011)
- Significant Pagoda Landforms
- River
- Road
- Town
- Large-eared Pied Bat

Scale 1:967,000

Data Source:
NPWS Atlas Data: dated 18/01/2013
Washington, H.G. and Wray, R.A.L., 2011

CUMBERLAND ECOLOGY

I:\...\13007\Figures\RP1_SOE_20130306\Figure C.12. Large-eared Pied Bat

Figure C.12. Large-eared Pied Bat Records (TSC Act & EPBC Act: Vulnerable)

10 0 10 20 30 40 km

C.2.3 Eastern Bentwing-bat (Miniopterus schreibersii oceanensis)

i. Conservation Status

The Eastern Bentwing-bat is listed as Vulnerable under the TSC Act. It is not listed elsewhere in Australia or under the EPBC Act.

The species is conserved in the following National Parks; Royal, Blue Mountains, Wollemi and Kanangra-Boyd.

ii. Species Habitat

Caves are the primary roosting habitat, but also the species also uses use derelict mines, storm-water tunnels, buildings and other man-made structures. They form discrete populations centred on a maternity cave that is used annually in spring and summer for the birth and rearing of young (OEH 2012c). Maternity caves have very specific temperature and humidity regimes. At other times of the year, populations disperse within about 300 km range of maternity caves. Cold caves are used for hibernation in southern Australia. Breeding or roosting colonies can number from 100 to 150,000 individuals. This species hunts in forested areas, catching moths and other flying insects above the tree tops.

This species has been recorded from most environments within the Greater Southern Sydney Region including: creeklines within semi-urban areas, above farm dams in cleared country, in sandstone woodland and in rainforest gullies. In this area it is possible that Eastern Bentwing-bats migrate to the coast for the winter as many large colonies have been reported during this period. Females disperse to maternity roosts in limestone caves in November and early December and return to coastal roosts in early March (DECC 2007) .

In most of the Catchment Management Areas (CMAs) in NSW within its range, it has been recorded from karst (limestone) caves, but no known maternity colonies have been recorded. However, in the Murrumbidgee CMA, it has been recorded in karst caves, including at a known maternity colony at Wee Jasper. In the Hawkesbury/Nepean CMA, there are identified maternity roosts in caves with specific temperature and humidity regimes. In the Northern Rivers CMA, it has been recorded from karst caves including known maternity colony at Willi Willi Caves, west of Kempsy near the boundary of Macleay Hastings and Upper Manning CMA Sub-regions (OEH 2012c). In the Southern Rivers CMA, it has been recorded from karst caves including a known maternity colony at Bungonia.

iii. Species Distribution

The Eastern Bentwing-bat is found along the east coast of Australia from Cape York in North Queensland to Castlemaine in Victoria. They predominantly occur east of the Great Dividing Range. In NSW they have been recorded from the following CMAs:

- Border Rivers-Gwydir;
- Central West;

- Hawkesbury-Nepean;
- Hunter-Central Rivers;
- Lachlan;
- Murray;
- Murrumbidgee;
- Namoi;
- Northern Rivers;
- Southern Rivers; and
- Sydney Metro

Sightings are widespread within the Sydney Basin Bioregion, though clusters of records are present in the Lower Hunter Valley and Central Coast, Cumberland Plain, Woronora Plateau and across the southern Blue Mountains. Many of these records are from reserves, including Royal, Blue Mountains and Wollemi NPs. There are numerous sightings from the South Eastern Highlands Bioregion from Kanangra-Boyd NP and the south west of the Blue Mountains NP. Outside this area there are occasional records, from near Bathurst, Marulan and Queanbeyan (DECC 2007).

iv. Assessment of Dependency on Pagoda Landforms

Although this species is highly likely to find suitable habitat in pagoda landforms, its requirements are not limited to these habitats. As discussed above, it has been recorded roosting in a large range of habitats, most of which do not contain pagodas. Many records have been made from limestone geology, including maternity caves, and therefore it is highly unlikely that this species is dependent on pagoda formations, which are found in sandstone areas.

This species is commonly found in pagoda habitat, however it is found in a range of other habitats and is not specifically limited to areas containing pagodas. It is therefore considered that although pagodas provide suitable habitat this species, it is not dependent on pagoda landforms.

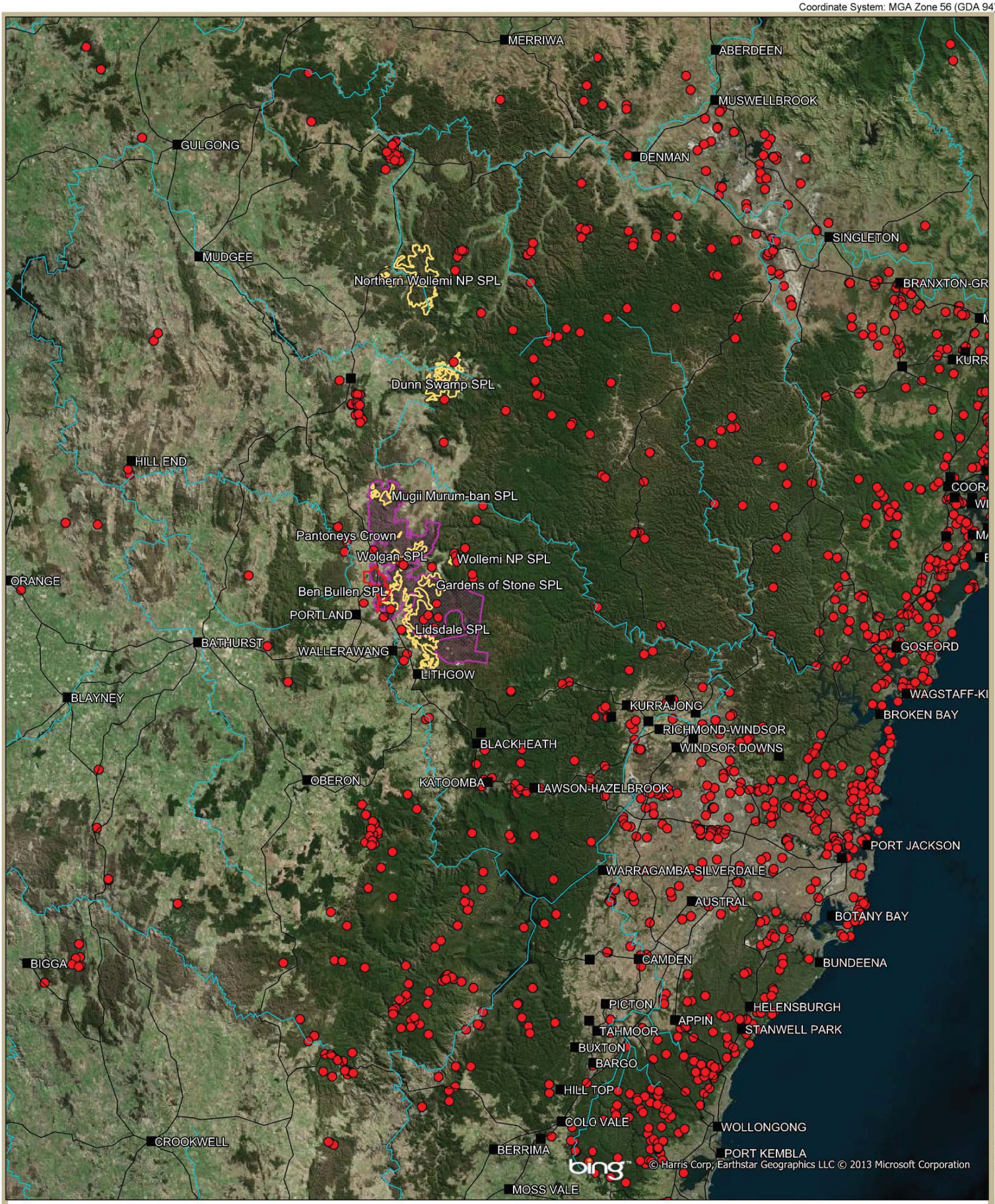


Figure C.13. Eastern Bentwing-bat Records (TSC Act: Vulnerable)

C.2.4 Glossy Black-Cockatoo (Calyptorhynchus lathami)

i. Conservation Status

The Glossy Black-Cockatoo is listed as Vulnerable under the TSC Act and in Queensland under the Nature Conservation Act 1992 (NC Act). The subspecies *lathami*, is listed as Threatened in Victoria under the Flora & Fauna Guarantee Act 1988 (FFG Act). An isolated population on Kangaroo Island in South Australia is listed as Endangered under the EPBC Act, and an Endangered Population listed under the TSC Act is present in the Riverina region of NSW (NSW Scientific Committee 2004b)

ii. Species Habitat

The Glossy Black-Cockatoo inhabits open forest and woodlands with hollow-bearing trees, from the coast to the Great Dividing Range up to 1000m, in which midstorey stands of She-oak species occur, particularly Black She-oak (*Allocasuarina littoralis*), Forest She-oak (*A. torulosa*) or Drooping She-oak (*A. verticillata*) occur. In the Riverina area, it is usually associated with woodlands containg Drooping She-oak but also recorded in open woodlands dominated by Belah (*Casuarina cristata*). This species feeds almost exclusively on the seeds of several species of she-oak (*Casuarina* and *Allocasuarina* species) shredding the cones with the massive bill. It is dependent on large hollow-bearing eucalypts for nest sites (OEH 2012d).

iii. Species Distribution

The species is uncommon although widespread throughout suitable forest and woodland habitats, from the central Queensland coast to East Gippsland in Victoria, and inland to the southern tablelands and central western plains of NSW, with a small population in the Riverina (OEH 2012d). An isolated population exists on Kangaroo Island, South Australia. Most of the NSW Glossy Black-Cockatoo population now exists in state forests and NSW National Park Estate (NSW Scientific Committee 2004b).

iv. Assessment of Dependency on Pagoda Landforms

Although this species may find suitable habitat in pagoda landforms, its requirements are not limited to these habitats. The key habitat requirements of this species are the presence of *Allocasuarina* or *Casuarina* species to feed on, and large hollows in Eucalypt trees in which to nest. Although these kinds of habitats may be found near pagodas, Glossy Black Cockatoos are not limited to this kind of habitat.

Historically, the main threat to the Glossy Black-Cockatoo has been clearing of forest for agriculture and settlements, and degradation of forests by logging, firewood harvesting (with sheoaks targeted for their fuel properties), frequent intense fire and 'timber stand improvement'; all of which remove the Glossy Black-Cockatoo's nest hollows and food sources (NSW Scientific Committee 2004b).

It is therefore considered that although pagodas may provide suitable habitat for this species (depending on the tree species present and the age of the vegetation) it is not dependent on pagoda landforms.

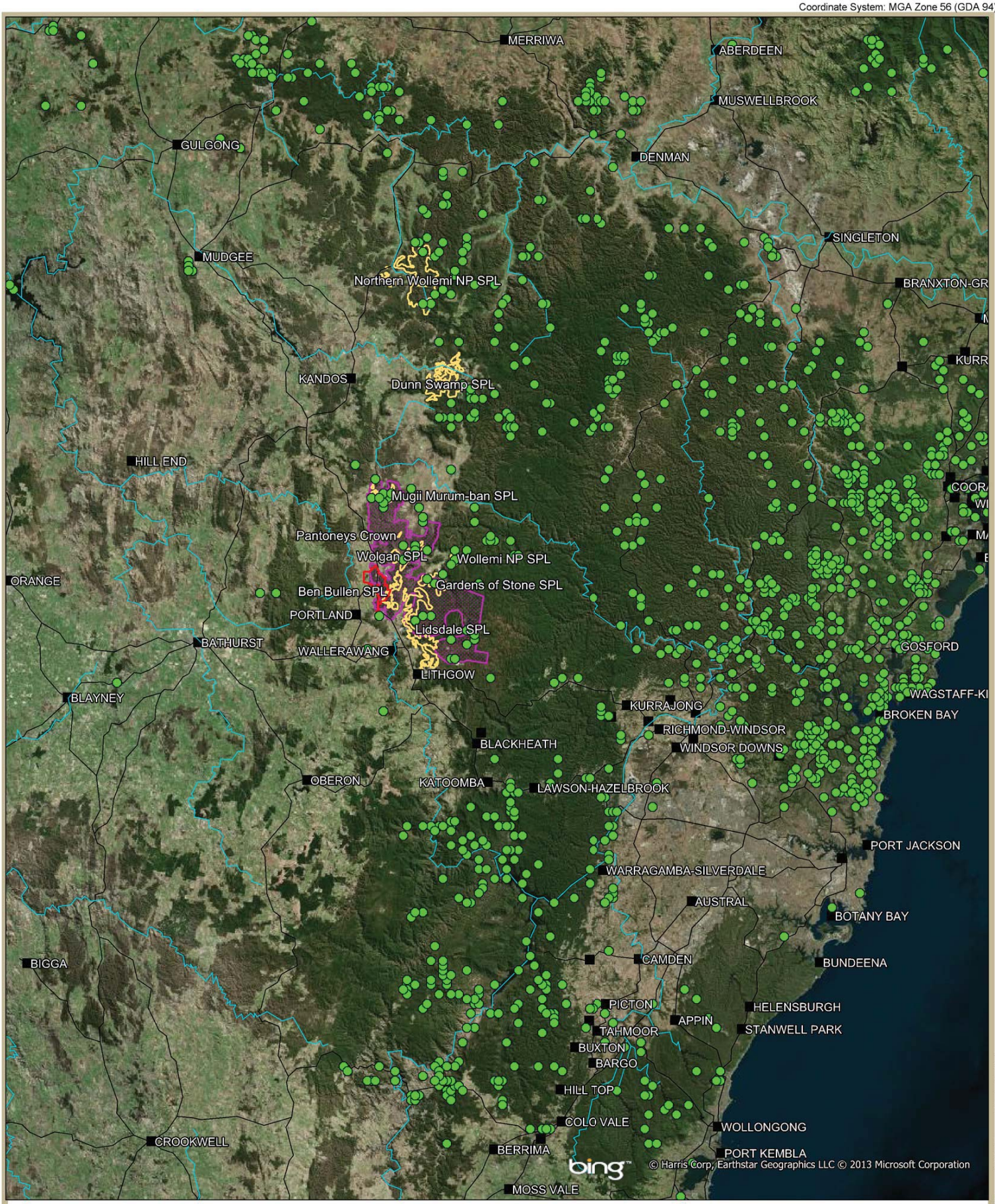


Figure C.14. Glossy Black-Cockatoo Records (TSC Act: Vulnerable)

C.2.5 Brush-tailed Rock Wallaby (Petrogale penicillata)

i. Conservation Status

The Brush-tailed Rock Wallaby is listed as Vulnerable under the EPBC Act and the QLD NC Act and Endangered under the NSW TSC Act and the ACT *Nature Conservation Act 1980*. It is listed as Critically Endangered under the Victorian FFG Act. The Warrumbungle population of the Brush-tailed Rock Wallaby is listed as an Endangered Population under the TSC Act.

Of the total 962 nationally-recorded sites, approximately half are within conservation reserves. It is present within Tidbinbilla Nature Reserve in the ACT and in the following reserves in NSW; Warrumbungle, Mt Kaputar, Blue Mountains, Kanangra Boyd, Oxley Wild Rivers, Guy Fawkes River, Yengo, Wollemi and Wadbilliga National Parks, and Jenolan Caves Reserve (SEWPaC 2013b). In Queensland it occurs within the following national parks; Queen Mary Falls, Mt Barney, Sundown and Main Range. In Victoria it is known from the Grampians and Snowy River Alpine National Parks.

ii. Species Habitat

Habitat for Brush-tailed Rock-wallabies includes refuge habitat, feeding habitat, and routes between the two. Refuge habitat includes rock faces or outcrops with large tumbled boulders, ledges and caves (often with vegetation cover) that provide shelter and some protection from predators. Rock refuges are usually on a steep slope (e.g. cliff lines, gorges, hillside outcrops and plateau edges). Preferred rocky habitat consists of three major types (NSW NPWS 2002):

- Loose piles of large boulders containing a maze of subterranean holes and passageways;
- Cliffs with many mid-level ledges and with some caves and/or ledges covered by overhangs; and
- Isolated rock stacks, usually sheer-sided and often girdled with fallen boulders.

Foraging habitat includes forest and woodland with a grassy understorey. Precise vegetation community type may not be critical in habitat selection as Brush-tailed Rock-wallabies eat a wide variety of mainly grass material (Menkhorst 2010).

Brush-tailed Rock-wallabies typically shelter during the day in rock crevices, caves and overhangs (SEWPaC 2013b). It appears that most Brush-tailed Rock-wallaby colonies are on north-facing slopes and cliff lines, although colonies have been found on south-facing cliffs, usually in lower densities.

iii. Species Distribution

The Brush-tailed Rock-wallaby was once widespread and abundant in south-eastern Australia. It was formerly found along the Great Dividing Range from Nanango in south-east

Queensland through to east Gippsland in Victoria. However, there has been a reduction in the species' range and numbers with the decline being greatest in Victoria and southern NSW. The species is known from 962 nationally-recorded sites; 876 of these sites are in NSW (SEWPaC 2013b).

Populations in NSW important to the survival of the species include:

- Warrumbungle Range (outlying population; loss would cause substantial range contraction).
- Mt Kaputar (outlying population; loss would cause range contraction).
- Wollemi National Park and Jenolan Caves [stronghold populations that have the greatest chance of persisting into the long term].
- Nattai National Park population (loss would create a large range gap between the Shoalhaven population and populations further north).
- Shoalhaven (southernmost population in NSW).
- Macleay Gorges region (largest known populations).

iv. Assessment of Dependency on Pagoda Landforms:

Rocky habitat and associated foraging habitat is considered to be critical to the survival of this species (Menkhorst 2010). Although the Brush-tailed Rock-wallaby is commonly found in sandstone escarpment areas including pagoda habitat, it is not specifically limited to areas containing pagodas. It is therefore considered that although pagodas provide suitable habitat for this species, it is not solely dependent on pagoda landforms.

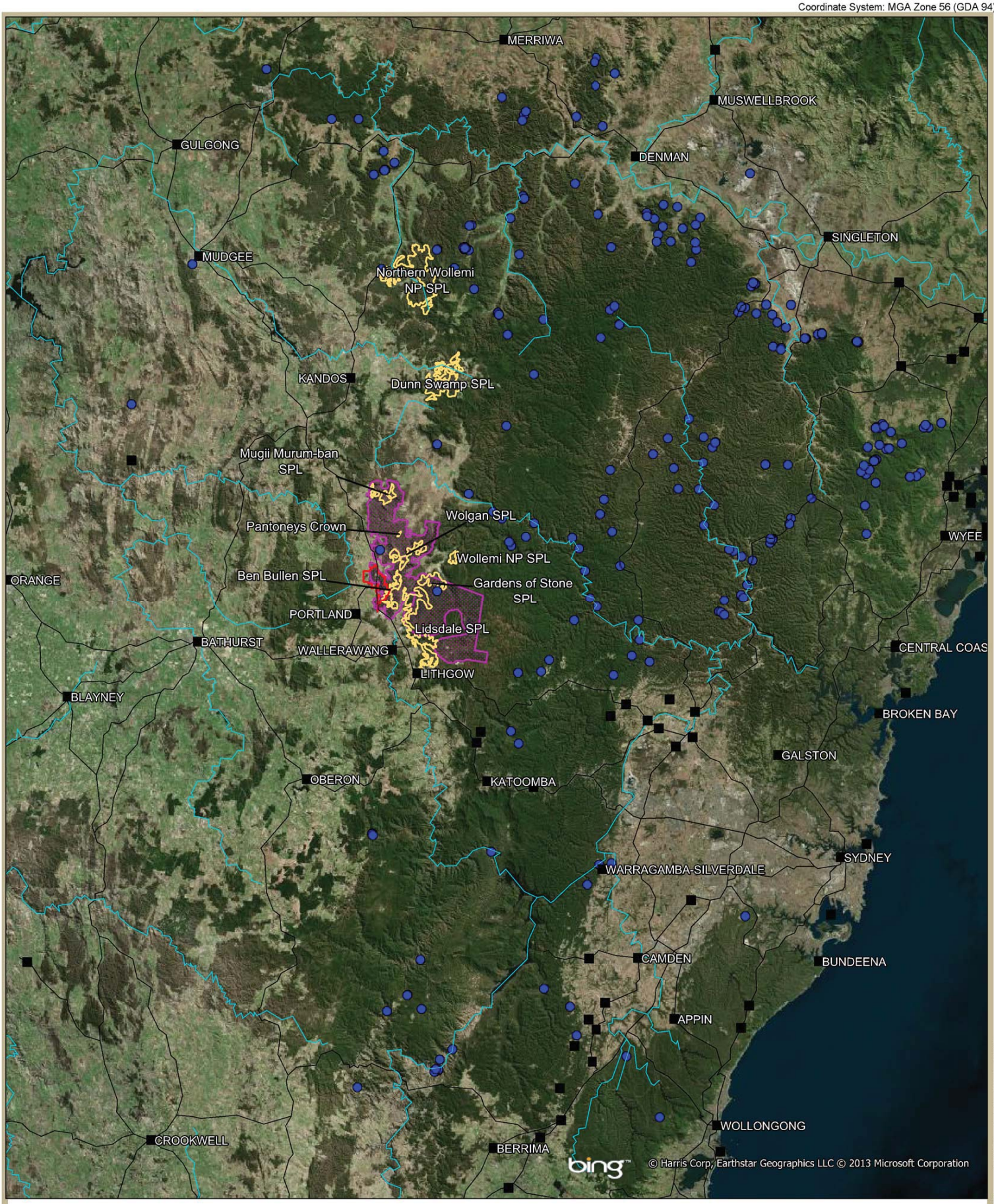


Figure C.15. Brush-tailed Rock Wallaby Records (TSC Act: Endangered; EPBC Act: Vulnerable)

C.2.6 Superb Lyrebird (Menura novaehollandiae)

i. Conservation Status:

The Superb Lyrebird is not listed under the NSW TSC Act or the Federal EPBC Act. Internationally, it is listed as Least Concern by the International Union for the Conservation of Nature (IUCN) where it is also evaluated as having a declining population (IUCN 2012).

ii. Species habitat:

The Superb Lyrebird forages in leaf litter for small invertebrates during the day and roosts in trees .(Australian Museum 2013, Birds in Backyards 2013) It is found in temperate to sub-tropical rainforests and woodlands and also be found in fern gullies, sandstone gorges and forest plantations (Knight 2003).

iii. Species Distribution:

This species is found in the south-eastern Australian mainland (Birds in Backyards 2013) from the highlands in south-east Queensland, through eastern New South Wales to the Dandenong Ranges, Kinglake and Wandong Districts in Victoria (Knight 2003). It was introduced to Tasmania between 1934 and 1945 and is found in the southern part of the state (Birds in Backyards 2013).

iv. Assessment of Dependency on Pagoda Landforms:

Although this species is highly likely to find suitable habitat in pagoda landforms, its requirements are not limited to these habitats. As discussed above, it occurs across eastern Australia from south-east Queensland, through eastern New South Wales to the Dandenong Ranges, Kinglake and Wandong Districts in Victoria.

This species is commonly found in pagoda habitat, however it is found in a range of other habitats and is not specifically limited to areas containing pagodas. It is therefore considered that although pagodas provide suitable habitat this species, it is not dependent on pagoda landforms.

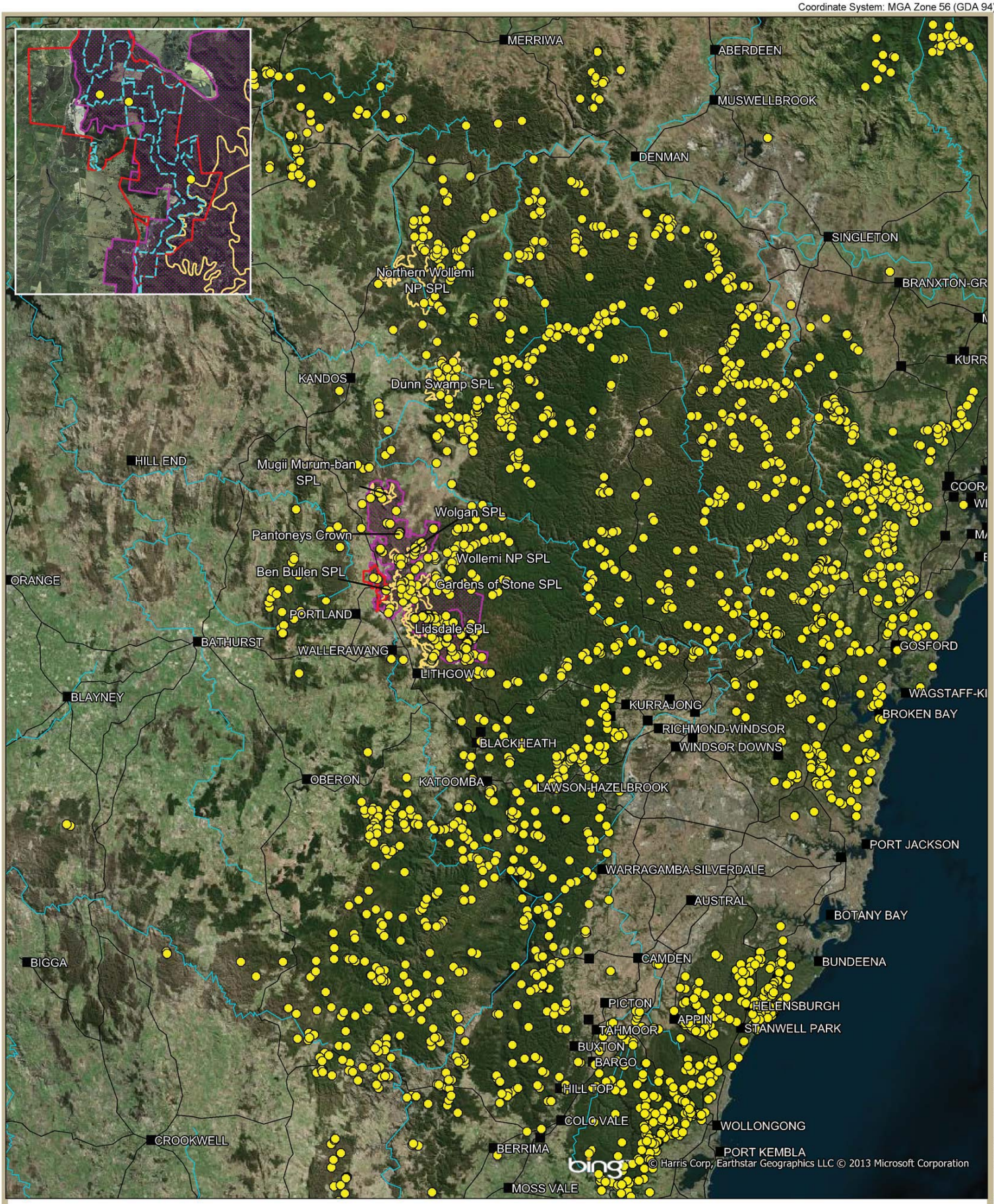


Figure C.16. Superb Lyrebird Records (Not Threatened)

Appendix D

Priority Actions for Threatened Species that Use Cliffs and Pagodas

Table D.1 Priority Actions for Broad-headed Snake (from OEH Website 2013)

Action Title	Scientific Name	Common Name	Species Type	Priority
Identify key populations and important habitat and assess threats at these sites to establish priorities for management.	Hoplocephalus bungaroides	Broad-headed Snake	Animal > Reptiles	High
Promote active management of Broad-headed Snake habitat on private land.	Hoplocephalus bungaroides	Broad-headed Snake	Animal > Reptiles	Medium
Promote options to control and regulate bushrock removal.	Hoplocephalus bungaroides	Broad-headed Snake	Animal > Reptiles	High
Develop guidelines in support of chosen options to regulate bushrock removal in accordance with outcomes from Action 2.2b.	Hoplocephalus bungaroides	Broad-headed Snake	Animal > Reptiles	Medium
Undertake a re-assessment of the species conservation status with the view to reconciling the Commonwealth and State listing discrepancy and ammending the respective schedules as necessary.	Hoplocephalus bungaroides	Broad-headed Snake	Animal > Reptiles	Low
Consider the merits of critical habitat during the third year of the plan.	Hoplocephalus bungaroides	Broad-headed Snake	Animal > Reptiles	Low
Guidelines are developed & disseminated to standardise & guide the approach to: EIA inc ofsetting, maintenance of infrastructure & easements; appropriate fire regimes, herps searches, and habitat restoration.	Hoplocephalus bungaroides	Broad-headed Snake	Animal > Reptiles	Medium
Undertake threat management, site protection and restoration works at identified priority sites, in accordance with approved threat management and restoration guidelines.	Hoplocephalus bungaroides	Broad-headed Snake	Animal > Reptiles	High
Review licenced Broad-headed Snake keepers	Hoplocephalus	Broad-	Animal >	Low

Table D.1 Priority Actions for Broad-headed Snake (from OEH Website 2013)

Action Title	Scientific Name	Common Name	Species Type	Priority
and establish a genetic database of held speciemens.	bungaroides	headed Snake	Reptiles	
Develop & implement a population monitoring protocol to monitor changes in populations and to evaluate the effectiveness of threat abatement and management actions for the BHS across its range.	Hoplocephalus bungaroides	Broad-headed Snake	Animal > Reptiles	High
Co-ordinate, encourage and support research into identified priorities and incorporate outcomes into threat abatement and management practices.	Hoplocephalus bungaroides	Broad-headed Snake	Animal > Reptiles	High
Conduct habitat restoration trials using a variety of methods including: vegetation manipulation, natural rock replacement, artifical rock and quarried rock.	Hoplocephalus bungaroides	Broad-headed Snake	Animal > Reptiles	High
Undertake research into the summer life cycle phase of the Broad-headed Snake.	Hoplocephalus bungaroides	Broad-headed Snake	Animal > Reptiles	Low
Investigate the influence of wildfire on the Broad-headed Snake and its main prey items to clarify direct and indirect impacts of planned and wildfire on this species.	Hoplocephalus bungaroides	Broad-headed Snake	Animal > Reptiles	Medium
Analyse the possible shift in obligatory versus facultative use of winter shelter retreat sites across the species north-south and altitudinal range.	Hoplocephalus bungaroides	Broad-headed Snake	Animal > Reptiles	Low
Develop and validate a detailed habitat model for the Broad-headed Snake.	Hoplocephalus bungaroides	Broad-headed Snake	Animal > Reptiles	Low
Carry out PVA using known information on the BHS and identify further data required to refine and improve the analysis.	Hoplocephalus bungaroides	Broad-headed Snake	Animal > Reptiles	Low
Design and carry out specific ecological	Hoplocephalus	Broad-	Animal >	Low

Table D.1 Priority Actions for Broad-headed Snake (from OEH Website 2013)

Action Title	Scientific Name	Common Name	Species Type	Priority
investigations to gather specific data to fill data gaps for PVA analysis.	bungaroides	headed Snake	Reptiles	
Rerun PVA using additional data sets and evaluate robustness.	Hoplocephalus bungaroides	Broad-headed Snake	Animal > Reptiles	Low
Undertake supplementary DNA analysis of individuals within the northern ESU to refine idnetifiation of management units.	Hoplocephalus bungaroides	Broad-headed Snake	Animal > Reptiles	Medium
Develop an education and communications strategy to disseminate key messages relating to to recovery and threat abatement planning initiatives and outcomes.	Hoplocephalus bungaroides	Broad-headed Snake	Animal > Reptiles	High
Undertake priority stakeholder and community group consultation to identify appropriate methods for the delivery of key messages and to promote involvement in the recovery program.	Hoplocephalus bungaroides	Broad-headed Snake	Animal > Reptiles	High
Develop and disseminate information resources and education materials to delivery key recovery messages to targeted audiences.	Hoplocephalus bungaroides	Broad-headed Snake	Animal > Reptiles	Medium
Assess the need for further suplementation of existing captive breeding program to address any identified representation gaps and facilitate program as necessary.	Hoplocephalus bungaroides	Broad-headed Snake	Animal > Reptiles	Low
Consider need for reintroduction and supplementation trials in the third year of the plan.	Hoplocephalus bungaroides	Broad-headed Snake	Animal > Reptiles	Low

Table D.2 Priority Actions for Eastern Bentwing Bat (OEH Website 2013)

Action Title	Scientific Name	Common Name	Species Type	Priority
Promote bats throughout the rural community as ecologically interesting and important, but sensitive to disturbance at caves/disused mine tunnels.	Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	Animal > Bats	Medium
Undertake non-chemical removal of weeds (e.g. lantana, blackberry) to prevent obstruction of cave entrances.	Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	Animal > Bats	Low
Restrict access where possible to known maternity sites. (e.g.: signs; bat-friendly, preferably external gates at caves).	Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	Animal > Bats	Low
Restrict caving activity during critical times of year in important roosts used by species, particularly maternity and hibernation roosts.	Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	Animal > Bats	Low
Establish a gating design for disused mines across species range that will not adversely impact species. Consultation with cave bat specialist prior to any gating operations.	Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	Animal > Bats	Medium
Determine the effectiveness of PVP assessment, offsets and actions for bats.	Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	Animal > Bats	Medium
Monitor the breeding success of a representative sample of maternity colonies in cave roosts over a number of years to determine the viability of regional populations.	Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	Animal > Bats	High
Regular censuses of maternity colonies (Wee Jasper, Bungonia, Willi-Willi, Riverton) and other key roosts in network, especially where there are population estimates from banding in the 1960s.	Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	Animal > Bats	High
For roost caves vulnerable to human disturbance, monitor their visitation by people, particularly during winter and spring/summer maternity season and in school holidays.	Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	Animal > Bats	Low

Table D.2 Priority Actions for Eastern Bentwing Bat (OEH Website 2013)

Action Title	Scientific Name	Common Name	Species Type	Priority
Measure genetic population structure among cave roosts of maternity colonies to estimate dispersal and genetic isolation, and vulnerability to regional population extinction.	Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	Animal > Bats	Low
Research the effect of different burning regimes on cave disturbance and surrounding foraging habitat.	Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	Animal > Bats	Medium
Control foxes and feral cats around roosting sites, particularly maternity caves and hibernation sites.	Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	Animal > Bats	Medium
Study the ecological requirements of maternity colonies and their environs and migratory patterns.	Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	Animal > Bats	Medium
Research to identify important foraging range and key habitat components around significant roosts.	Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	Animal > Bats	Medium
Confirm species taxonomy of NSW populations, relative to other Australian populations.	Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	Animal > Bats	Medium
Search for significant roost sites and restrict access where possible. Significant includes maternity, hibernation and transient sites including in artificial structures. .	Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	Animal > Bats	Medium
Compile register of all known roost sites in natural and artificial structures including current and historical data and identify signifance of roost, e.g. maternity, hibernation, transient roost.	Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	Animal > Bats	Medium
Promote the conservation of these key roost areas using measures such as incentive funding to landholders, offseting and biobanking, acquisition for reserve establishment or other means.	Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	Animal > Bats	Medium
Prepare fire management plans for significant	Miniopterus	Eastern	Animal >	Low

Table D.2 Priority Actions for Eastern Bentwing Bat (OEH Website 2013)

Action Title	Scientific Name	Common Name	Species Type	Priority
roost caves, disused mines, culverts, especially maternity and winter roosts.	schreibersii oceanensis	Bentwing-bat	Bats	
Exclude prescription burns from 100m from cave entrance, ensure smoke/flames of fires do not enter caves/roosts in artificial structures.	Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	Animal > Bats	Low
Ensure protection of known roosts and forest within 10 km of roosts in PVP assessments (offsets should include nearby remnants in high productivity) and other environmental planning instruments.	Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	Animal > Bats	Medium
Prepare management plans for significant bat roosts especially all known maternity colonies and winter colonies.	Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	Animal > Bats	Low
Restrict caving activities at significant roosts during important stages of the annual bat life cycle (eg winter hibernation, summer maternity season).	Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	Animal > Bats	Low
Identify and protect significant roost habitat in artificial structures (eg culverts, old buildings and derelict mines).	Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	Animal > Bats	Low
Identify the susceptibility of the species to pesticides.	Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	Animal > Bats	Medium

Table D.3 Priority Actions for Large-eared Pied Bat (from OEH Website 2013)

Action Title	Scientific Name	Common Name	Species Type	Priority
Ensure protection of caves and overhangs in area of suitable geology when undertaking PVP assessments (offsets should include nearby	Chalinolobus dwyeri	Large-eared Pied Bat	Animal > Bats	High

Table D.3 Priority Actions for Large-eared Pied Bat (from OEH Website 2013)

Action Title	Scientific Name	Common Name	Species Type	Priority
remnants in high productivity) or other land assessment tools.				
Measure the genetic population structure among roosts of maternity colonies to estimate dispersal and genetic isolation, and thus vulnerability of regional populations to extinction.	Chalinolobus dwyeri	Large-eared Pied Bat	Animal > Bats	Medium
Promote bats throughout the rural community as ecologically interesting and important, but sensitive to disturbance at caves/overhangs.	Chalinolobus dwyeri	Large-eared Pied Bat	Animal > Bats	High
Control feral goats in rock overhangs and caves in the species range.	Chalinolobus dwyeri	Large-eared Pied Bat	Animal > Bats	Medium
Identify important foraging range and key habitat components for this species.	Chalinolobus dwyeri	Large-eared Pied Bat	Animal > Bats	Medium
Study the ecology, habitat requirements and population dynamics.	Chalinolobus dwyeri	Large-eared Pied Bat	Animal > Bats	Medium
Determine suitable geology for roosting habitat for this species.	Chalinolobus dwyeri	Large-eared Pied Bat	Animal > Bats	Medium
Implement key threat abatement actions for longwall mining.	Chalinolobus dwyeri	Large-eared Pied Bat	Animal > Bats	High
Research the effect of different burning regimes.	Chalinolobus dwyeri	Large-eared Pied Bat	Animal > Bats	Medium
Prepare EIA guidelines which address the retention of hollow bearing trees maintaining diversity of age groups, species diversity, structural diversity. Give priority to largest hollow bearing trees.	Chalinolobus dwyeri	Large-eared Pied Bat	Animal > Bats	High

Table D.3 Priority Actions for Large-eared Pied Bat (from OEH Website 2013)

Action Title	Scientific Name	Common Name	Species Type	Priority
Identify the effects of fragmentation on the species in a range of fragmented landscapes such as the farmland/forest interface. For example movement and persistence across a range of fragment sizes. .	Chalinolobus dwyeri	Large-eared Pied Bat	Animal > Bats	High
Identify and protect roost habitat artificial structures (eg culverts, old buildings and derelict mines).	Chalinolobus dwyeri	Large-eared Pied Bat	Animal > Bats	High
Undertake long-term monitoring of populations cross tenure in conjunction with other bat species to document changes.	Chalinolobus dwyeri	Large-eared Pied Bat	Animal > Bats	High
Identify the susceptibility of the species to pesticides.	Chalinolobus dwyeri	Large-eared Pied Bat	Animal > Bats	Low
Undertake a targeted survey to determine distribution and status in parts of their range, such as the western edge of range.	Chalinolobus dwyeri	Large-eared Pied Bat	Animal > Bats	Medium
Determine location and attributes of maternity sites and restrict access where possible. (e.g. signage; bat-friendly, preferably external, gating of caves).	Chalinolobus dwyeri	Large-eared Pied Bat	Animal > Bats	High
Restrict access where possible to known maternity sites (e.g. signage; bat-friendly, preferably external, gating of caves).	Chalinolobus dwyeri	Large-eared Pied Bat	Animal > Bats	Medium

Table D.4 Priority Actions for Brush-tailed Rock-Wallaby (from OEH Website 2013)

Action Title	Scientific Name	Common Name	Species Type	Priority
Continue to support part-time statewide Brush-tailed Rock-wallaby recovery coordinator to ensure	Petrogale penicillata	Brush-tailed Rock-	Animal > Marsupials	Medium

Table D.4 Priority Actions for Brush-tailed Rock-Wallaby (from OEH Website 2013)

Action Title	Scientific Name	Common Name	Species Type	Priority
effective delivery of the plan actions.		wallaby		
Undertake a systematic desktop review of existing and potential threatening processes to better understand their impact at the site scale.	Petrogale penicillata	Brush-tailed Rock-wallaby	Animal > Marsupials	High
Review and collate what is known of Brush-tailed Rock-wallaby ecology.	Petrogale penicillata	Brush-tailed Rock-wallaby	Animal > Marsupials	Medium
Conduct field research on Brush-tailed Rock-wallaby ecology to improve our understanding of how individuals, colonies and populations respond to threatening processes.	Petrogale penicillata	Brush-tailed Rock-wallaby	Animal > Marsupials	Medium
Undertake an assessment of current threat abatement programs and determine their effectiveness and provide recommendations for their improvement where required.	Petrogale penicillata	Brush-tailed Rock-wallaby	Animal > Marsupials	High
Design and trial new ameliorative threat abatement methods at field sites where a monitoring program is in place.	Petrogale penicillata	Brush-tailed Rock-wallaby	Animal > Marsupials	Medium
Develop a system to provide ongoing information on Brush-tailed Rock-wallaby distribution within each genetic sub-group (Evolutionary Significant Unit) to improve baseline knowledge of the species.	Petrogale penicillata	Brush-tailed Rock-wallaby	Animal > Marsupials	Medium
Develop a standardised survey technique for determining presence/absence.	Petrogale penicillata	Brush-tailed Rock-wallaby	Animal > Marsupials	Medium
Develop, compare and evaluate monitoring techniques for estimating abundance and recommend a standard method applicable to future management.	Petrogale penicillata	Brush-tailed Rock-wallaby	Animal > Marsupials	Medium
Establish a network of sites to be monitored for presence/absence and abundance within both of the	Petrogale penicillata	Brush-tailed Rock-	Animal > Marsupials	Medium

Table D.4 Priority Actions for Brush-tailed Rock-Wallaby (from OEH Website 2013)

Action Title	Scientific Name	Common Name	Species Type	Priority
Northern and Central genetic sub-groups (Evolutionary Significant Units).		wallaby		
Determine the biogeographic boundaries between the Northern and Central genetic sub-groups (Evolutionary Significant Units).	Petrogale penicillata	Brush-tailed Rock-wallaby	Animal > Marsupials	Medium
Determine the degree of taxonomic separation between each of the genetic sub-groups (Evolutionary Significant Units).	Petrogale penicillata	Brush-tailed Rock-wallaby	Animal > Marsupials	Low
Establish a database to collate information on past and present occupation of Brush-tailed Rock-wallaby sites and the management actions being undertaken at each site, and implement an ongoing review program for this information.	Petrogale penicillata	Brush-tailed Rock-wallaby	Animal > Marsupials	Medium
Develop Best Management Practice Guidelines for Site Management. Includes tasks such as developing methods for determining priority sites for management actions.	Petrogale penicillata	Brush-tailed Rock-wallaby	Animal > Marsupials	Medium
Develop site specific management programs for priority Brush-tailed Rock-wallaby sites within the framework provided by the Best Practice Management Guidelines.	Petrogale penicillata	Brush-tailed Rock-wallaby	Animal > Marsupials	High
Develop a coordinated management network for predator control across the species range.	Petrogale penicillata	Brush-tailed Rock-wallaby	Animal > Marsupials	Medium
Develop a coordinated management network for feral competitor control across the species range and implement control programs at priority sites.	Petrogale penicillata	Brush-tailed Rock-wallaby	Animal > Marsupials	Medium
Develop a broader, more robust community-wide support base for ongoing predator and competitor control programs. Involves supporting community based control programs, training and informing authorities on the use of 1080 and provision of	Petrogale penicillata	Brush-tailed Rock-wallaby	Animal > Marsupials	Medium

Table D.4 Priority Actions for Brush-tailed Rock-Wallaby (from OEH Website 2013)

Action Title	Scientific Name	Common Name	Species Type	Priority
supplies.				
Identify sites and appropriate land management mechanisms to ameliorate significant impacts caused by habitat loss where such specific management actions are required.	Petrogale penicillata	Brush-tailed Rock-wallaby	Animal > Marsupials	Medium
Develop a policy paper which clearly articulates the criteria for captive breeding and translocation.	Petrogale penicillata	Brush-tailed Rock-wallaby	Animal > Marsupials	High
Develop techniques for evaluating the effectiveness of translocation events in terms of the animals survival and breeding potential.	Petrogale penicillata	Brush-tailed Rock-wallaby	Animal > Marsupials	Medium
Establish and maintain a genetically healthy captive population.	Petrogale penicillata	Brush-tailed Rock-wallaby	Animal > Marsupials	High
The recovery team to identify priority sites for each Evolutionary Significant Unit as appropriate using the criteria established in the policy papers.	Petrogale penicillata	Brush-tailed Rock-wallaby	Animal > Marsupials	High
Release captive bred individuals into priority sites within the Central Evolutionary Significant Unit.	Petrogale penicillata	Brush-tailed Rock-wallaby	Animal > Marsupials	High
Facilitate the monitoring for presence/absence and abundance in Warrumbungles NP (PWD lead)	Petrogale penicillata	Brush-tailed Rock-wallaby	Animal > Marsupials	High
Establish a network of sites to be monitored for presence/absence and abundance	Petrogale penicillata	Brush-tailed Rock-wallaby	Animal > Marsupials	High
Co-supervise ongoing research (PhD Sydney Uni) on large macropod competition with rock-wallabies	Petrogale penicillata	Brush-tailed Rock-wallaby	Animal > Marsupials	High
Develop and distribute generic community	Petrogale	Brush-tailed	Animal >	Medium

Table D.4 Priority Actions for Brush-tailed Rock-Wallaby (from OEH Website 2013)

Action Title	Scientific Name	Common Name	Species Type	Priority
information and participation kit.	penicillata	Rock-wallaby	Marsupials	
Promote opportunities for community involvement in Brush-tailed Rock-wallaby recovery management.	Petrogale penicillata	Brush-tailed Rock-wallaby	Animal > Marsupials	Medium
Continue to foster efforts of the Friends of the Brush-tailed Rock-wallaby in Kangaroo Valley.	Petrogale penicillata	Brush-tailed Rock-wallaby	Animal > Marsupials	Medium
Establish, where feasible, community support groups within each Evolutionary Significant Unit, at the regional or priority Brush-tailed Rock-wallaby site level.	Petrogale penicillata	Brush-tailed Rock-wallaby	Animal > Marsupials	Medium
Incorporate information provided through Aboriginal community consultation into the recovery plan.	Petrogale penicillata	Brush-tailed Rock-wallaby	Animal > Marsupials	Medium
Seek advice from local Aboriginal community elders on appropriate site management regimes based on indigenous knowledge.	Petrogale penicillata	Brush-tailed Rock-wallaby	Animal > Marsupials	Low
Involve local Aboriginal communities in on-ground management of Brush-tailed Rock-wallaby sites.	Petrogale penicillata	Brush-tailed Rock-wallaby	Animal > Marsupials	Low
Involve local Aboriginal communities in surveys and monitoring programs.	Petrogale penicillata	Brush-tailed Rock-wallaby	Animal > Marsupials	Low
Finalise the recovery plan for the Brush-tailed Rock-wallaby by 2007.	Petrogale penicillata	Brush-tailed Rock-wallaby	Animal > Marsupials	Low

Appendix E

Helicopter Photographs of SPLs in the Project Boundary

Photograph E.1 Photo View 1

Photograph E.2 Photo View 2

Photograph E.3 Photo View 3

Photograph E.4 Photo View 4

Photograph E.5 Photo View 5

Photograph E.6 Photo View 6

Photograph E.7 Photo View 7

Photograph E.8 Photo View 8

Photograph E.9 Photo View 9

Photograph E.10 Photo View 10

Appendix F

Threatened Plant Species - Profiles, Maps and Analysis

F.1.1 Acacia bynoeana

i. Conservation Status:

a. Acacia bynoeana is listed as Vulnerable under the EPBC Act, and Endangered under the TSC Act. It is considered to be Near Threatened according to the IUCN (Bell 2008). It is classified as ROTAP: 3VC- (geographic range of greater than 100km, listed as vulnerable, at least one population occurs in a national park (i.e Wollemi), size unknown).

The species is known from 30 locations, with 1-5 individuals at each location. The population is estimated to be only a few hundred plants (SEWPaC 2011a). Conserved populations of the species are present in Blue Mountains and Royal NPs. Other reserved populations are known in Yengo, Marramarra and Popran NPs, Lake Macquarie State Conservation Area, and Castlereagh, Dharawal and Agnes Banks Nature Reserves. Large populations are also present in the Cessnock area of the Hunter Valley, but none of these are currently present in conservation reserves) (Bell, 2008).

ii. Species Habitat:

A. bynoeana occurs mainly in heath and dry sclerophyll forest. The substrate is typically sand and sandy clay, often with ironstone gravels and is usually very infertile and well-drained. The species seems to prefer open, sometimes slightly disturbed sites such as trail margins, edges of roadside spoil mounds (from grading) and in recently burnt open patches. Associated overstorey species often include; *Corymbia gummifera*, *Eucalyptus haemastoma*, *E. gummifera*, *E. parramattensis*, *E. sclerophylla*, *Banksia serrata* and *Angophora bakeri*. Shrubs often associated with the species include *B. spinulosa*, *B. serrata*, *A. oxycedrus*, *A. myrtifolia* and *Kunzea spp* (NSW NPWS 1999a).

iii. Species Distribution:

Acacia bynoeana is known to extend from the Sydney area north to Cessnock (Bell, 2008). The SPRAT profile (SEWPaC, 2011a) notes that the species is distributed south to Berrima and Mittagong in the Southern Highlands. The majority of records are confined to the central coast and eastern tablelands (**Figure F.1**).

The closest record of this species to the Project is approximately 30 km to the north.

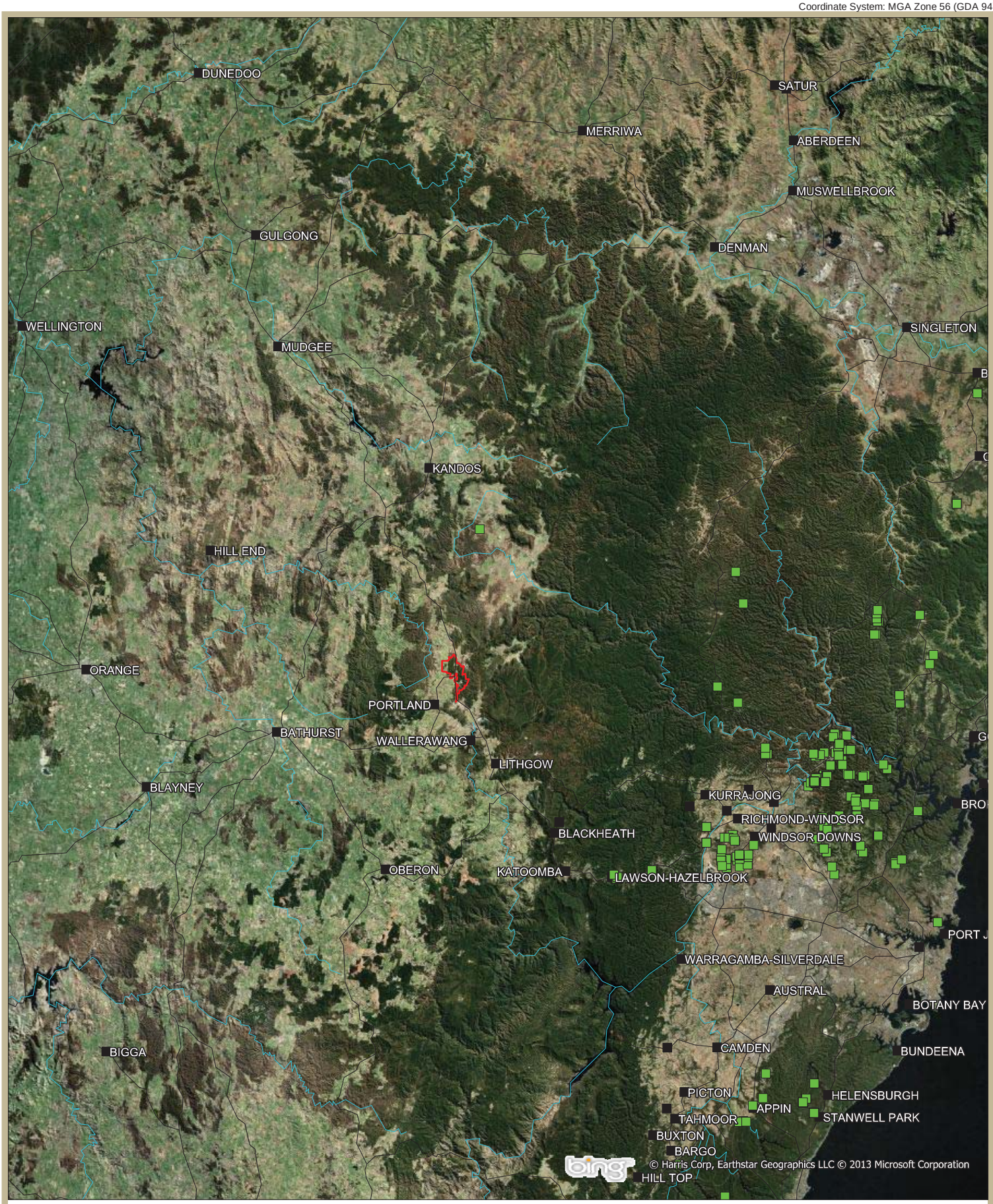


Figure F.1. Acacia bynoeana Records
(TSC Act: Endangered; EPBC Act: Vulnerable)

F.1.2 Prostanthera stricta

i. Conservation Status:

Prostanthera stricta is listed as Vulnerable under the EPBC Act, and Vulnerable under the TSC Act. It is considered to be Vulnerable according to the International Union for Conservation of Nature (IUCN) (Bell 2008). It is classified as ROTAP: 2V (geographic range of less than 100km, listed as vulnerable).

P. stricta ssp. str. is not known to occur in any conservation reserves. *P. aff. stricta* is recorded within the Wollemi National Park, but is poorly conserved (NSW NPWS 2000b).

ii. Species Habitat:

The species is divided into two subspecies. Plants assigned to *Prostanthera stricta* from the northern Wollemi area, referred to as *Prostanthera aff. stricta*, *P. stricta ssp. stricta* is restricted to the Mount Vincent and Genowlan Mountain areas outside of the national park (NSW NPWS 2000b).

P. stricta s. str. occurs in areas receiving a rainfall of 600–700mm annually, primarily at the geological interface of fertile basalt caps and infertile sandstones at 800–1050m. The habitat is often characterised by steep rocky slopes, cliff lines, sandstone platforms or gentle slopes with exposed sandstone outcroppings. The species grows both in areas of skeletal soil and on deeper, well drained soil profiles. At Mount Vincent the habitat of *P. stricta s. str* is restricted. to the gradation from basalt to sandstone, which is frequently abrupt, occupying a narrow band of 5-50m. *P. stricta s str* is often a locally dominant undershrub in heath/scrub communities along cliff edges, or as an understorey species within a range of open–forest or tall open–forest types, or in adjacent transitional communities. *P. aff. stricta* occurs on Narrabeen Formation and Quaternary alluvial and colluvial deposits. It can be a locally dominant shrub on and at the base of conglomerate slope/cliffs and on ledges and crevices, sandy colluvium at the base of cliffs, in fluvial depositional zones such as banks and bars, and on sandy alluvial deposits, and rocky side slopes on the above substrate types. *P. aff. stricta* respectively occurs in: low scrub community with *Backhousia myrtifolia*, *Cryptandra buxifolia*, *Isopogon dawsonii* and *Leucopogon muticus*; open-forest of *Eucalyptus caleyi*, *E. punctata*, *E. sideroxylon*, *Allocasuarina torulosa* and *Macrozamia communis*; open-forest of *Eucalyptus tereticornis*, *E. sideroxylon*, *Angophora floribunda*, *Acacia caesiella* and *Callistemon salignus*, and open-forest of *Angophora floribunda*, *Eucalyptus fibrosa* and *E. punctata. (NSW NPWS 2000b)*

iii. Species Distribution:

The northern distributional limit of *P. stricta* occurs at Dingo Creek (southwest of Sandy Hollow), and the southern limit occurs at Genowlan Mountain, east of Capertee (NSW NPWS 2000b) The species also occurs in the Widden and Baerami Valleys (NSW NPWS 2000b).

The closest record of this species to the Project is approximately 15 km to the north. Locations of records of the species can be found in **Figure F.2**.

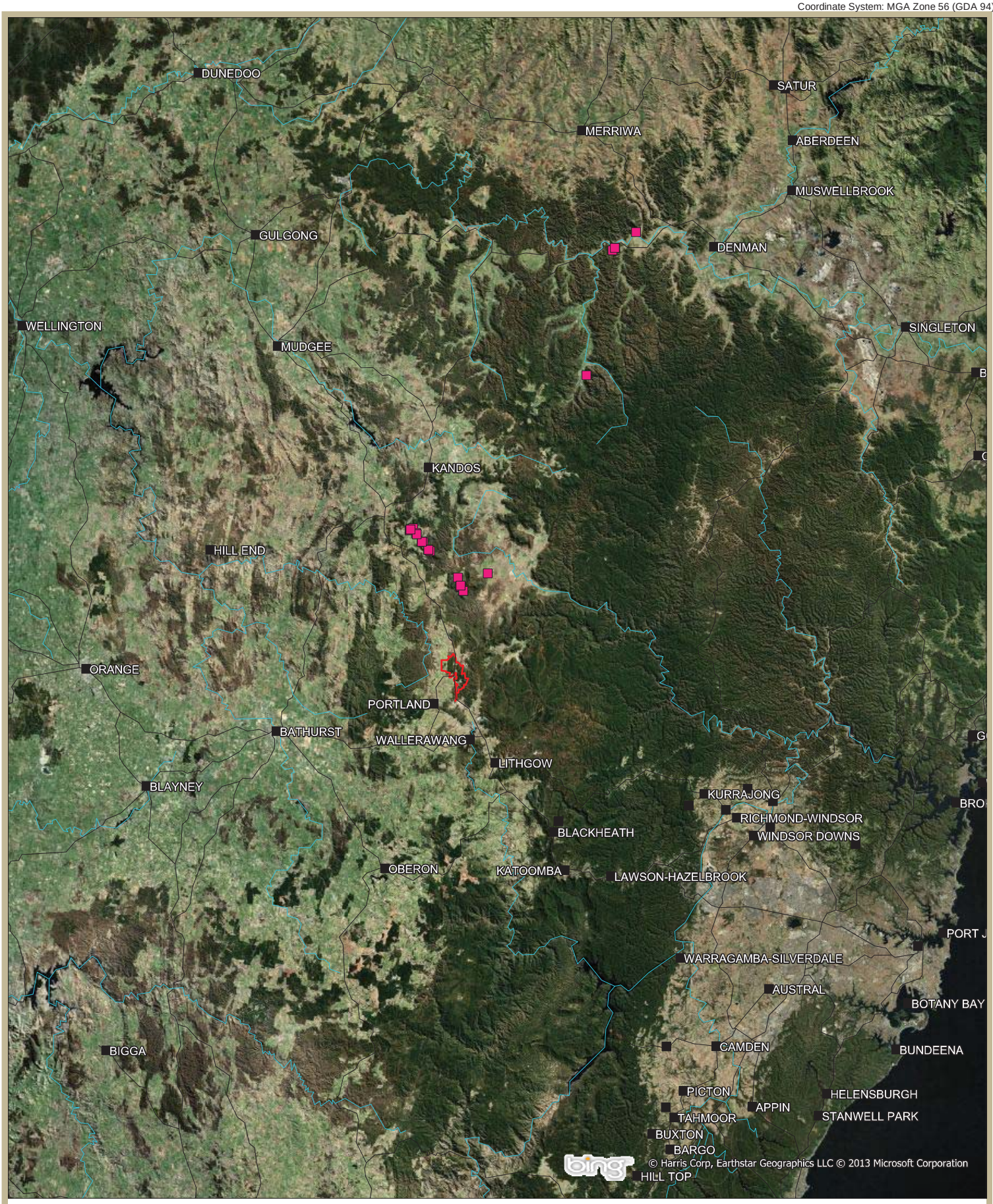


Figure F.2. Prostanthera stricta Records
(TSC Act: Vulnerable; EPBC Act: Vulnerable)

F.1.3 Darwinia peduncularis

i. Conservation Status:

Darwinia peduncularis is listed as Vulnerable under the TSC Act. The species is not listed under the EPBC Act. The species is listed as Least Concern on the IUCN Redlist. The species is classified as 3RCi (Geographic range of greater than 100km, rare, at least one population reserved in a national park or other conservation reserve, with less than 1000 plants being known within conservation reserves) (Bell, 2008). Local populations are small with a total population likely to be less than 2500 and possibly less than 1500.

ii. Species Habitat:

Within the Wollemi National Park, the species occurs on exposed ridgelines above Wollemi Creek in the centre of the park, in an open woodland/ heath of *Eucalyptus rossii*, *E. bensonii* and *E. multicaulis.* Other populations in this area occur in sheltered locations in an open forest of *Eucalyptus consideniana* and *E. piperita*. The species is is locally common in this area, and appears to be sporadically distributed in the remote parts of the park (Bell, 2008). Broadly, the species occurs on or near rocky outcrops on sandy, well drained, low nutrient soil over sandstone (OEH 2012b).

The species appears to be vulnerable to fire and disturbance and little is known about its recovery from either (NSW Scientific Committee 2004a).

iii. Species Distribution:

Within Wollemi the species is distributed from the Mt Iris to Mt Boonbourwa area in the west of Wollemi (Bell, 2008) The broader distribution of the species occurs from Hornsby to Hawkesbury R. and west to Glen Davis (Botanic Gardens Trust 2013a). The species occurs as local disjunct populations in coastal New South Wales with a couple of isolated populations in the Blue Mountains. It has been recorded from Brooklyn, Berowra, Galston Gorge, Hornsby, Bargo River, Glen Davis, Mount Boonbourwa and Kings Tableland. Some populations are within the Marramarra National Park, Wollemi National Park, Blue Mountains National Park and Berowra Valley Regional Park (NSW Scientific Committee 2004a).

The closest record of this species to the Project is approximately 22 km to the north-east. Locations of records of the species can be found in **Figure F.3**.

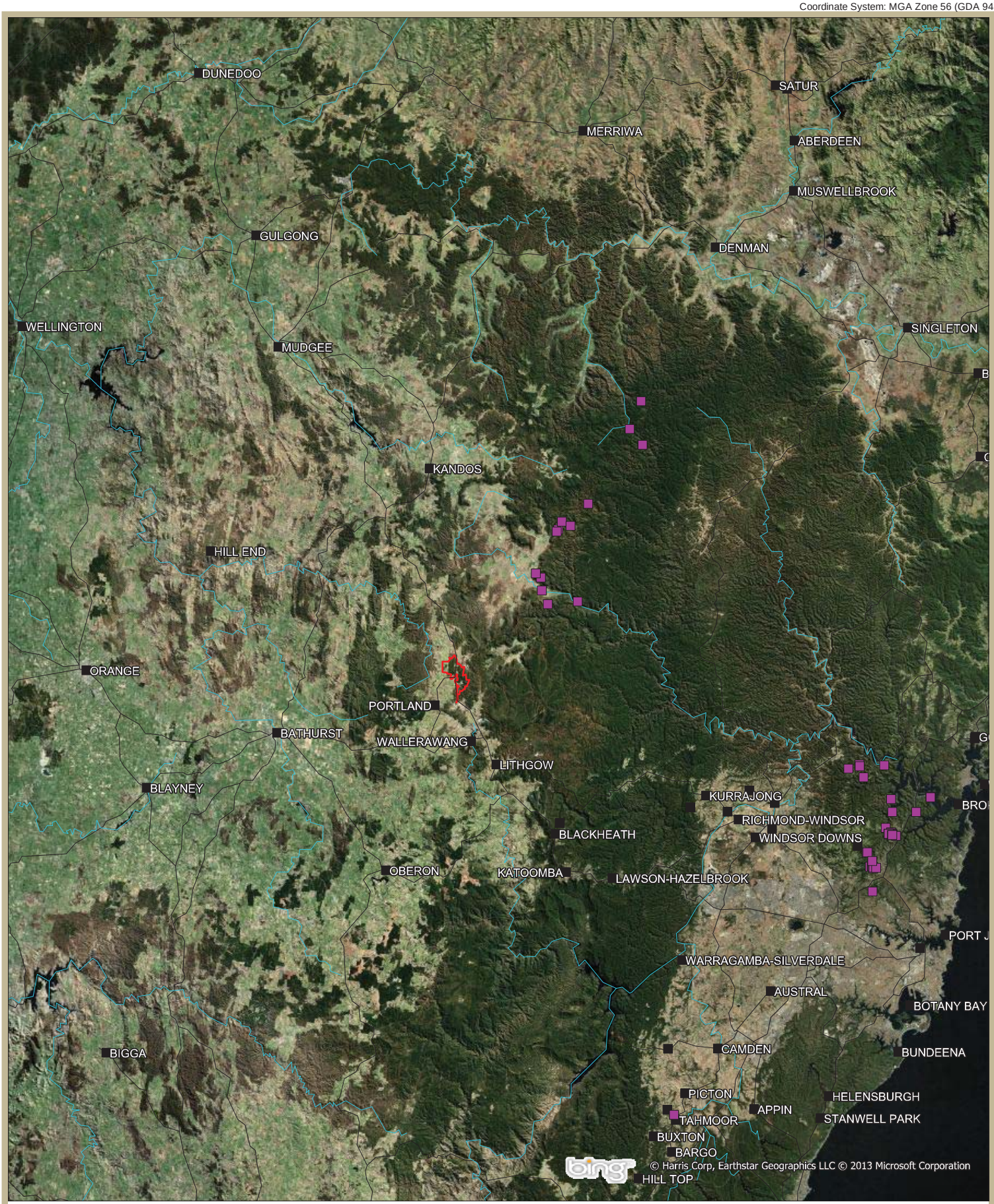


Figure F.3. Darwinia penduncularis Records (TSC Act: Vulnerable)

F.1.4 Persoonia acerosa

i. Conservation Status:

Persoonia acerosa is listed as Vulnerable under both the TSC and EPBC Acts. The species is classified as 2VC- (Geographic range of less than 100km, Vulnerable, at least one population reserved in a national park or other conservation reserve, reserved population size not accurately known(Leigh et al. 1984) *P. acerosa* is considered unlikely to be adequately conserved in conservation reserves or other protected areas because the largest known populations are outside conservation estate and under threat, while those within conservation estate are generally small, and often consist of isolated individuals (NSW NPWS 2000a). The species was not recorded during surveys for rare or threatened species within the Wollemi National Park (Bell, 2008).

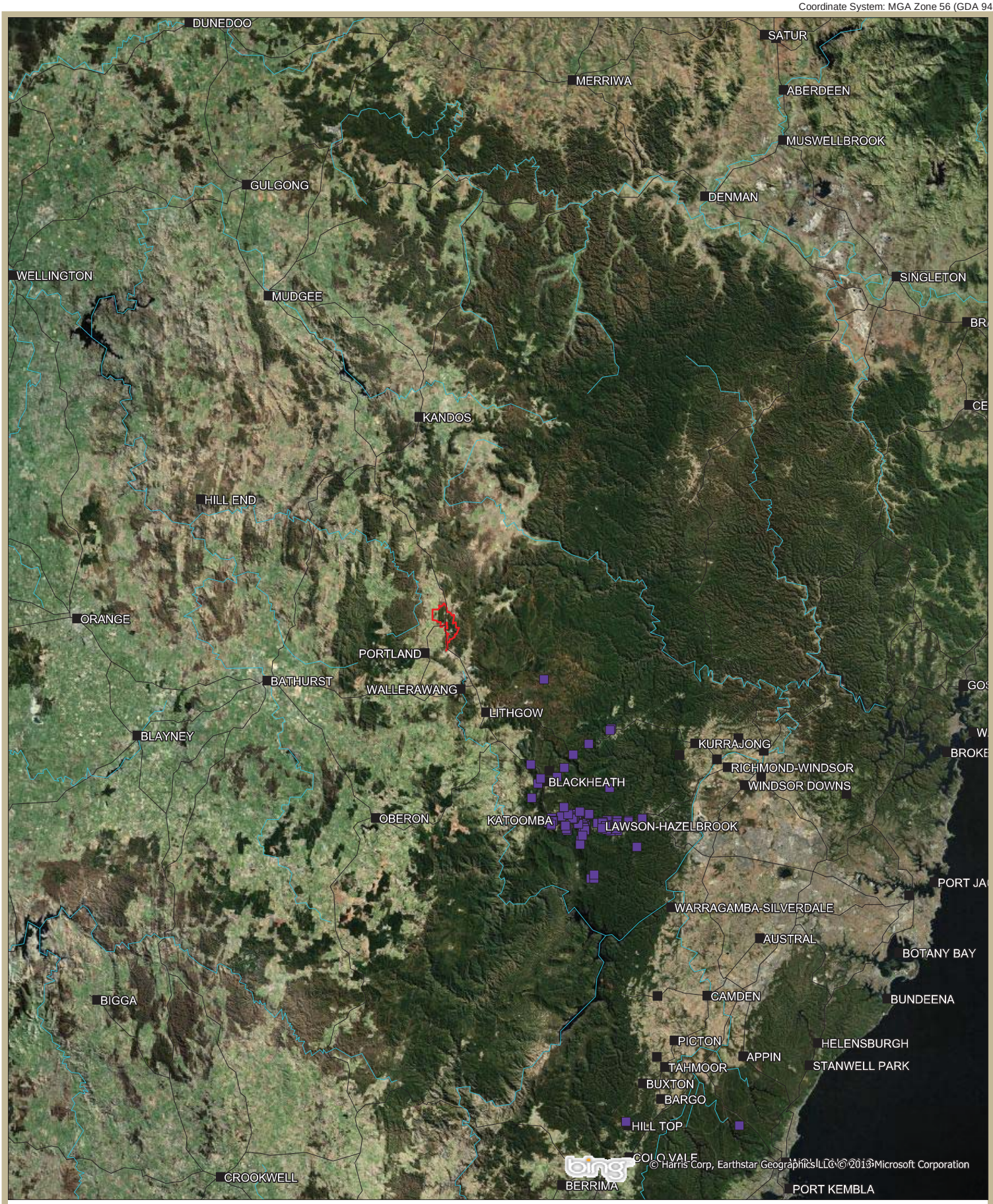
ii. Species Habitat:

Persoonia acerosa occurs in dry sclerophyll forest, scrubby low-woodland and heath, principally on clayey sandstone and laterites of the Narrabeen Group (Medlow Bath Soil Landscape) as well as the Hawkesbury Group (Faulconbridge Soil Landscape) where soils are very infertile and stony. The species prefers ridge-tops and plateaus with duplex soils, that is, sandy topsoil over clayey subsoil. The species is typically associated with *Eucalyptus sieberi*, *E. piperita*, *E. sclerophylla*, occasionally *E. stricta* and *E. ligustrina*, *Lambertia formosa*, *Leptospermum trinervium*, *Hakea dactyloides*, *Platysace linearifolia*, *Petrophile pulchella*, *A. terminalis*, and *Acacia obtusifolia* (NPWS 2000).

iii. Species Distribution:

P. acerosa has been recorded in the Blue Mountains from the Newnes Plateau south through Kings Tableland to Hilltop near the Southern Highlands and east to the lower Mountains. Within this range, the primary habitat is very linear and has been extensively fragmented by housing (NSW NPWS 2000a)..The species occurs mainly in the Katoomba/ Wentworth Falls/ Springwood area (OEH 2012g).

The closest record of this species to the Project is approximately 25 km to the north-east. Locations of records of the species can be found in **Figure F.4**.



Legend

- Project Boundary
- River
- Road
- Town
- *Persoonia acerosa*

Scale 1:968,000

Data Source:
NPWS Atlas Data: dated 18/01/2013
Washington, H.G. and Wray, R.A.L., 2011.

CUMBERLAND ECOLOGY

I:\...\13007\Figures\RP1_SOE_20130207\Figure F.4. Persoonia acerosa

Figure F.4. Persoonia acerosa Records
(TSC Act: Vulnerable; EPBC Act: Vulnerable)

5 0 5 10 15 20 km

F.1.5 Thesium australe

i. Conservation Status:

Thesium australe is listed as Vulnerable under both the EPBC and TSC Acts. It is listed as Presumed Extinct under the Tasmanian Threatened Species Protection Act (1995), and Threatened under Schedule 2 of the Flora and Fauna Guarentee Act (1988). It is classified as ROTAP: 3VCi+ (geographic range of greater than 100km, Vulnerable, has at least one population within conservation reserve or national park, less than 1000 plants known to occur within a conservation reserve, species has natural occurrence overseas) (Briggs and Leigh 1995). The species was not recorded during surveys for rare or threatened species within the Wollemi National Park (Bell, 2008).

ii. Species Habitat:

Thesium australe has a wide ecological tolerance having been recorded from subtropical, temperate and sub-alpine climates, and on soils derived from sedimentary, igneous and metamorphic rocks as well as recent alluvium. However, it is largely confined to grasslands, grassy woodlands or sub-alpine grassy heathlands (DSE (VIC) 2003). In New South Wales, the species is found in grassland on coastal headlands or grassland and grassy woodland away from the coast. It is often found in association with Kangaroo Grass (*Themeda australis*), which it parasitises the roots of (OEH 2012a).

iii. Species Distribution:

The species is found in very small populations scattered across eastern NSW, along the coast, and from the Northern to Southern Tablelands. It is also found in Tasmania and Queensland and in eastern Asia (OEH 2012a). The species is considered to be extinct in Tasmania (Tas. DPIPWE 2003). Collections in Australian herbaria indicate that the species was widespread in eastern Australia, from the Bunya Mountains in Queensland south to eastern Tasmania (DSE (VIC) 2003).

The closest record of this species to the Project is approximately 180 km to the north. Locations of records of the species can be found in **Figure F.5**.

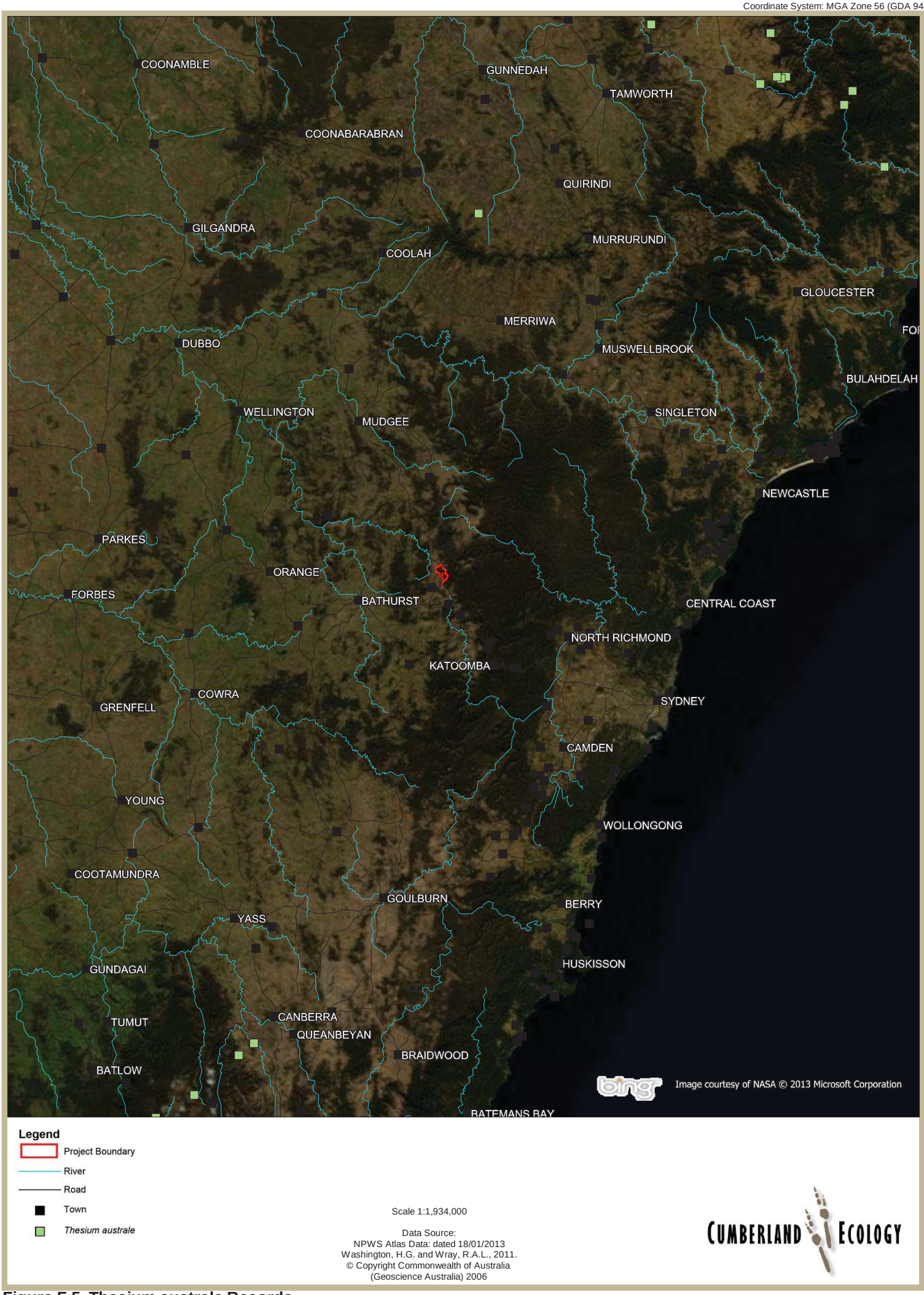


Figure F.5. Thesium australe Records
(TSC Act: Vulnerable; EPBC Act: Vulnerable)

F.1.6 Euphrasia arguta

i. Conservation Status:

Euphrasia arguta is listed as Critically Endangered under both the TSC and EPBC Acts. The species was, until 2008, thought to be extinct.

ii. Species Habitat:

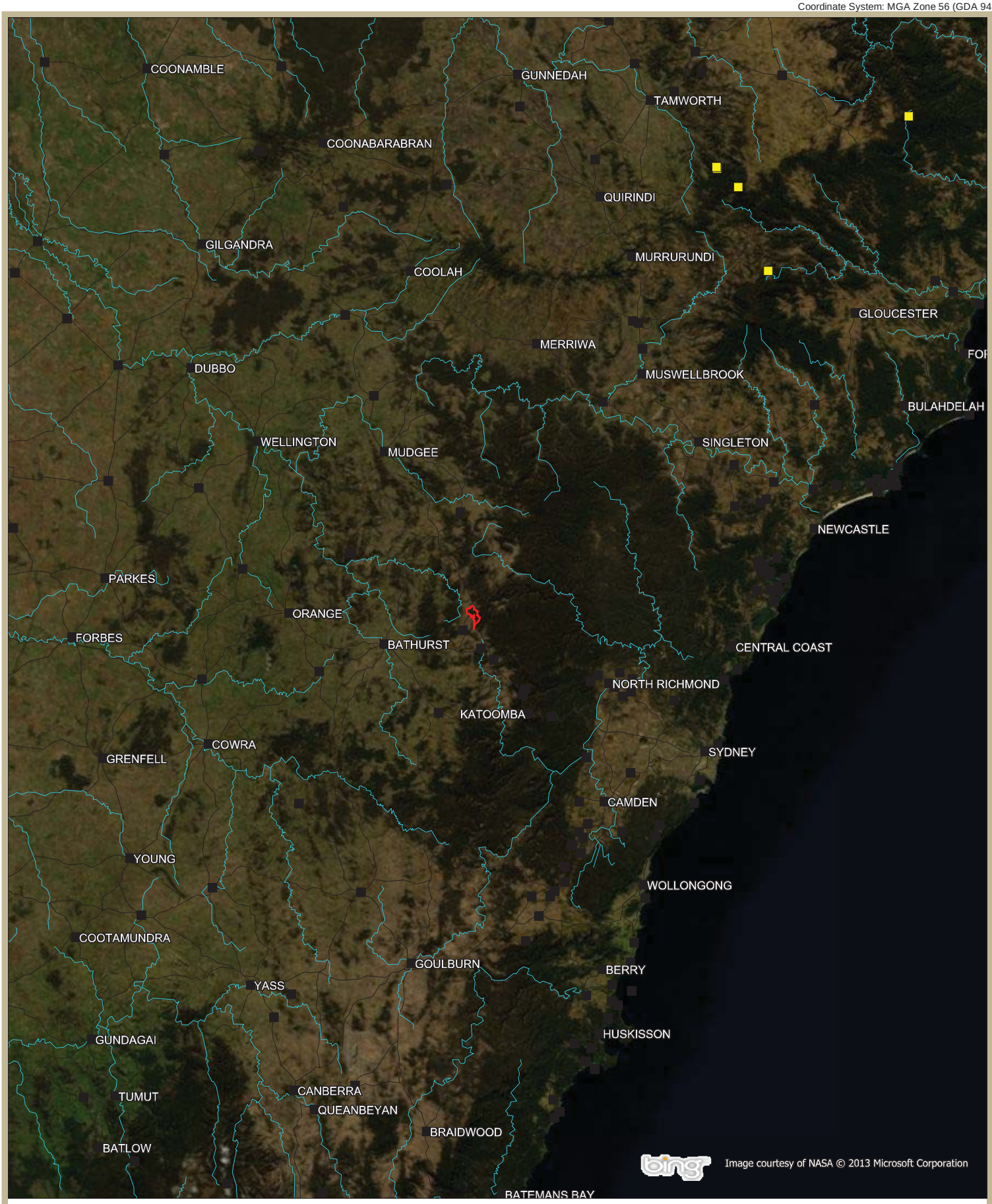
No specific habitat requirements for the species are known, however inferences can be drawn from historical records of the species and the locations of the current population. Historic records of the species noted the following habitats: 'in the open forest country around Bathurst in sub humid places', 'on the grassy country near Bathurst', and 'in meadows near rivers'. Additionally, plants from the Nundle area have been reported from eucalypt forest with a mixed grass and shrub understorey; here, plants were most dense in an open disturbed area and along the roadside, indicating the species had regenerated following disturbance (OEH 2013b).

iii. Species Distribution:

The species was rediscovered in the Nundle area of the NSW north western slopes and tablelands in 2008. Historically, *Euphrasia arguta* has only been recorded from relatively few places within an area extending from Sydney to Bathurst and north to Walcha. The Royal Botanic Gardens Specimen Register records an additional location reported and vouchered in 2002 from near the Hastings River; and Euphrasia arguta was also recorded from the Barrington Tops in 2012 (OEH 2013b).

A population was detected in the Nundle region of NSW, which contained four populations of the species located in three areas approximately 23 km apart (NSW Scientific Commitee 2011). A population of approximately 15, 000 individuals was detected in 2009 in an area that had been cleared for a fire break in 2007. This site was then cleared of vegetation again in late 2009, and approximately 80% of the population at this site was lost. Two additional populations are located approximately 14 km to the south-east and are themselves separated by some 3 km. One contained 6 plants at the time of observation in February, 2009, and the other 1120 plants. A fourth population has been located on private land and contains approximately 45 plants. There are no known occurrences of *Euphrasia arguta* in a conservation reserve. The majority of *E. arguta* plants are located in Nundle State Forest. A small part of the largest population of *E. arguta* is located on private land that is adjacent to the State Forest. The land is currently used for rough grazing by sheep or cattle(NSW Scientific Commitee 2011).

The closest record of this species to the Project is approximately 212 km to the north-east. Locations of records of the species can be found in **Figure F.6**.



Legend

- Project Boundary
- River
- Road
- Town
- *Euphrasia arguta*

Scale 1:1,934,000

Data Source:
NPWS Atlas Data: dated 18/01/2013
Washington, H.G. and Wray, R.A.L., 2011.

CUMBERLAND ECOLOGY

25 0 25 50 75 100 km

I:\...\13007\Figures\RP1_SOE_20130207\Figure F.6. Euphrasia arguta

Figure F.6. Euphrasia arguta Records (TSC Act: Critically Endangered; EPBC Act: Critically Endangered)

Appendix G

CVs of Expert Peer Review

8. Résumé: Dr Stephen Bell

Dr Stephen A.J. Bell Principal, **Eastcoast Flora Survey** (PO Box 216 Kotara Fair NSW 2289)
Telephone (02) 4953 6523 / (0407) 284 240
Email sajbell@bigpond.com

PRÉCIS - Stephen is a well respected vegetation scientist and contract botanist, based in the Hunter Valley of NSW. He has been involved in vegetation survey, classification and mapping in the Greater Sydney and Hunter Regions since 1990. During this time, he has undertaken comprehensive surveys for the NSW National Parks & Wildlife Service in over 30 conservation reserves, and has been contracted to the Office of Environment & Heritage as Senior Botanist and Team Leader for several large scale regional projects within the Sydney Basin. Under contract to local Councils, Stephen has co-ordinated and completed LGA-wide vegetation classification and mapping projects for Wyong, Gosford, Cessnock, Pittwater and Lake Macquarie Councils, and assisted in similar mapping projects for Blue Mountains LGA. Stephen has published several scientific papers on various aspects of the vegetation of the Sydney Basin, including classifications of vegetation within conservation reserves, threatened and rare plant species, significant and threatened ecological communities, and the description of new plant species. Most recently, Stephen has completed his PhD thesis, undertaken on a part-time basis through the University of Newcastle, on the topic of improving recognition, identification and mapping of restricted and significant vegetation communities, such as Threatened Ecological Communities. Stephen has also completed over 3700 standard full floristic sampling plots within the Sydney Basin, which are stored and used in classification analyses for many projects. Other skills include extensive multivariate data analysis experience, and GIS mapping.

QUALIFICATIONS

Bachelor of Science [1990]
Bachelor of Science (Honours) [1991]
Doctor of Philosophy [School of Environmental & Life Sciences, University of Newcastle 2013]

PhD Thesis title: "*Defining and mapping rare vegetation communities: Improving techniques to assist land-use planning and conservation*"

LICENCES & INDUCTIONS

OEH Scientific Licence No. SL100046	Exp. March 2013
Xstrata XCN Generic Induction	Exp. January 2014
Work Safely Around Aircraft (PUAFIR209B)	Exp. March 2015
Coal Industry Generic Induction (Standard 11)	Exp. April 2017
General Induction for Construction Work in NSW (White Card)	No expiry

EMPLOYMENT HISTORY

Eastcoast Flora Survey	Consultant Botanist (Principal)	Oct. 1996 - Present
Ecotone Ecological Consultants Pty Ltd	Manager - Flora Studies	Jan. 1996 - Oct. 1996
Private Ecological Consultant	Sole trader (Consultant Botanist)	Jan. 1991 - Dec. 1995
NSW National Parks and Wildlife Service	Project Officer (Vegetation mapping)	Sept. 1993 - Jan. 1994
University of Newcastle, Geography Dept.	Field Tutor (Scientific)	July 1993 - Aug. 1993
NSW National Parks and Wildlife Service	Project Officer (Vegetation mapping)	Jan. 1993 - June 1993

University of NSW, School of Biol. Sciences	Research Assistant (Bird ecology)	Sept. 1992 - Jan. 1993
NSW National Parks and Wildlife Service	Technical Officer (Scientific)	Jan. 1992 - June 1992
RZ Mines (Newcastle)	Environmental Research Officer	Oct. 1990 - Dec. 1991
Wayne Perry & Associates P/L	Environmental Officer (Casual)	June 1990 - Oct. 1990

RESEARCH INTERESTS

- Vegetation classification and mapping, at local and regional scales
- Rare vegetation communities
- Vegetation on sand bodies
- Classification of hanging swamps
- Population ecology and habitat of rare and threatened plants
- Taxonomy and significance of Hunter Region plants

SIGNIFICANT POSITIONS/ CONSULTANCIES

- **Vegetation survey, classification and mapping of the Singleton Army Training Area**, a project for the Department of Defence (2011-12).
- **Attribution of endemic Hunter Region vegetation communities into the NSW Vegetation Classification & Assessment (NSW VCA Database)**, a project for the Hunter-Central Rivers CMA & the Royal Botanic Gardens and Domain Trust (2011).
- Consultant Botanist for ***Revised Classification and Mapping of Wollemi National Park,*** a project for DECC (2008-present).
- Consultant Botanist for ***Native Vegetation of the Putty Valley,*** a project for DECC & Hawkesbury-Nepean Catchment Management Authority (2007-2008).
- Consultant Botanist for ***Native Vegetation of the Northern Hawkesbury LGA,*** a project for DECC & Hawkesbury-Nepean Catchment Management Authority (2007-2008).
- Consultant Botanist for ***Native Vegetation of Yengo and Parr Reserves and Surrounds,*** a project for Department of Environment & Climate Change (2006-2007).
- **Review of Central Coast Vegetation Communities** for DECC bioregional conservation assessments (2007).
- Member of Steering Committee (and co-supervisor of Newcastle University Honours student) for the CCCEN NSW Wetland Action Grants-funded project on "**Biodiversity assessment and conservation of hanging swamps on the Central Coast Plateau, NSW**" (2004).
- Founding member of *Hunter Region Botanic Gardens'* **Hunter Region Rare Plants Committee** (2000-present).
- Consultant botanist for ***Vegetation survey and analysis of Warragamba Special Area and Lake Burragorang catchment (incorporating Blue Mountains, Kanangra-Boyd & Nattai National Parks, and Yerranderie, Burragorang & Nattai SRA's)*** for NPWS and the Sydney Catchment Authority (2001-2002).
- Consultant Botanist/ Vegetation Mapping Consultant (Hunter Region) for ***NPWS CRA Lower North East (south of the Hunter).*** 1998-1999.
- Consultant Botanist/ Vegetation Mapping Consultant for ***Lower Hunter & Central Coast Regional Environmental Management Strategy*** for NPWS CRA Unit & Department of Urban Affairs & Planning. 1998-1999.

MEMBERSHIP OF EXPERT PANELS

- Member of Expert Panel for **review of benchmarks for Greater Hunter Vegetation Classification** (2012)
- Member of Hunter-Central Rivers CMA's **Hunter Vegetation and the NSWVCA** Expert Panel (2009)

- Member of Port Stephens Shire Council **Conservation Assessment Database** Expert Panel (2009)
- Member of **DECC Climate Change & Biodiversity Impacts** Expert Panel (2008)
- Member of **Hunter-Central Rivers CMA** Vegetation Classification Expert Panel (2008)
- Ecological Expert for the **HotSpots Fire Project**, Hawkesbury Pilot Program (2007)
- Member (Technical Advisor) of **Hunter Valley Threatened Flora Recovery Team** (2006-7)
- Member of **Kurri Sands Swamp Woodland EEC Recovery Team** (2005)
- Member of **CMA Expert Panel** advising the Hunter-Central Rivers Catchment Management Authority on Regionally Significant Vegetation (2005)
- Member of **DIPNR Expert Panel** advising the Hunter Regional Vegetation Committee on High Conservation Value vegetation (2003)
- *Ecological Society of Australia* representative on the **Hunter Regional Vegetation Committee** (2001-2003)
- Member of *Environment Australia's* **Expert Panel for the Lower North-east CRA division** (1998)

CONFERENCE & WORKSHOP PRESENTATIONS

- HOTSPOTS Fire Project: Awabakal and Worimi Fire Forum, 27th July 2011, Williamtown, Never Never Resources: "**Vegetation of the Worimi Conservation Lands**".
- HOTSPOTS Fire Project: Wanaruah Fire Forum, 17th – 19th August 2010, Sandy Hollow, Upper Hunter Valley, Nature Conservation Council: "**Vegetation of Wanaruah Lands, Sandy Hollow**".
- Coastal Groundwater Dependent Ecosystems Workshop, 3rd – 4th September 2009, South West Rocks, NSW (Geoscience Australia): "**Surveying, classifying and mapping vegetation on the Tomago Sandbeds**".
- Vegetation Management and Biodiversity Conservation in the Hunter Region, May 2000, Singleton, NSW (Hunter Environment Lobby Inc.): "**An evaluation of vegetation survey and threatened plant species listings in the Hunter Region**"

PROFESSIONAL MEMBERSHIPS

- Ecological Society of Australia (ESA)
- Australian Network for Plant Conservation Inc. (ANPC)
- International Association for Vegetation Science (IAVS)
- Australasian Native Orchid Society Inc. (ANOS)

AWARDS

- UDIA NSW Award for Excellence (Professional Consultancy) 2003 for the *Thornton-Killingworth Sub-regional Conservation & Development Strategy.*

PUBLICATIONS - PEER REVIEWED

Bell, S.A.J. (submitted) Experiences in translocation of threatened terrestrial orchids in the upper Hunter Valley of New South Wales: *Diuris tricolor* and *Prasophyllum* sp. Wybong. *Ecological Management & Restoration*

DeLacey, C., Bell, S., Chamberlain, S., & Bossard, K. (submitted) Prediction of and realised habitat for a cryptic plant species: the Leafless Tongue Orchid *Cryptostylis hunteriana* Nicholls. *Cunninghamia*

Bell, S.A.J. & Nicolle, D. (2012) *Eucalyptus expressa* (Myrtaceae): a new and distinctive species from the sandstone ranges north-west of Sydney, New South Wales. *Telopea* 14: 69-76.

DeLacey, C., Bell, S., & Chamberlain, S. (2012) Habitat of the Leafless Tongue Orchid *Cryptostylis hunteriana* Nicholls throughout its known Australian distribution. *The Orchadian* 17(4): 162-174.

Bell, S.A.J. & Stables, M. (2012) Floristic variability, distribution and an extension of range for the endangered Pittwater Sp otted Gum Forest, Central Coast, New South Wales. *Cunninghamia* 12(2): 143-152.

Bell, S.A.J. (2009) Vegetation and floristics of Columbey National Park, lower Hunter Valley, New South Wales. *Cunninghamia* 11(2): 241-275.

Bell, S.A.J. (2008) Rare or threatened vascular plant species of Wollemi National Park, central eastern New South Wales. *Cunninghamia* 10(3): 331-371.

Bell, S., Branwhite, B., & Driscoll, C. (2005) *Thelymitra 'adorata'* (Orchidaceae): population size and habitat of a highly restricted terrestrial orchid from the Central Coast of New South Wales. *The Orchadian* 15(1): 6-10.

Bell, S.A.J. (2004) Distribution and habitat of the vulnerable tree species, *Angophora inopina* (Myrtaceae), on the Central Coast of New South Wales. *Cunninghamia* 8(4): 477-484.

Bell, S.A.J. (2004) Vegetation of Werakata National Park, Hunter Valley, New South Wales. *Cunninghamia* 8(3): 331-347.

Bell, S.A.J. & Copeland, L.M. (2004) *Commersonia rosea* (Malvaceae *s.l.*: Lasiopetaleae): a new, rare fire-ephemeral species from the upper Hunter Valley, New South Wales. *Telopea* 10(2): 581-587.

Bell, S.A.J. (2002) Habitat of the endangered *Hibbertia procumbens* (Labill.) DC (Dilleniaceae) from the Central Coast of New South Wales. *Victorian Naturalist* 119(2): 69-74.

Bell, S.A.J. (2001) Notes on population size and habitat of the vulnerable *Cryptostylis hunteriana* Nicholls (Orchidaceae) from the Central Coast of New South Wales. *Cunninghamia* 7(2): 195-204.

Bell, S.A.J. (2001) Notes on the distribution and conservation status of some restricted plant species from sandstone environments of the upper Hunter Valley, New South Wales. *Cunninghamia* 7(1): 77-88.

Bell, S. (2000) An evaluation of vegetation survey and threatened plant species listings in the Hunter Region. Pp. 19-34 IN *Vegetation Management and Biodiversity Conservation in the Hunter Region - Where to from here ?* Ed. by M.Fallding. Proceedings of the Public Workshop. Hunter Environment Lobby. Singleton, 12 May 2000.

PUBLICATIONS - OTHER

DeLacey, C., Bell, S., & Chamberlain, S. (2012) Habitat of the Leafless Tongue Orchid *Cryptostylis hunteriana* Nicholls throughout its known Australian distribution. *Australasian Plant Conservation* 20(4): 23-25.

Bell, S.A.J. (2010) Defining and mapping an endangered ecological community within Lake Macquarie Local Government Area, New South Wales. *Australasian Plant Conservation* 18(3): 18-19.

Bell, S., Peake, T. & Driscoll, C. (2007) Dealing with taxonomic uncertainty in Weeping Myall *Acacia pendula* from the Hunter catchment, New South Wales. *Australasian Plant Conservation*. 16(1): 14-15.

Bell, S. & Driscoll, C. (2005) New records of the endangered *Hibbertia procumbens* from the Central Coast of NSW. *Australasian Plant Conservation* 13(4): 24-25.

Bell, S.A.J., Parsons, J., & Meldrum, R. (2005) Towards the protection and management of hanging swamps on the Somersby Plateau, Central Coast, New South Wales. *Australasian Plant Conservation* 13(3): 10-11.

Bell, S. (2003) Another new and highly restricted mallee from the Hunter Valley, *Eucalyptus castrensis*. *Hunter Flora* 11: 2.

Peake, T., Bell, S., Tame, T., Simpson, J., & Curran, T. (2003) *The Hunter Rare Plants Database: Identification and listing of regionally significant flora for the Hunter Region, New South Wales*. Poster Presentation at the Ecological Society of Australia Annual Conference 2003, Armidale NSW.

Peake, T., Bell, S., Tame, T., Simpson, J., & Curran, T. (2002) *Warkworth Sands Woodland – An Endangered Ecological Community: Distribution, Ecological Significance and Conservation Status*. Hunter Region Botanic Gardens Technical Paper [www.huntergardens.org.au/]

CURRICULUM **VITAE**

Hydro**biology Pty Ltd**

Name	**Dr Andrew James Markham**
Profession/Position	**Geomorphologist and Chartered Environmental Scientist**

Specialist Skills

Fluvial Geomorphology, River and Floodplain Processes and Management, Surface Water Hydrology & Hydrometry, Sediment/Particulate Transport and Deposition, Erosion management, Applied Fluvial Geomorphology, Mining Environmental Management, Impact Assessment.

Affiliations

Member, Australasian Institute of Mining and Metallurgy (M.AusIMM (CP) Registration No 112846)

Fellow of the Royal Geographical Society and accredited Chartered Geographer (Cgeog)

Member, Australian Water Association

Education

University of London, UK	Ph.D (Geomorphology, awarded 1990)
University of East Anglia, Norwich, UK	BSc Hons. (Environmental Science, awarded 1985)

Publications

Refereed Journals (5), Periodicals (4), Numerous conference proceedings and unpublished reports

Country Experience

Consulting/Residence	Australia, Papua New Guinea, Laos, Bangladesh, Indonesia, Tanzania
Graduate Studies	UK, USA
Exchanges/work experience	India, Canada

Dr Andy Markham is a Geomorphologist specialising in fluvial processes and surface water hydrology. He is an accredited Chartered Environmental Scientist (M.AusIMM (CP)) and Chartered Geographer (Cgeog, Royal Geographical Society). He has a PhD in fluvial geomorphology from London University, 23 years experience and has worked on consulting assignments worldwide. His particular areas of expertise relate to links between catchment and river geomorphology, hydrology and sediment processes with a particular focus on the processes of landscape erosion and sediment movements through catchments. He was appointed as Technical Advisor (geomorphology) on five Water Resources Planning processes for the Queensland Government which have focussed on environmental flows, and the impacts of infrastructure and water allocation scenarios on riverine processes. He has also provided high-level advice and review services for mining clients. Andy has undertaken a number of studies relating to mining landscapes, including peer review and advisory services relating to waste dump management for and impacts associated with landslide risk in tropical environments.

Abbreviated Curriculum Vitae

Name: Dr. Arthur William White
Home Address: 69 Bestic Street, Rockdale, N.S.W. Australia 2216
Home Phone Number (and Fax No.): (02) 9599 -1161

Date of Birth: 22 . 2 . 51
Marital Status: Married , two children.
Occupation: Director, Biosphere Environmental Consultants Pty. Ltd.

Degrees/Diplomas/Fellowships:

1973 B.Sc (Hons)	University of New South Wales
1982 Ph. D (Biological Sciences)	University of New South Wales
1984 Dip. Ed. (Science)	University of New England
2001.	Fellow of the Royal Zoological Society of NSW

Scientific Societies/Honoraria:

Honorary Batrachiologist	Taronga Zoo, Sydney (since 1981).
Council Member	Royal Zoological Society of New South Wales (since 1978)
Council member / President	Riversleigh Society (since 1987)
Member	Australian Society of Herpetologists (since 1978)
Scientific Adviser	Frog and Tadpole Study Group (1992-97)
President	Frog and Tadpole Study Group of NSW (since1998)
Research Associate	School of Biological Sciences, University of NSW (1989-1998)
Honorary Research Fellow	Australian Museum (since 1999)

Fellow of the Royal Zoological Society of New South Wales (2001)

Brief Resume of Activities:

- Director of Biosphere Environmental Consultants Pty Ltd, a company that specialises in fauna-related projects
- Dr White has been involved in field surveys and studies on native fauna since 1978. These have included all vertebrate groups but special expertise has been developed in the area of threatened and endangered herpetofauna (frogs and reptiles).
- Dr White has been involved in various aspects of frog research in Australia since 1979. This research has included studies of the natural history, distribution, conservation status and ecology of a range of species (see publication list).

- Other major research areas include the taxonomy of fossil and modern turtles (see abbreviated publication list).
- Biosphere Environmental Consultants have undertaken various major and minor faunal studies on behalf of both private and government agencies. These include general fauna surveys, targeted surveys for threatened and endangered species, Species Impact Statement, Plans of Management and habitat management and creation programs.
- Dr White is an adviser to the NSW Scientific Committee (National Parks and Wildlife Service).

Selected Recent Faunal Statements, Major Surveys and Management Plans

2003. Herpetofauna Surveys. Coalcliff Colliery Site. Maddens Plains.
2002. Survey for Threatened and Endangered Frogs. Wises Farm Site, Maroochydore
2001. Plan of Management. Red-crowned Toadlets. 179a Great Western Highway, Blaxland, Frog Blue Mountains City Council.
2001. Herpetofauna Survey. Peregian Springs Development Area. Peregian Beach Qld.
2000. Fauna of Willoughby Bushland reserves. Prepared for Willoughyby City Council.
1999/2000. Surveys for Endangered Barred Frogs *Mixophyes iteratus* and *M. balbus* in the Greater Sydney Basin. NSW Nat. Parks and Wildlife, Environment Australia.
1998/9 Frogs as Bio-indicators. Urban Bio-indicator Study for the Upper Blue Mountains, Urban Run-off Task Force, Sydney Water, NSW National Parks and Wildlife, Blue Mountains City Council.
1996/20023Monitoring program: Green and Golden Bell Frogs, Olympic Site, Homebush Bay. Olympic Co-ordination Authority and AMBS.

Selected Recent Publications

Pyke, G.H., White, A.W., Bishop, P.J., and Waldman, B. (2002). Habitat-use by Green and Golden Bell frog *Litoria aurea* in Australia and New Zealand . *Australian Zoologist* **32**(1): 12-31.

Pyke, G.H. and A.W. White (2001). A Review of the Biology of the Green and Golden Bell Frog *Litoria aurea. Aust. Zool.* **31**(4): 563-598.

White, A.W. (2001).Editor. *Frog Diseases and Frog Hygiene*. Special Publication of the NSW Frog and Tadpole Study Group Inc. Pp 1- 127.

White, A.W. (2001). Frogs of the Sydney Region. *FrogFacts* 7: 1- 4. NSW Frog and Tadpole Study Group Inc.

Voigt, L. and White, A.W. (2001). Collecting, Raising and Releasing Tadpoles *FrogFacts* 6: 1- 4. NSW Frog and Tadpole Study Group Inc.

Pyke, G.H., and A.W.White. (2000). Factors influencing predation on eggs and tadpoles of the endangered Green and Golden Bell Frog *Litoria aurea* by the introduced Plague Minnow *Gambusia holbrooki. Aust. Zool.* **31**(3): 496-505.

White, A,W, and G.H.Pyke (1999) Past distribution of *Litoria aurea* and *Litoria castanea* in the Bathurst-Orange District of New South Wales. *Herpetofauna* **29** (1): 2-9.

Pyke, G.H., and A.W.White (1999). Dynamics of co-occuring frog species in three ponds utilised by the endangered Green and Golden Bell Frog *Litoria aurea. Aust. Zool.* **31**(1): 230-239.

White. A.W. (1997). Green and Golden Bell Frog *Litoria aurea.* In *Threatened Frogs of New South Wales*. Ed. H.Ehmann. Frog and Tadpole Study Group of New South Wales.Pp 149-156.

Ehmann, H., and A.W.White (1997). The Southern Bell Frog *Litoria raniformis*.In *Threatened Frogs of New South Wales*. Ed. H.Ehmann. Frog and Tadpole Study Group of New South Wales.pp 195-202.

White. A.W.and Ehmann ,H (1997). The New England Bell Frog *Litoria castanea.* In *Threatened Frogs of New South Wales*. Ed. H.Ehmann. Frog and Tadpole Study Group of New South Wales. Pp 165-170.

White. A.W. and Ehmann,H (1997). The Southern Tablelands Bell Frog *Litoria castanea* (part). In *Threatened Frogs of New South Wales*. Ed. H.Ehmann. Frog and Tadpole Study Group of New South Wales.Pp 171-176.

White. A.W. (1997). Heath Frog *Litoria littlejohni.* In *Threatened Frogs of New South Wales*. Ed. H.Ehmann. Frog and Tadpole Study Group of New South Wales. Pp 177-182.

White, A.W., and G.H. Pyke (1996). Distribution and conservation status of the Green and Golden Bell Frog *Litoria aurea* in New South Wales. *Aust. Zool.* **30**: 177- 189.

Pyke, G.H., and A.W.White. (1996) Habitat requirements of the Green and Golden Bell Frog *Litoria aurea* (Anura:Hylidae). *Aust. Zool.* **30**: 224-232.

Curriculum Vitae of

Dr Jonathan Kennedy Webb

BSc (Hons), PhD (University of Sydney)

Lecturer in Environmental Science
School of the Environment, University of Technology Sydney
PO Box 123, Broadway NSW 2007
E: jonathan.webb@uts.edu.au Telephone: 02 9314 4037

Research interests: Invasive species, ecology, conservation biology, restoration ecology, animal behaviour, wildlife management, physiological ecology.

Research Grants: Over $1 million in funding awarded from grants from the Australian Research Council, the Mazda Foundation, Hermon Slade Foundation, National Geographic Conservation Trust, Northern Territory Government, and Federal Government.

Publications: 100 papers in peer-reviewed journals.

Current Research Projects:

Restoring habitats for the endangered broad-headed snake.
Aims: To restore degraded habitats for the broad-headed snake. Collaborators: University of Sydney, NSW Department of Environment and Climate Change, NSW State Forests, the Australian Reptile Park and Zoos Victoria. Funding: Australian Research Council.

Teaching northern quolls to avoid eating cane toads.
Aims: To reduce the impacts of cane toads on northern quoll populations. Collaborators: University of Sydney, WA Department of Environment and Conservation, the Territory Wildlife Park, Kakadu National Park, Australian Wildlife Conservancy. Funding: Australian Research Council, Mazda Foundation, National Geographic Society.

Excluding cane toads from water
Aims: To measure biodiversity benefits that result from excluding cane toads from water. Collaborators: Dr Mike Letnic (University of NSW), Dr Tim Dempster (Melbourne University). Funding: Hermon Slade Foundation.

Supervision of students:

Completions: 9 Honours students, 7 PhD students. Current: 1 Honours, 2 PhD students

Professional Appointments:

2009-present Associate editor, *Austral Ecology*
2009-present Associate editor, *Wildlife Research*

Consultancy Work: I have done consultancy work for clients including local councils, NSW DECC, WWF, NSW State Forests, BHP and private firms. I have over 20 years of experience carrying out fauna surveys, and I have worked in NSW, WA and the NT.

Professional Memberships:

Australian Society of Herpetologists, Royal Zoological Society of NSW.

Peer reviewed publications

1 March 2013

100. Croak BM, Webb JK, Shine R. 2013. The benefits of habitat restoration for rock-dwelling velvet geckos *Oedura lesueurii*. Journal of Applied Ecology, in press.

99. Kämper W, Webb JK, Crowther MS, Greenlees MJ, Shine R. 2013.Behaviour and survivorship of a dasyurid predator *(Antechinus flavipes*) in response to encounters with the toxic and invasive cane toad (*Rhinella marina*). Australian Mammalogy, in press.

98. Price-Rees, S., Webb JK, Shine R. 2013. Reducing the impact of a toxic invader by inducing taste-aversion in an imperilled native reptile predator. Animal Conservation, in press.

97. Pike DA, Webb JK, Shine. 2012. Reply to comment on 'chainsawing for conservation: ecologically informed tree removal for habitat management'. Ecological Management and Restoration 13:e12-e13. doi: 10.1111/j.1442-8903.2012.00666.x

96. Somaweera R, Webb JK, Dempster T, Letnic M, Shine R. 2012. Why does vulnerability to toxic invasive cane toads vary among populations of Australian freshwater crocodiles? Animal Conservation, in press. Doi: 10.1111/j.1469-1795.2012.00578.x

95. Shine R, Webb JK, Lane A, Mason RT. 2012. Familiarity with a female does not affect a male's courtship intensity in garter snakes *Thamnophis sirtalis parietalis.* Current Zoology, 58: 805 - 811.

94. Elzer AL, Pike DA, Webb JK, Hammill K, Bradstock RA, Shine R. 2012. Forest-fire regimes affect thermoregulatory opportunities for terrestrial ectotherms. Austral Ecology, in press. 10.1111/j.1442-9993.2012.02391.x

93. Croak BM, Pike DA, Webb JK, Shine R. 2012. Habitat selection in a rocky landscape: experimentally decoupling the influence of retreat site attributes from that of landscape features. PLoS One 7:e37982.

92. Dubey S, Croak B, Pike DA, Webb JK, Shine R. 2012. Phylogeography and dispersal in the velvet gecko (*Oedura lesueurii*), and potential implications for conservation of an endangered snake (*Hoplocephalus bungaroides*). BMC Evolutionary Biology 12:67. doi:10.1186/1471-2148-12-67

91. Pike DA, Webb JK, Shine R. 2012. Hot mothers, cool eggs: nest-site selection by egg-guarding spiders accommodates conflicting thermal optima. Functional Ecology 26:469-475.

90. Kovacs EK, Crowther MS, Webb JK, Dickman CR. 2012. Population and behavioural responses of native prey to alien predation. Oecologia 168:947-957.

89. Somaweera R, Brown GP, Webb JK, Shine R. 2011. Determinants of habitat selection by hatchling Australian freshwater crocodiles. PLoS One 6(12): e28533. doi:10.1371/journal.pone.0028533

88. Kelehear C, Webb JK, Hagman M, Shine R. 2011. Interactions between infective helminth larvae and their anuran host. Herpetologica 67:378-385.

87. Webb JK, Pearson D, Shine R. 2011. A small dasyurid predator (*Sminthopsis virginiae*) rapidly learns to avoid a toxic invader. Wildlife Research 38:726-731.

86. Price-Rees SJ, Webb JK, Shine R. 2011. School for skinks: Can conditioned taste aversion enable bluetongue lizards (*Tiliqua scincoides*) to avoid toxic cane toads (*Rhinella marina*) as prey? Ethology 117: 749-757.

85. Dubey S, Sumner J, Pike DA, Keogh JS, Webb JK, Shine R. 2011. Genetic connectivity among populations of an endangered snake species from southeastern Australia (*Hoplocephalus bungaroides*, Elapidae). Ecology and Evolution 1:218-227.

84. Pike DA, Webb JK, Shine R. 2011. Chainsawing for conservation: ecologically informed tree removal for habitat management. Ecological Management and Restoration 12:110-118.

83. Somaweera R, Webb JK, Brown GP, Shine R. 2011. Hatchling Australian freshwater crocodiles rapidly learn to avoid toxic invasive cane toads. Behaviour 148:501-517.

82. Pike DA, Webb JK, Andrews RM. 2011. Social and thermal cues influence nest-site selection in a nocturnal gecko, *Oedura lesueurii*. Ethology 117:796-801.

81. Somaweera R, Webb JK, Shine R. 2011. It's a dog-eat-croc world: dingo predation on the nests of freshwater crocodiles in northern Australia. Ecological Research 26:957-967.

80. Florance D, Webb JK, Dempster T, Kearney MR, Worthing A, Letnic M. 2011. Excluding access to invasion hubs can contain the spread of an invasive vertebrate. Proceedings of the Royal Society of London Series B 278:2900-2908.

79. Pike DA, Webb JK, Shine R. 2011. Removing forest canopy cover restores a reptile assemblage. Ecological Applications 21:274-280

78. Webb JK, Pike DA, Du WG, Shine R. 2010. Generalization of predator recognition: velvet geckos display anti-predator behaviours in response to chemicals from non-dangerous elapid snakes. Current Zoology 56:337-342.

77. O'Donnell S, Webb JK, Shine R. 2010. Conditioned taste aversion enhances the survival of an endangered predator imperiled by a toxic invader. Journal of Applied Ecology 47:558-565.

76. Pike DA, Croak BM, Webb JK, Shine R. 2010. Subtle - but easily reversible - anthropogenic disturbance seriously degrades habitat quality for rock-dwelling reptiles. Animal Conservation 13:411-418.

75. Llewelyn J, Webb JK, Schwarzkopf L, Alford R, Shine R. 2010. Behavioural responses of carnivorous marsupials (*Planigale maculata*) to toxic invasive cane toads (*Bufo marinus*). Austral Ecology 35:560-567.

74. Webb JK, Pike DA, Shine R. 2010. Olfactory recognition of predators by nocturnal lizards: safety outweighs thermal benefits. Behavioural Ecology 21:72-77.

73. Penman TD, Pike DA, Webb JK, Shine R. 2010. Predicting the impact of climate change on Australia's most endangered snake, *Hoplocephalus bungaroides*. Diversity and Distributions 16:109-118.

72. Pike DP, Croak B, Webb JK, Shine R. 2010. Context-dependent avoidance of predatory centipedes by nocturnal geckos (*Oedura lesueurii*). Behaviour 147:397-412.

71. Pike DA, Webb JK, Shine R. 2010. Nesting in a thermally challenging environment: nest-site selection in a rock-dwelling gecko, *Oedura lesueurii* (Reptilia:Geckonidae). Biological Journal of the Linnean Society 99:250-259.

70. Llewelyn J, Webb JK, Shine R. 2010. Flexible defense: context-dependent antipredator responses of two species of Australian elapid snakes. Herpetological Monographs 66:1-11.

69. Du WG, Webb JK, Shine R. 2010. Heat, sight and scent: multiple cues influence foraging site selection by an ambush-foraging snake (*Hoplocephalus bungaroides*, Elapidae). Current Zoology 55:266-271.

68. Sumner J, Webb JK, Keogh JS, Shine R. 2010. Molecular and morphological assessment of Australia's most endangered snake, *Hoplocephalus bungaroides*, reveals two evolutionarily significant units for conservation. Conservation Genetics 11:747-758.

67. Croak BM, Pike DA, Webb JK, Shine R. 2010. Using artificial rocks to restore non-renewable shelter sites in anthropogenically degraded systems: colonization and use by fauna. Restoration Ecology 18: 428–438.

66. Webb JK, Du WG, Pike DA, Shine R. 2009. Chemical cues from both dangerous and non-dangerous snakes elicit antipredator behaviours from a nocturnal lizard. Animal Behaviour 77:1471-1478.

65. Kelehear C, Webb JK, Shine R. 2009 *Rhabdias pseudosphaerocephala* infection in *Bufo marinus*: lung nematodes reduce viability of metamorph cane toads. Parasitology 136:919-927.

64. Pringle RM, Syfert M, Webb JK, Shine R. 2009. Quantifying historical changes in habitat availability for endangered species: used of pixel- and object-based remote sensing. Journal of Applied Ecology 46:544-553.

63. Whiting MJ, Webb JK, Keogh SK. 2009. Flat lizard female mimics use sexual deception in visual but not chemical signals. Proceedings of the Royal Society of London 276:1585-1591.

62. Webb JK, Pringle RM, Shine R. 2009. An intraguild predator influences microhabitat selection by juveniles of an endangered snake. Behavioural Ecology, 20:271-277.

61. Croak BM, Pike DA, Webb JK, Shine R. 2008. Three-dimensional crevice structure affects retreat site selection by reptiles. Animal Behaviour 76:1875-1884.

60. Letnic M, Webb JK, Shine R. 2008. Invasive cane toads (*Bufo marinus*) cause mass mortality of freshwater crocodiles (*Crocodylus johnstoni*) in tropical Australia. Biological Conservation 141:1773-1782.

59. Webb JK, Shine R. 2008. Differential effects of an intense wildfire on survival of sympatric snakes. Journal of Wildlife Management 72:1394-1398.

58. Webb JK, Pike D, Shine R. 2008. Population ecology of the velvet gecko, *Oedura lesueurii* in southern Australia: implications for the persistence of an endangered snake. Austral Ecology 33:839-847.

57. Schultz TJ, Webb JK, Christian KA. 2008. The physiological cost of pregnancy in a live-bearing snake. Copeia 2008:637-642.

56. Webb JK, Brown GP, Child T, Greenless MJ, Phillips BL, Shine R. 2008. A native dasyurid predator (common planigale, *Planigale maculata*) rapidly learns to avoid toxic cane toads. Austral Ecology 33:821-839.

55. Greenlees MJ, Brown GP, Webb JK, Phillips BL, Shine R. 2007. Do invasive cane toads (*Chaunus marinus*) compete with Australian frogs (*Cyclorana australis*)? Austral Ecology 32:900-907.

54. Christian KA, Webb JK, Schultz TJ, Green BW. 2007. Effects of seasonal variation in prey abundance on field metabolism, water flux and activity of a tropical ambush foraging snake. Journal of Physiological and Biochemical Zoology 80:522-523.

53. Keogh JS, Webb JK, Shine R. 2007. Fine-scale spatial genetic and long-term mark-recapture data demonstrate male-biased dispersal in a snake. Biology Letters 3:33-35.

52. Phillips B, Brown GP, Greenlees M, Webb JK, Shine R. 2007. Rapid expansion of the cane toad (*Bufo marinus*) invasion front in tropical Australia. Austral Ecology 32:169-176.

51. Shine R, Branch WR, Webb JK, Harlow PS, Shine T, Keogh JS. 2007. Ecology of cobras (*Aspidelaps, Hemachatus*, and *Naja*; Elapidae) from southern Africa. Journal of Zoology 272:183-193.

50. Brown GP, Phillips BL, Webb JK, Shine R. 2006. Toad on the road: use of roads as dispersal corridors by cane toads (*Bufo marinus*) at an invasion front in tropical Australia. Biological Conservation 133:88-94.

49. Webb JK, Whiting MJ. 2006. Habitat disturbance, not predation, is all that is required to influence habitat choice in juvenile snakes: a rejoinder to Lill. Austral Ecology 31:905-906.

48. Greenlees MJ, Brown GP, Webb JK, Phillips BL, Shine R. 2006. Effects of an invasive anuran (the cane toad, *Bufo marinus*) on the invertebrate fauna of a tropical Australian floodplain. Animal Conservation 9:431-438.

47. Phillips BL, Brown GP, Webb JK, Shine R. 2006. Runaway toads: an invasive species evolves speed and thus spreads more rapidly through Australia. Nature 439:803.

46. Webb JK, Shine R, Christian KA. 2006. The adaptive significance of reptilian viviparity in the tropics: testing the "maternal manipulation" hypothesis. Evolution 60:115-122.

45. Kelehear C, Webb JK. 2006. Effects of tail autotomy on anti-predator behaviour and locomotor performance in a nocturnal gecko. Copeia 2006:803-809.

44. Shine R, Branch WR, Harlow PS, Webb JK, Shine T. 2006. Biology of burrowing asps (Actractaspididae) from Southern Africa. Copeia 2006:103-115.

43. Shine R, Branch WR, Webb JK, Shine T. 2006. Sexual dimorphism, reproductive biology and dietary habits of psammophiine snakes (Colubridae) from Southern Africa. Copeia 2006:650-664.

42. Llewelyn J, Shine R, Webb JK. 2006. Time of testing affects locomotor performance in nocturnal versus diurnal snakes. Journal of Thermal Biology 31:268-273.

41. Webb JK. 2006. Effects of tail autotomy on survival, growth and territory occupation in free-ranging juvenile geckos (*Oedura lesueurii*). Austral Ecology 31:432-440.

40. Shine, R., Webb JK, Lane A, Mason RT. 2006. Flexible mate choice: a male snake's preference for larger females is modified by the sizes of females that he encounters. Animal Behaviour 71:203-209.

39. Webb JK, Whiting MJ. 2006. Does an ecosystem engineer (superb lyrebird *Menura novaehollandiae*) influence habitat selection by sympatric snakes? Austral Ecology 31:58-67.

38. Shine R, Webb JK, Lane A, Mason RT. 2005. Mate-location tactics in garter snakes: effects of rival males, interrupted trails, and non-pheromonal cues. Functional Ecology 19:1017-1024.

37. Webb JK, Pringle RM, Shine R. 2005. Canopy removal restores habitat quality for an endangered snake in a fire suppressed landscape. Copeia 2005:893-899.

36. Webb JK, Whiting MJ. 2005. Why don’t small snakes bask? Juvenile broad-headed snakes trade thermal benefits for safey. Oikos 110:515-522.

35. Llewelyn J, Shine R, Webb JK. 2005. Thermal regimes and diel activity patterns of four species of small elapid snakes from southeastern Australia. Australian Journal of Zoology 53:1-8.

34. Greenless M, Webb JK, Shine R. 2005. Led by the blind: bandy-bandy snakes *Vermicella annulata* (Elapidae) follow blindsnake chemical trails. Copeia 2005:184-187.

33. Webb JK, Shine R, Christian KA. 2005. Does intraspecific niche partitioning in a native predator influence its response to an invasion by a toxic prey species? Austral Ecology 30: 201-209.

32. Stapley J, Hayes CM, Webb JK, Keogh JS. 2005. Novel microsatellite loci identified from the Australian eastern small-eyed snake (Elapidae: *Rhinoplocephalus nigrescens*) and cross species amplification in the related genus *Suta*. Molecular Ecology Notes 5: 54-56.

31. Webb JK, Pringle RM, Shine R. 2004. How do nocturnal snakes select diurnal retreat sites? Copeia 2004: 919–925.

30. Webb JK. 2004. Pregnancy decreases swimming performance of female northern death adders (*Acanthophis praelongus*). Copeia 2004: 357-363.

29. Christian KA, Webb JK, Schultz T. 2003. Energetics of blue-tongue lizards (*Tiliqua scincoides*) in a seasonal tropical environment. Oecologia 136: 515-523.

28. Webb JK, Brook BW, Shine R. 2003. Does foraging mode influence life history traits? A comparative study of growth, maturation and survival of two species of sympatric snakes from southeastern Australia. Austral Ecology 28:601-610.

27. Pringle RM, Webb JK, Shine R. 2003. Canopy structure, microclimate, and habitat selection by a nocturnal snake, *Hoplocephalus bungaroides*. Ecology 84:2668-2679.

26. Webb JK, Brook BW, Shine R. 2002. What makes a species' vulnerable to extinction? Comparative life history traits of two sympatric snakes. Ecological Research 17:59-67.

25. Webb JK, Brook BW, Shine R. 2002. Reptile collectors threaten Australia's most endangered snake, the broad-headed snake *Hoplocephalus bungaroides*. Oryx 36:170-181.

24. Webb JK, Christian KA, Fisher P. 2002. Fast growth and early maturation in a viviparous ambush foraging elapid snake from tropical Australia. Journal of Herpetology 36:505-509.

23. Webb JK, Brown GP, Shine R. 2001. Body size, locomotor speed and antipredator behaviour in a tropical snake (*Tropidonophis mairii,* Colubridae): the influence of incubation environments and genetic factors. Functional Ecology 15:561-568.

22. Webb JK, Shine R, Branch WR. 2001. Dietary habits and reproductive biology of typhlopid snakes from southern Africa. Journal of Herpetology 35:558-567.

21. Scott IAW, Hayes C, Keogh JS, Webb JK. 2001. Isolation and characterization of novel microsatellite markers from the Australian tiger snakes (Elapidae: *Notechis*) and amplification in the closely related genus *Hoplocephalus*. Molecular Ecology Notes 1:117-120.

20. Webb JK, Shine R. 2000. Paving the way for habitat restoration: can artificial rocks restore degraded habitats for endangered reptiles? Biological Conservation 92:93-99.

19. Webb JK, Shine R, Branch WR, Harlow PS. 2000. Life underground: food habits and reproductive biology of two amphisbaenian species (*Monopeltis anchietae* and *Zygaspis quadrifrons*) from Southern Africa. Journal of Herpetology 34:510-516.

18. Webb JK, Shine R, Branch WR, Harlow PS. 2000. Life history strategies in basal snakes: natural history of two races of the African threadsnake, *Leptotyphlops scutifrons* (Serpentes, Leptoyphlopidae). Journal of Zoology (London) 250:321-327.

17. Webb JK, Shine R. 1998. Ecological characteristics of a threatened snake species, *Hoplocephalus bungaroides* (Serpentes, Elapidae). Animal Conservation 1:185-193.

16. Webb JK, Shine R. 1998. Thermoregulation by a nocturnal elapid snake (*Hoplocephalus bungaroides*) in south-eastern Australia. Physiological Zoology 71:680-692.

15. Webb JK, Shine R. 1998. Using thermal ecology to predict retreat-site selection by an endangered snake species. Biological Conservation 86:233-242.

14. Shine R, Branch WR, Harlow PS, Webb JK. 1998. Reproductive biology and food habits of horned adders, *Bitis caudalis* (Viperidae) from South Africa. Copeia 1998:391-401.

13. Shine R, Webb JK, Fitzgerald M, Sumner J. 1998. The impact of bush-rock removal on an endangered snake species, *Hoplocephalus bungaroides*. Wildlife Research 25:285-295.

12. Webb JK, Shine R. 1997. A field study of spatial ecology and movements of a threatened snake species, *Hoplocephalus bungaroides*. Biological Conservation 82:203-217.

11. Webb JK, Shine R. 1997. Out on a limb: conservation implications of tree-hollow use by a threatened snake species (*Hoplocephalus bungaroides*: Serpentes, Elapidae). Biological Conservation 81:21-33.

10. Branch WR, Shine R, Harlow PS, Webb JK. 1997. Sexual dimorphism, diet and aspects of reproduction of the western keeled snake, *Pythonodipsas carinata* (Serpentes: Colubridae). African Journal of Herpetology 46:89-97.

9. Webb JK. 1996. Observation of three dingoes killing a large lace monitor (Varanus varius). Australian Mammalogy 19:55-56.

8. Shine R, Haagner GV, Branch WR, Harlow PS, Webb JK. 1996. Natural history of the African shieldnose snake *Aspidelaps scutatus* (Serpentes, Elapidae). Journal of Herpetology 30:361-366.

7. Shine R, Harlow PS, Branch WR, Webb JK. 1996. Life on the lowest branch: sexual dimorphism, diet and reproductive biology of an African twig snake *Thelotornis capensis* (Serpentes: Colubridae). Copeia 1996:290-299.

6. Shine R, Branch WR, Harlow PS, Webb JK. 1996. Sexual dimorphism, reproductive biology and food habits of two species of African filesnakes (*Mehelya*, Colubridae). Journal of Zoology (London) 240:327-340.

5. Webb JK, Shine R. 1994. Feeding habits and reproductive biology of Australian pygopodid lizards of the genus *Aprasia*. Copeia 1994:390-398.

4. Webb JK, Shine R. 1993. Dietary habits of Australian blindsnakes. Copeia 1993:762-770.

3. Webb JK, Shine R. 1993. Prey-size selection, gape limitation and predator vulnerability in Australian blindsnakes. Animal Behaviour 45: 1117-1126.

2. Webb JK, Shine R. 1992. To find an ant: trail-following in Australian blindsnakes (Typhlopidae). Animal Behaviour 43:941-948.

1. Shine R, Webb JK. 1990. Natural history of Australian typhlopid snakes. Journal of Herpetology 24:357-363.

Appendix H

Results of Potential Offset Properties Desktop Assessment

Table H.1 Results of Desktop Assessment of Potential Offset Properties

Property Name	Size (ha)	Located in Project LGA (Lithgow) ?	located in Project CMA (Central West) ?	Adjoins Conservation Area ?	Underlying Geology is Permian?	Vegetation	Vegetation Class by Keith (2004)	Threatened Species within 5 km
Potential Offset Property 1*	200.31	No - Mid-Western Regional Council	No - Hunter/ Central Rivers	No - 1km west of Wollemi NP	Yes – Permian and Triassic	Permian Capertee Talus Woodland Narrabeen West	Sydney Montane Dry Sclerophyll Forests	**Flora**
						Wollemi Sheltered Dry Forest Narrabeen Wollemi Woodland Complex	Sydney Hinterland Dry Sclerophyll Forest .	Pultenaea sp. Olinda
						Agricultural	North-west Slopes Dry Sclerophyll Forest	**Fauna**
								Broad-headed Snake
								Brush-tailed Rock-wallaby
								Powerful Owl
								Regent Honeyeater
								Spotted-tailed Quoll,
Potential Offset Property 2*	540.55	No - Mid-Western Regional Council	No - Hunter/ Central Rivers	No - 3.5km west of Wollemi NP	Yes – Permian and Triassic	Narrabeen Upper Cudgegong Sandslope Woodland	Sydney Hinterland Dry Sclerophyll Forest	**Flora**
						Permian Capertee Talus	Sydney Montane Dry	Eucalyptus cannonii,

Table H.1 Results of Desktop Assessment of Potential Offset Properties

Property Name	Size (ha)	Located in Project LGA (Lithgow) ?	located in Project CMA (Central West) ?	Adjoins Conservation Area ?	Underlying Geology is Permian?	Vegetation	Vegetation Class by Keith (2004)	Threatened Species within 5 km
						Woodland	Sclerophyll Forests	
						Narrabeen West-Wollemi Sheltered Dry Forest	North-west Slopes Dry Sclerophyll Forest	**Fauna**
						Narrabeen Bylong Arid Woodland,		Black-chinned Honeyeater
						Narrabeen Wollemi Woodland Complex		Brown Treecreeper
						Agricultural		Diamond Firetail
								Gang-gang Cockatoo
								Little Lorikeet,
								Speckled Warbler
								Squirrel Glider
								Turquoise Parrot
Potential Offset Property 3*	580.98	No - Mid-Western Regional Council	No - Hunter/ Central Rivers	No - 1.2km west of Wollemi NP	Yes – Permian and Triassic	Permian Capertee Talus Woodland	Western Slopes Dry Sclerophyll Forest	Flora
						Narrabeen Bylong Arid Woodland,	Western Slopes Dry Sclerophyll Forests	Eucalyptus cannonii
						Narrabeen Wollemi Woodland Complex,	Sydney Hinterland Dry Sclerophyll Forest	**Fauna**

Table H.1 Results of Desktop Assessment of Potential Offset Properties

Property Name	Size (ha)	Located in Project LGA (Lithgow) ?	located in Project CMA (Central West) ?	Adjoins Conservation Area ?	Underlying Geology is Permian?	Vegetation	Vegetation Class by Keith (2004)	Threatened Species within 5 km
						Cleared,	North-west Slopes Dry Sclerophyll Forest	Broad-headed Snake
						Agricultural.		Brush-tailed Rock-wallaby
								Powerful Owl
								Regent Honeyeater
								Spotted-tailed Quoll
								Turquoise Parrot.
Potential Offset Property 4*	578.84	Yes - Lithgow City Council	No - Hawkesbury/ Nepean	No - 2.5km east of Capertee NP, 4km west of Wollemi NP	Yes – Permian and Lower to middle Devonian	Capertee - Wolgan Riparian Rough-barked Apple - River Oak Open Forest	Western Slopes Grassy Woodland	**Flora**
						Capertee Grey Gum - Narrow-leaved Stringybark - Scribbly Gum - Callitris - Ironbark Shrubby Open Forest	Eastern Riverine Forests	Phebalium bifidum,
						Narrow-leaved Ironbark - Callitris Riparian Grassy Woodland	Western Slopes Dry Sclerophyll Forests.	Grevillea obtusiflora,
						Narrow-leaved Ironbark - Callitris Shrubby Woodland		Acacia bynoeana

Table H.1 Results of Desktop Assessment of Potential Offset Properties

Property Name	Size (ha)	Located in Project LGA (Lithgow) ?	located in Project CMA (Central West) ?	Adjoins Conservation Area ?	Underlying Geology is Permian?	Vegetation	Vegetation Class by Keith (2004)	Threatened Species within 5 km
						Narrow-leaved Ironbark - Tumbledown Red Gum - Callitris Shrubby Woodland		**Fauna**
						White Box - Narrow-leaved Ironbark Woodland		Barking Owl
						Exotic Grasslands		Black-chinned Honeyeater
						Native Grassland,		Brown Treecreeper
						Cleared and Severely Disturbed Land.		Diamond Firetail
								Gang-gang Cockatoo
								Hooded Robin
								Little Eagle
								Little Lorikeet
								Powerful Owl
								Regent Honeyeater
								Scarlet Robin
								Speckled Warbler
								Swift Parrot

Table H.1 Results of Desktop Assessment of Potential Offset Properties

Property Name	Size (ha)	Located in Project LGA (Lithgow) ?	located in Project CMA (Central West) ?	Adjoins Conservation Area ?	Underlying Geology is Permian?	Vegetation	Vegetation Class by Keith (2004)	Threatened Species within 5 km
								Varied Sittella
								White-fronted Chat.
Potential Offset Property 5*	2,559.41	No - Mid-Western Regional Council	No - Hunter/ Central Rivers	3km west of Wollemi NP	No – Tertiary, Triassic and Quaternary	Dry Basalt Cap Woodland	Western Slopes Grassy Woodland	**Flora**
						Dry Basalt Diatreme Forest	Western Slopes Dry Sclerophyll Forest	Eucalyptus cannonii,
						Narrabeen Arid Acacia Woodland	Southern Tableland Dry Sclerophyll Forest	Leucopogon confertus
						Narrabeen Bylong Arid Woodland	Sydney Hinterland Dry Sclerophyll Forest	**Fauna**
						Narrabeen Goulburn Valley Exposed Woodland	North-west Slopes Dry Sclerophyll Forest	Black-chinned Honeyeater
						Narrabeen Upper Cudgegong Sandslope Woodland		Brown Treecreeper
						Narrabeen West-Wollemi Sheltered Dry Forest		Diamond Firetail
						Narrabeen Wollemi Woodland Complex		Gang-gang Cockatoo
						Permian Capertee Talus		Little Lorikeet,

Table H.1 Results of Desktop Assessment of Potential Offset Properties

Property Name	Size (ha)	Located in Project LGA (Lithgow) ?	located in Project CMA (Central West) ?	Adjoins Conservation Area ?	Underlying Geology is Permian?	Vegetation	Vegetation Class by Keith (2004)	Threatened Species within 5 km
						Woodland		
						Permian Grey Box Woodland		Speckled Warbler
						Permian Widden Talus Woodland		Squirrel Glider
								Turquoise Parrot
Potential Offset Property 6*	50.56	Yes - Lithgow City Council	No - Hawkesbury/ Nepean	Yes - Gardens of Stone National Park	Yes – Permian and Lower to middle Devonian	Capertee Box - Kurrajong - Grey Gum Grassy Woodlands	Western Slopes Grassy Woodland	**Flora**
						Capertee Marl Box Grassy Woodlands	Western Slopes Dry Sclerophyll Forest	Prostanthera cryptandroides subsp. cryptandroides
						Capertee Box - Narrow-leaf Ironbark - Callitris Grassy Woodland		Eucalyptus cannonii
						Capertee Grey Gum - Narrow-leaved Stringybark - Scribbly Gum - Callitris - Ironbark Shrubby Open Forest		Grevillea obtusiflora
						Cleared and Severely Disturbed Lands		Phebalium bifidum

Table H.1 Results of Desktop Assessment of Potential Offset Properties

Property Name	Size (ha)	Located in Project LGA (Lithgow) ?	located in Project CMA (Central West) ?	Adjoins Conservation Area ?	Underlying Geology is Permian?	Vegetation	Vegetation Class by Keith (2004)	Threatened Species within 5 km
								Fauna
								Black-chinned Honeyeater
								Brown Treecreeper
								Brown Treecreeper
								Diamond Firetail
								Gang-gang Cockatoo
								Glossy Black-Cockatoo
								Grey-crowned Babbler
								Hooded Robin
								Hooded Robin
								Large-eared Pied Bat
								Little Eagle
								Little Lorikeet
								Regent Honeyeater
								Scarlet Robin
								Speckled Warbler
								Square-tailed Kite

Table H.1 Results of Desktop Assessment of Potential Offset Properties

Property Name	Size (ha)	Located in Project LGA (Lithgow) ?	located in Project CMA (Central West) ?	Adjoins Conservation Area ?	Underlying Geology is Permian?	Vegetation	Vegetation Class by Keith (2004)	Threatened Species within 5 km
								Swift Parrot
								Turquoise Parrot
Potential Offset Property 7*	507.74522	Yes - Lithgow City Council	Hawkesbury/Nepean (only 600m from CMA border Central West)	Adjacent to Kandos State Forest	Yes – Permian and Lower to middle Devonian	Tableland Gully Ribbon Gum - Blackwood - Apple Box Forest	Southern Tableland Dry Sclerophyll Forest	**Flora**
						Capertee Rough-barked Apple - Redgum - Yellow Box Grassy Woodlands	Western Slopes Grassy Woodland	Eucalyptus cannonii
						Capertee - Wolgan Slopes Red Box - Grey Gum - Stringybark Grassy Open Forest	Central Gorge Dry Sclerophyll Forest	Grevillea obtusiflora
						Hillslope Talus Mountain Gum - Brown Stringybark - Grey Gum - Broad-leaved Hickory Moist Forest	Southern Escarpment West Sclerophyll Forest	**Fauna**
						Capertee Grey Gum - Narrow-leaved Stringybark - Scribbly Gum - Callitris - Ironbark Shrubby Open Forest	Western Slopes Dry Sclerophyll Forest	Barking Owl
						Capertee Hills White Box -	Eastern Riverine	Black-chinned

Table H.1 Results of Desktop Assessment of Potential Offset Properties

Property Name	Size (ha)	Located in Project LGA (Lithgow) ?	located in Project CMA (Central West) ?	Adjoins Conservation Area ?	Underlying Geology is Permian?	Vegetation	Vegetation Class by Keith (2004)	Threatened Species within 5 km
						Tumbledown Redgum - Ironbark - Callitris Shrubby Woodland	Forests	Honeyeater (eastern subspecies)
						Capertee - Wolgan Riparian Rough-barked Apple - River Oak Open Forest		Brown Treecreeper (eastern subspecies)
						Unclassified (<1ha patch of remnant vegetation adjacent / within cleared lands)		Diamond Firetail
						Cleared and Severely Disturbed Lands		Eastern Bentwing-bat
								Eastern Cave Bat
								Eastern False Pipistrelle
								Gang-gang Cockatoo
								Greater Broad-nosed Bat
								Large-eared Pied Bat
								Little Eagle
								Powerful Owl
								Regent Honeyeater
								Scarlet Robin

Table H.1 Results of Desktop Assessment of Potential Offset Properties

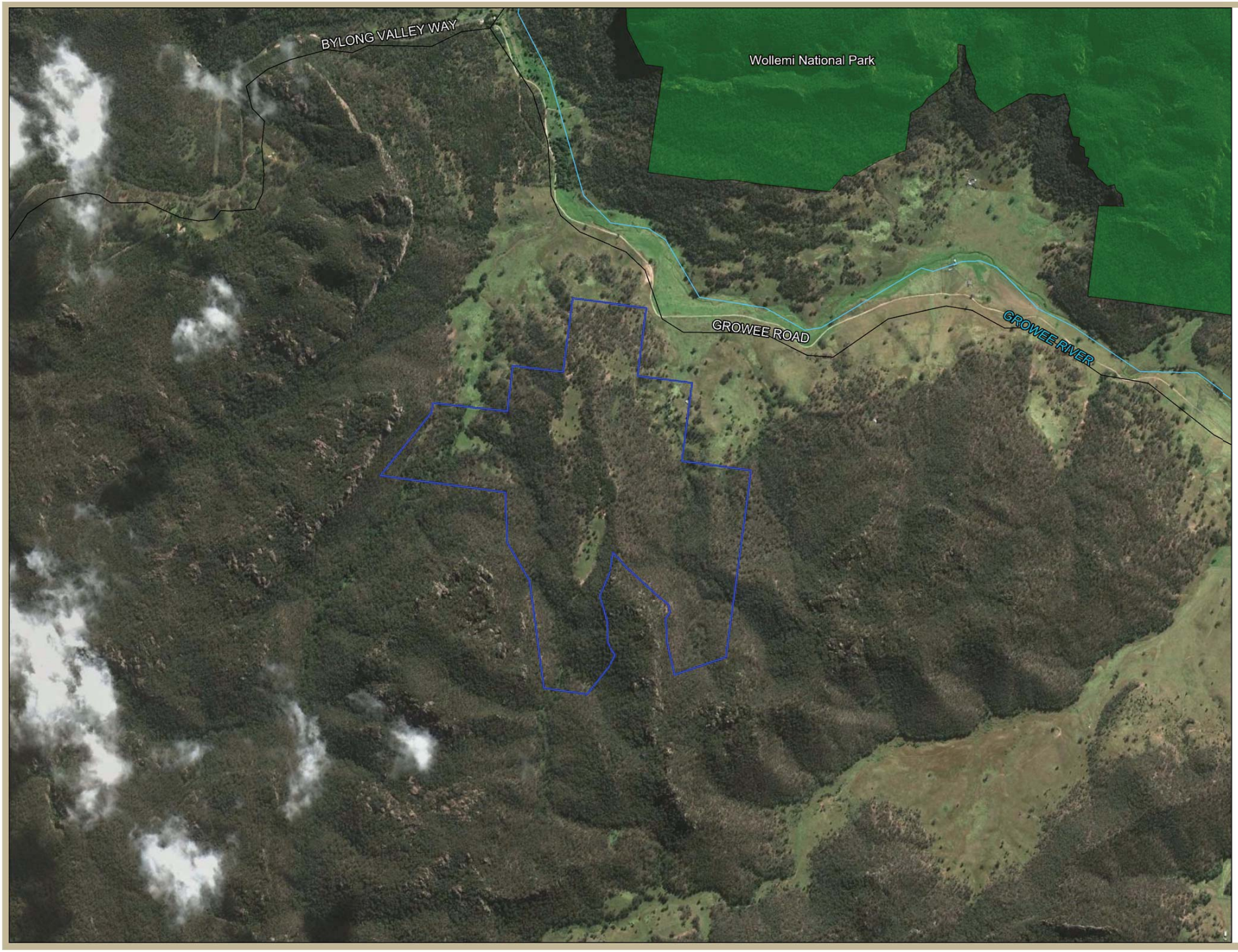
Property Name	Size (ha)	Located in Project LGA (Lithgow) ?	located in Project CMA (Central West) ?	Adjoins Conservation Area ?	Underlying Geology is Permian?	Vegetation	Vegetation Class by Keith (2004)	Threatened Species within 5 km
								Speckled Warbler
								Turquoise Parrot
								Varied Sittella
								Yellow-bellied Sheathtail-bat
Potential Offset Property 8*	399.83 ha	Yes - Lithgow City Council	Hawkesbury/Nepean (only approx. 200m from CWCMA border)	Adjacent to Gardens of Stone National Park	Yes – Permian and Lower to middle Devonian	Tableland Gully Ribbon Gum - Blackwood - Apple Box Forest	Southern Tableland Dry Sclerophyll Forest	**Flora**
						Capertee Rough-barked Apple - Redgum - Yellow Box Grassy Woodlands	Western Slopes Grassy Woodland	Eucalyptus cannonii
						Capertee - Wolgan Slopes Red Box - Grey Gum - Stringybark Grassy Open Forest	Central Gorge Dry Sclerophyll Forest	Grevillea obtusiflora
						Capertee Grey Gum - Narrow-leaved Stringybark - Scribbly Gum - Callitris - Ironbark Shrubby Open Forest	Western Slopes Dry Sclerophyll Forest	Persoonia marginata

Table H.1 Results of Desktop Assessment of Potential Offset Properties

Property Name	Size (ha)	Located in Project LGA (Lithgow) ?	located in Project CMA (Central West) ?	Adjoins Conservation Area ?	Underlying Geology is Permian?	Vegetation	Vegetation Class by Keith (2004)	Threatened Species within 5 km
						Pagoda Rock Sparse Shrubland	Sydney Montane Heath	**Fauna**
						Non-native Vegetation - Pine plantation / woodlot / shelter		Little Eagle
						Unclassified (<1ha patch of remnant vegetation adjacent / within cleared lands)		Square-tailed Kite
						Cleared and Severely Disturbed Lands		Gang-gang Cockatoo
						Other mapping		Glossy Black-Cockatoo
								Little Lorikeet
								Turquoise Parrot
								Powerful Owl
								Brown Treecreeper
								Regent Honeyeater
								Varied Sittella
								Flame Robin
								Eastern False Pipistrelle
								Little Bentwing-bat

** Property name and Lot and DPs have been excluded for confidentiality reasons. Property details can be supplied upon request by DP&I and/or other NSW regulators.*

Coordinate System: MGA 94 Zone 56



Legend

- Potential Biodiversity Offset Property 1
- National Park
- Waterways

Grid North

Image Source:
Image © 2013 GeoEye,
dated 31/03/2010

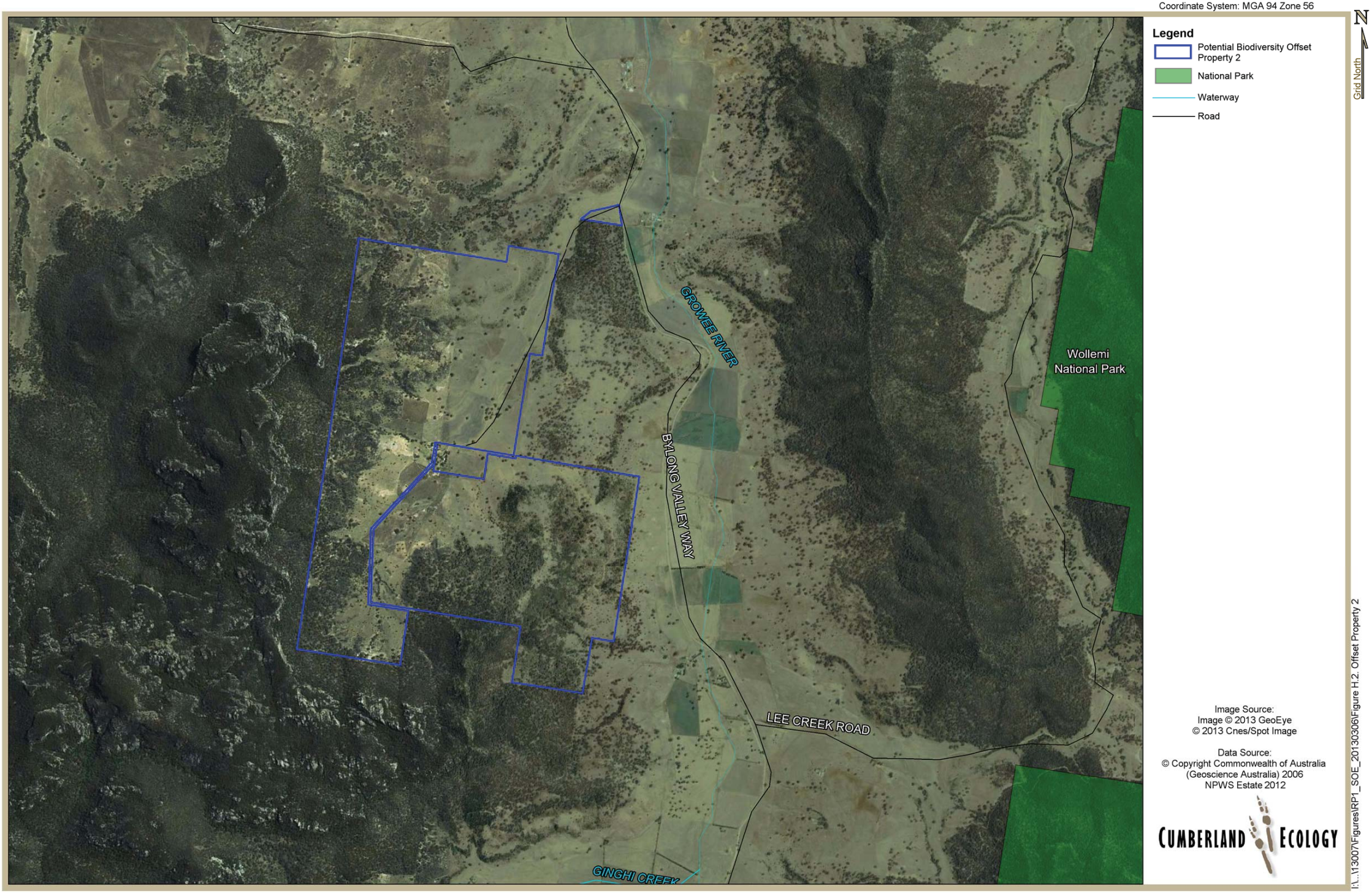
Data Source:
NPWS Estate 2012
© Copyright Commonwealth of Australia
(Geoscience Australia) 2006

CUMBERLAND ECOLOGY

I:\..\13007\Figures\RP1_SOE_20130306\Figure H.1. Offset Property 1

Figure H.1. Contracted Project Potential Biodiversity Offset Property 1

0.5 0 0.5 1 1.5 2 km



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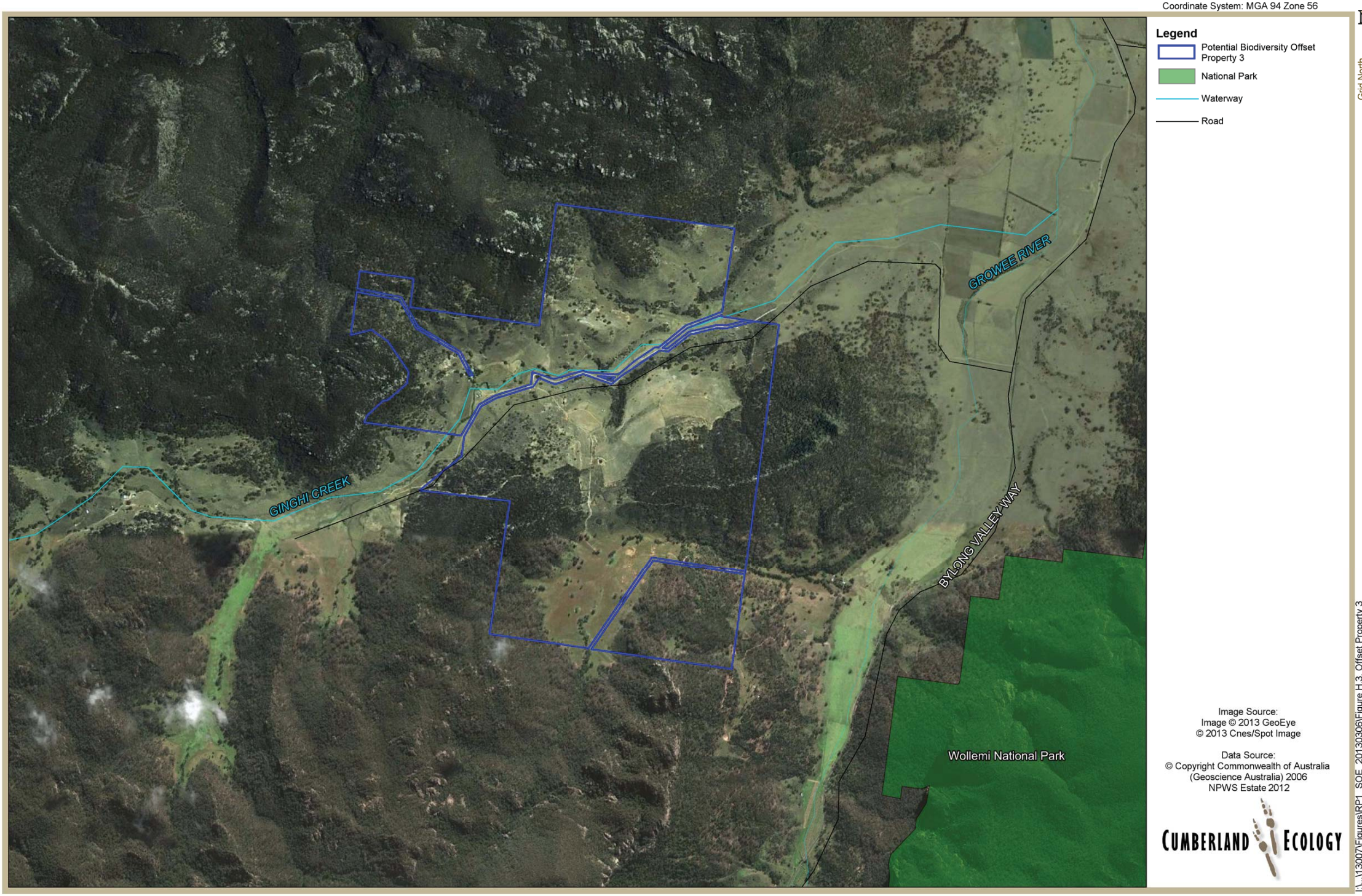
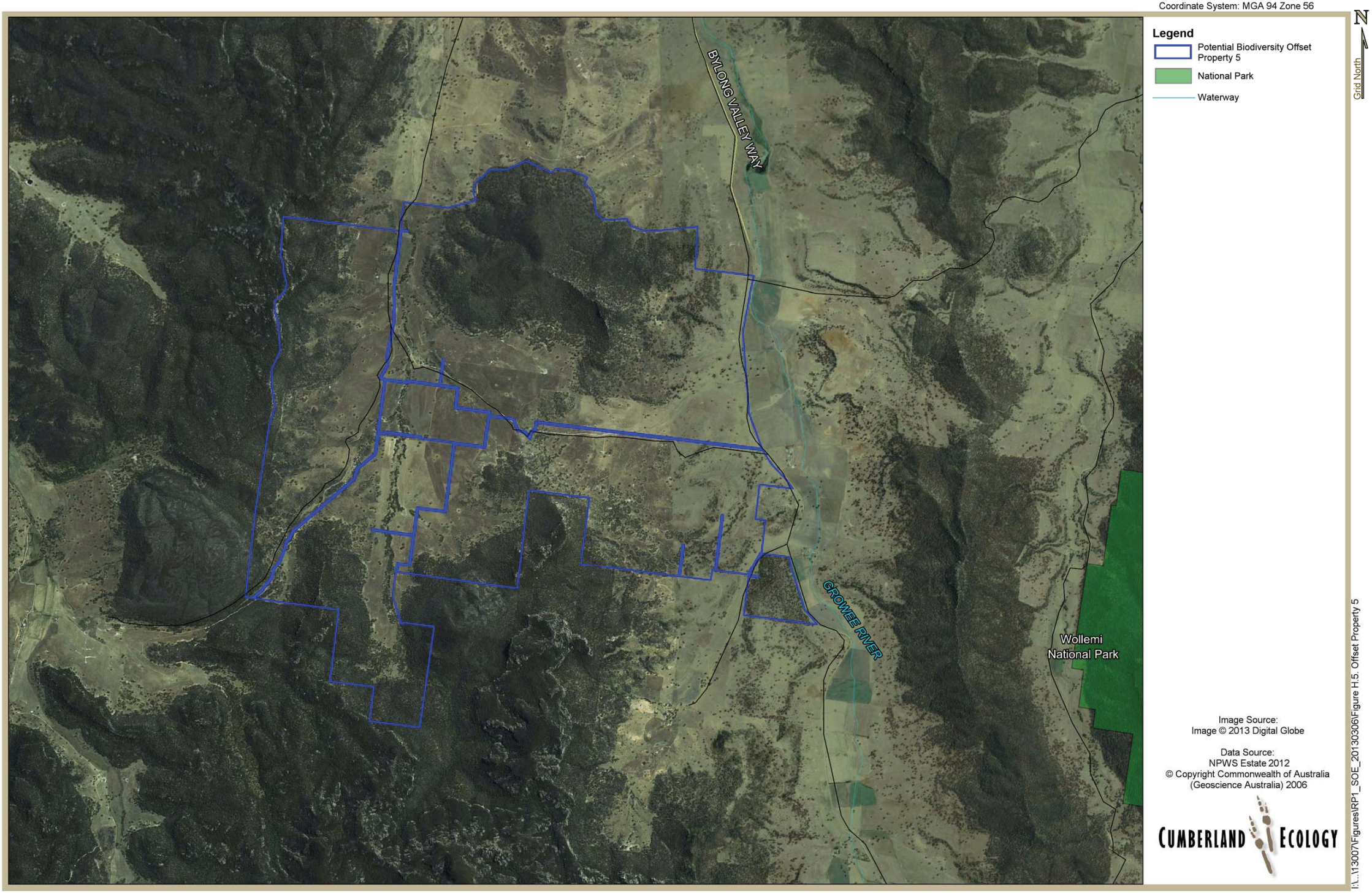


Figure H.3. Contracted Project Potential Biodiversity Offset Property 3

Figure H.4. Contracted Project Potential Biodiversity Offset Property 4



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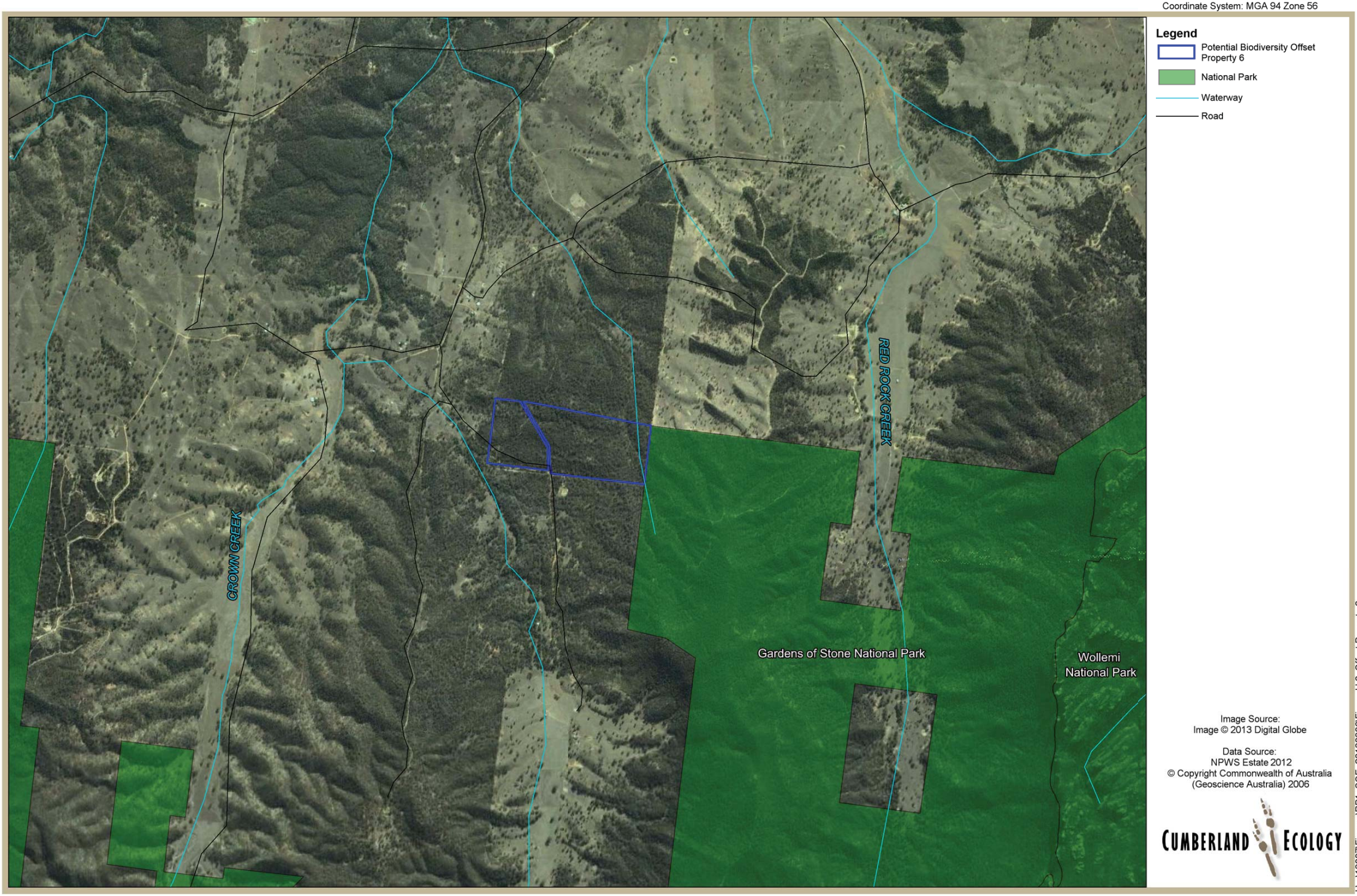


Figure H.6. Contracted Project Potential Biodiversity Offset Property 6

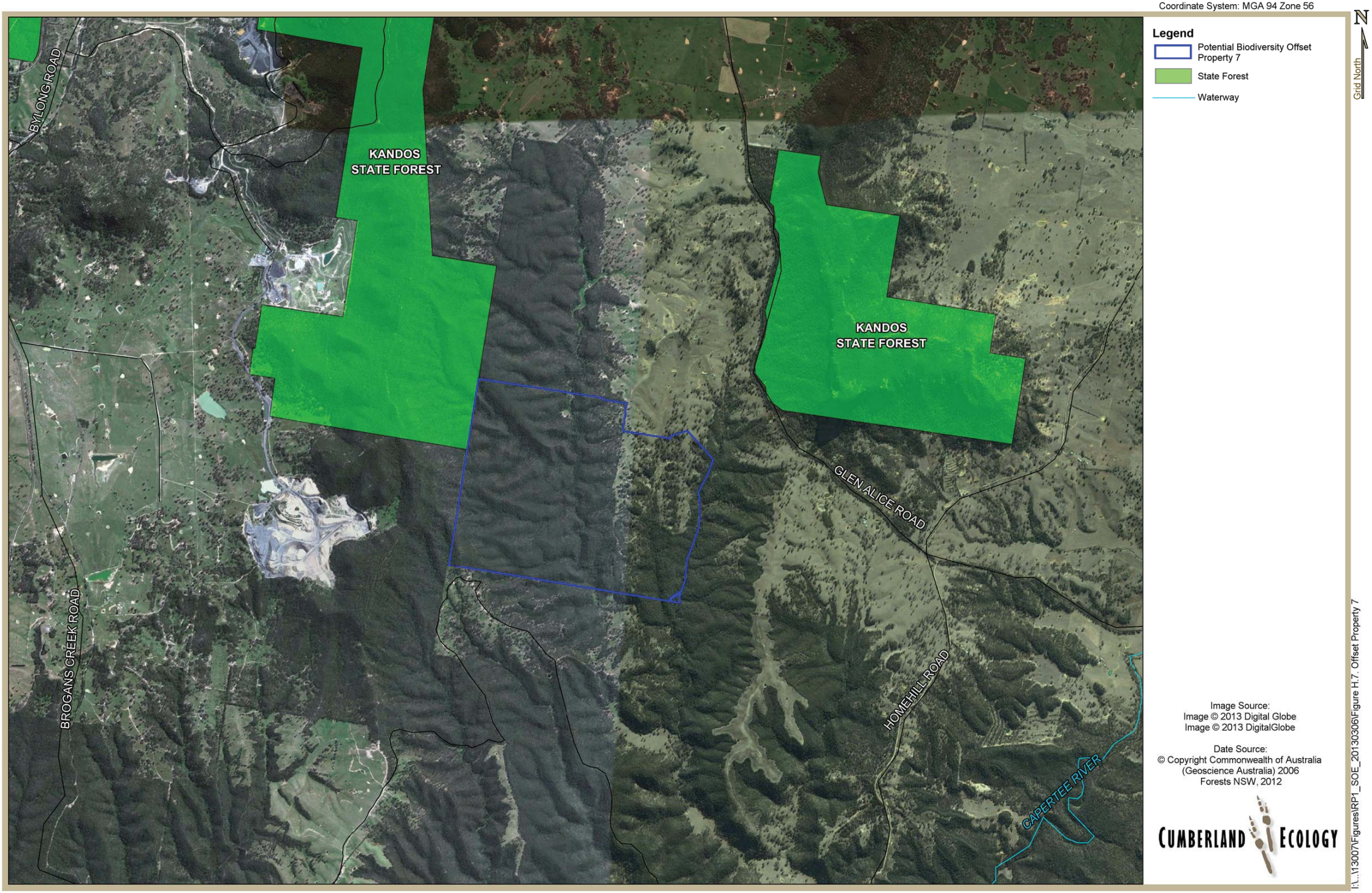


Figure H.7. Contracted Project Potential Biodiversity Offset Property 7

Figure H.8. Contracted Project Potential Biodiversity Offset Property 8

Appendix I

Mt Piper Power Station Rehabilitation 2013

This Appendix provides qualitative data collected at Mt Piper Power Station rehabilitation, which is 18 years old.

Photograph 1 Shows strong growth of Eucalyptus on areas that have had been disturbed

Photograph 2 Numerous large trees and strong ground cover

Photograph 3 Shows the size of the growth on areas that have had been disturbed

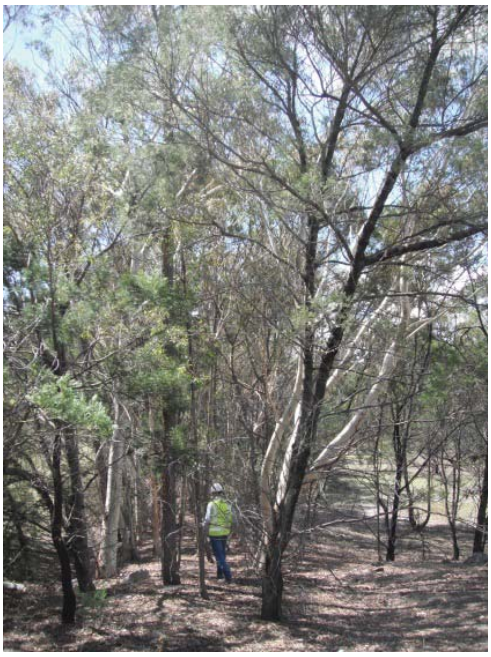
Photograph 4 Strong growth of ground cover and established trees

Photograph 5 A *Eucalyptus* and *Acacia* both >10m high in a heavily disturbed area

Photograph 6 The heavily disturbed area has both strong overstorey and dense shrubs

Photograph 7 Evidence of seed production within the rehabilitated area.

Photograph 8 Evidence of flower and seed production within the rehabilitated area.



Photograph 9 A combination of *Eucalyptus* and *Acacia* thriving to a height >10m

Photograph 10 Evidence of midstorey and over story trees within the heavily disturbed area.

Photograph 11 Strong growth of *Eucalyptus* trees and some younger Acacias

Photograph 12 Established trees but poor ground and shrub cover

Photograph 13 Young *Eucalyptus* striking from natural seeding.

Photograph 14 The boundary where the rehabilitation meets the natural growth. The ground cover in the natural growth is significantly denser.

Photograph 15 Grove of Eucalyptus on the mine waste dump

Photograph 16 Native open woodland adjacent to rehabilitated area.

Photograph 15 Aerial view of photo locations at Mt Piper Power Station.

Appendix J

Andy Markham Peer Review Report

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Bret Leisemann
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26 February 2013

Dear Bret,

Peer Review – Geomorphology of 'Pagodas'

Introduction
As requested, please find herewith a peer review of information and conclusions contained within the report *Ecological Assessment for the Coalpac Consolidation Project – Contracted Project, Response to PAC Review Report (Final Report)*, referred to hereafter as the Response Report.

The review has paid particular attention to chapters 2 and 4 of the above report and considered in particular:

- Definitions used by Cumberland Ecology relating to the definition and description of the pagodas; and
- Appropriateness of the approach used in discussion of pagoda landforms (nomenclature used by Planning Assessment Commission (PAC)).

Qualification to provide this assessment
My experience with reference to this assessment includes:

- Academic (B.Sc (Hons) Environmental Science, Ph.D Fluvial Geomorphology).
- Work experience. Since completing my Ph.D in 1990 I have worked as a consultant on projects relating to fluvial geomorphology, surface hydrology and broader environmental management in Australia, PNG, South East Asia and Africa. For the past 13 years I have worked at Hydrobiology, a consulting company that I co-founded. My CV is attached hereto.

I am a member of the AusIMM and a Chartered Environmental Scientist (M.AusIMM (CP)). I am also a Fellow of the Royal Geographical Society of London and a Chartered Geographer (CGeog).

Background
Pagoda is a term used to describe distinctive rock and associated cliff formations that have formed as a result of the complex weathering of Sandstone. The term pagoda,

according to Washington and Wray (2011) was coined by local interest and conservation groups in the 1980s. Examples of pagodas can be found in the Sydney Basin, including areas immediately adjacent to the Coalpac Consolidation Project (the Project) area where weathering of the Triassic Narrabeen sandstone has occurred. The physiography of the pagodas has been described by Washington & Wray (2011) and was adopted in the Response Report. Washington and Wray (2011) referred to pagodas as being part of a suite of regional sandstone landforms or *pagoda country*, being land that is characterised by these features, and *pagoda complexes* as *...wonderfully intricate, ruinlike, landforms that resemble lost cities and temples...*

Two types of pagodas (based on their shape) have been described by Washington and Wray (2011), platy and smooth. Other descriptions of these features exist in the literature of the Sydney basin. For example, Adamson *et al.* 1983 referred to a *'landscape of rocky towers described locally as minarets'*.

Morphological Processes

Washington & Wray (2011) also described uncertainty with respect to the detail of the processes of Pagoda formation. Processes of weathering are better understood, although acknowledged to be complex. The role of the resistant ironstone banding causing differential rates of aeolian weathering is particularly important in defining the stepped morphology of pagodas while mechanical separation/dissection and vertical incision define the 'pinnacle' morphology.

A variety of other processes affect pagoda morphology at a range of scales as described in the literature. Examples include the interplay of bushfire and faunal activity (Adamson *et al.* 1983), erosional and deposition processes of rainwash, rock and soil creep and bioturbation (with particular reference to sandstone hillslopes (Humphreys & Mitchell 1983)). All of these processes are likely to be variable in time in response to climate cycles and climate change. Young (1982) described block gliding in the Sydney Basin as a process by which separation of sandstone towers from adjacent clifflines could occur.

Geomorphology

Geomorphology describes form and process. From an impact assessment perspective, the geomorphic values of a feature and the risks to those values from the proposed activity need to be considered. The geomorphological values of the pagodas might include aesthetic/recreational (*form*), morphological processes of erosion and deposition (*process*) and ecological (*habitat*) values that are created and supported by these processes.

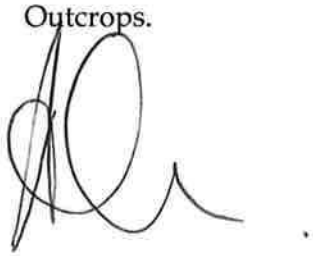
The definition of SPLs used in the Response Report refers to complexes that include rock formations, cliff faces, dissected gullies (characterised by banded ironstone) and associated rock structures and their attributes. Also referred to are the areas between pagodas that support habitat within these complexes. The report also refers to a

relevant landform dimension of *typically greater than 10 hectares*.

From a geomorphological perspective this is considered to be a reasonable classification of a landform unit in the context of the Project. From an impact assessment perspective it allows the values associated with pagoda complexes to be more clearly defined and accurately mapped (both inside and outside the Project boundary) compared to the more broadly defined *pagoda country* referred to by Washington and Wray (2011).

The SPLs represent agglomerations of morphological features including sandstone cliffs and outcrops but are considered distinct from these features which, in isolation, do not exhibit the specific range of values attributed to the SPLs, in particular, the variety of habitat types, topographic variability, and their striking visual appearance. The *pagoda country* of Washington & Wray (2011) encompasses an area containing both SPLs and sandstone features such as cliffs and outcrops (although it is noted that both the Lidsdale-Newnes and Ben Bullen SPLs extend, in places, beyond the boundaries of the defined *pagoda country* in those areas demonstrating more clearly defined mapping). While the SPLs are intended to represent a geomorphological unit, *pagoda country* represents an area in which these units are found.

Figure 1 demonstrates the difference between an SPL and an area of Sandstone Outcrops (as defined in the Response Report) in the Ben Bullen State Forest. The SPL is a more striking and clearly-defined aggregation that exhibits a more varied and distinct morphology and variety of habitat types compared to the Sandstone Outcrops.



Hydrobiology QLD Pty Ltd
Dr Andy Markham (Director)

Figure 1 SPL (top) and Sandstone Outcrops (bottom) in the Ben Bullen State Forest

References

Adamson, D., Selkirk, P.M., and Mitchell, P., 1983, The Role of Fire and Lyre Birds, in the Sandstone Landscape of the Sydney Basin, in R.W. Young and G.C. Nanson (eds), Aspects of Australian Sandstone Landscapes, ANZGG group special publication no. 1.

Humphreys, G.S., and Mitchell, P.B., 1983, A Preliminary Assessment of the Role of Bioturbation and Rainwash on Sandstone Hillslopes in the Sydney Basin, in R.W. Young and G.C. Nanson (eds), Aspects of Australian Sandstone Landscapes, ANZGG group special publication no. 1.

Washington, H. G. and A. L. Wray. 2011. The Geoheritage and Geomorphology of the Sandstone Pagodas of the North-western Blue Mountains Region (NSW). Proceedings of the Linnean Society of NSW 132:131-143.

Young, R.W, 1983, Block Gliding in Sandstones of the Southern Sydney Basin, in R.W. Young and G.C. Nanson (eds), Aspects of Australian Sandstone Landscapes, ANZGG group special publication no. 1.