Cool Country Koala project 2016/2017
Northern Section - Final Report

Prepared for Northern Tablelands Local Land Services

By the University of the Sunshine Coast, Detection Dogs for Conservation

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Contents

List of Acronyms

KHE	koala habitat envelope
NT	Northern Tablelands
NT KRS	Northern Tablelands Koala Recovery Strategy
NT LLS	Northern Tablelands Local Land Services
SD	Standard deviation
PCT	Plant Community Type
USC	in this report: University of the Sunshine Coast's Detection Dogs for Conservation team

Executive Summary

Purpose

The purpose of this study was to determine the status of the koala (*Phascolarctos cinereus*) and describe the tree species used by koalas on the Northern Tablelands of New South Wales. To do this, the study aimed to determine the presence/absence and habitat utilisation of koalas in priority areas of the Northern Tablelands, as identified by the Northern Tablelands Koala Recovery Strategy.

Survey Methods

Field-based surveys of koala scats and flora surveys to confirm Plant Community Types (PCT) were conducted in priority areas. Accessible land tenures were identified within the priority areas in consultation with the Northern Tablelands Local Land Services and community stakeholders.

Survey sites were randomly generated using GIS in Travelling Stock Reserves, National Parks and private properties within the priority areas. Additionally, private landholders volunteered their properties for surveys. Koala scat surveys were primarily conducted using detection dogs trained to locate koala scats (faecal pellets). Trees were also checked for the presence of koalas. Field surveys were conducted on the following dates: 19th June; 19th-31st August; and 13th November-10th December 2016.

Limitations

The sites were surveyed on only one occasion; therefore, the results presented here provide a snapshot of the population during this period and it can be noted that evidence of koalas found within the study areas are likely to change with increased sample size as well as seasonally.

A negative site might reflect that koalas are not using the area (true negative) or that koalas are using the area but the survey failed to detect any scat (false negative), which could occur for example if koalas have not deposited any scat in the 30 trees searched during each survey or if scats have decayed before the survey occurred.

Summary of Findings

USC conducted 267 koala surveys across the northern part of Northern Tablelands, with a focus around Ashford, Delungra and Inverell. An additional 104 flora surveys were conducted.

We detected koala presence at 81 of our 267 surveys (30.3%, SD = 46.1), including 16 koalas. Koala presence in the Ashford priority area was very low (1.3%), whereas the Inverell / Delungra priority area had a large number of sites positive for koala presence (54.4%).

Comparing the current survey to past records, it seems that the Ashford area has seen a large decline in koala presence since 2010.

The tree species, and the presence of scats under them, were ascertained for 5,136 trees. In total, we found scats under 368 trees (7.2%, SD = 25.8). Altogether, 18 individual species were recorded being used by koalas. Tree species commonly used by koalas for this project included: *Eucalytpus blakelyi*, *Eucalyptus melliodora*, *Eucalyptus albens*, *Angophora floribunda*, *Eucalyptus camaldulensis* and *Eucalyptus moluccana.*

For each systematic site, we calculated the activity level which is the number of trees used divided by the number of trees searched. We found that the average activity level per positive site was 21.0% (SD = 17.7).

In this project, we detected koala presence in some plant community types (PCT) more than in others. For instance, Blakely's Red Gum - Yellow Box grassy tall woodland (PCT = 599) was always utilised by koalas, while White Box grassy woodland (PCT = 590) was used more frequently than not.

Wild dog scats were found at 19 sites. In addition, we identified five additional sites with evidence of dogs: four with presence of domestic dogs and one with dog footprints. This resulted in 9.4% of the sites surveyed with some evidence of dog presence.

Grazing was present at most sites (94.2%) with most of them recently grazed (<1 year: 49%; between 1 to 3 years: 27.9%; >3 years 9.6%). However, grazing intensity was classified as light in the majority of cases (moderate only 4.1% of sites, severe 7.1%).

Most flora sites had more than one introduced species, or weed, present (92.3%), and up to 13 species. The infestations, however, were rarely considered to be high enough to prevent natural regrowth. Dieback was encountered across seven sites and classified as light. No severe nor moderate dieback was recorded during the surveys.

Of the 16 individual koalas (including nine adults) we observed, none presented external signs of *Chlamydiosis* (conjunctivitis and/or coloured rump signalling a urinary tract infection).

None of the threats we measured in the field explained the presence or absence of koalas at the survey sites. Although threats to koala survival are well known, quantifying them is difficult. Specific recommendations are given for the Ashford and the Inverell / Delungra priority areas. Some general recommendations (i.e. not specific to particular locations), are also discussed within the following categories:

- management actions to curb threats;
- legislation;
- community engagement; and

- areas for research.

1. Introduction

The koala (*Phascolarctos cinereus*) is an iconic Australian marsupial that is broadly distributed across south-eastern Australia, particularly in regions that have experienced high levels of habitat fragmentation due to human residential, commercial and industrial activities (Martin and Handasyde 1999). Despite their iconic status and global appeal, koala conservation has become a growing national concern (McAlpine et al. 2015). The combined koala populations of Queensland, New South Wales and the Australian Capital Territory are listed as Vulnerable under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (Shumway et al. 2015). In New South Wales, the koala is listed as Vulnerable under the *Threatened Species Conservation Act 1995*. Koala conservation is emphasised heavily in policy and planning at both Federal and State levels, as is demonstrated by the development of the *National Koala Conservation Management Strategy 2009-2014* and the *New South Wales Recovery Plan for the Koala 2008*.

The University of the Sunshine Coast's Detection Dogs for Conservation team (USC) were engaged by the Northern Tablelands Local Land Services (NT LLS) to deliver the Northern Tablelands Koala Habitat Project 2016/2017 – Northern Section, or "*Cool Country Koala project (Northern Section)*". As a whole the *Cool Country Koala project* (i.e. both Northern and Southern) contributes to the objectives of the *Northern Tablelands Koala Recovery Strategy* (NT KRS). The purpose of the NT KRS is to promote recovery, avert any ongoing decline and minimise the risk of extinction of koalas within the Northern Tablelands region in New South Wales.

The Northern Tablelands is a highland region of the Great Dividing Range in northern New South Wales. The region has a temperate climate with mild summers and cold winters. The major towns of the Northern Tablelands are Armidale, Glen Innes, Guyra, Inverell, Tenterfield, Uralla and Walcha. Beef and sheep grazing are the predominant land uses in the region, as well as wool. Other minor land uses include forestry, cropping (cereals, legumes and oil seeds), fruit, vegetables, dairy, alpacas and wine (New South Wales Department of Industry).

The headwaters of the Murray-Darling Basin are on the western side of the Northern Tablelands and the streams on the eastern side of the Northern Tablelands supply the New South Wales north coast (New South Wales Department of Industry). The geology of the Northern Tablelands region is diverse, comprising a mixture of basalts, granites and alluvial soils. This geology, combined with the soils and topography of the region, supports a diverse range of vegetation communities.

Limited scientific information is available regarding the status of koalas on the Northern Tablelands (Hawes et al. 2016). Until recently, the Armidale Regional Council was the only

Council that maintained a record of koala sightings. It is thought that koalas in this Council are relatively stable, however, information suggests that koalas are declining elsewhere on the Northern Tablelands. Most koala sightings on the Northern Tablelands were on private land and, as such, engaging private stakeholders was a key component of this project.

USC performed field-based surveys of koalas in priority areas of the Northern region of the Northern Tablelands, as identified in the NT KRS. Koala surveys were needed in the Northern Tablelands because the status of the koala in this region was previously unknown. USC used highly-trained detection dogs to locate koala faecal pellets (scats) in sites in the priority areas, a method which was proven to be accurate and efficient (Cristescu et al. 2015).

Surveys were conducted over a 6-month period between June and December 2016. USC surveyed sites for koala scats in the following towns and localities: Auburn Vale, Atholwood, Bolivia, Bonshaw, Bukkulla, Copeton, Delungra, Dundee, Emmaville, Frasers Creek, Glen Innes, Gravesend, Gum Flat, Inverell, Liston, Little Plain, Mole River, Mount Russell, Nullamanna, Oakwood, Pindaroi, Sandy Flat, Tenterfield, Tingha, Wallangra, Warialda, Wellingrove and Wylie Creek.

2. Research Aims

2.1 Objectives of the NT KRS and Aims of the NT "*Cool Country Koala project*"

The Northern Tablelands *Cool Country Koala project* contributes to the objectives of the NT KRS, which are to:

- Consolidate and improve baseline knowledge of koala distribution and abundance, threatening processes and impacts upon koala populations on the Northern Tablelands;
- Develop a recovery strategy in collaboration with stakeholders that prioritises actions for koala protection and areas for effective investment on the Northern Tablelands; and
- Build community capacity and engagement across the region through community monitoring of koala populations (Hawes et al. 2016).

As defined by the NT LLS, the aims of the Northern Tablelands *Cool Country Koala project* are:

- To address data deficiencies through systematic, field-based surveys in priority areas, as identified in the Northern Tablelands Koala Recovery Strategy;
- To inform future investment in koala habitat restoration and revegetation; and
- To build a platform of community engagement to initiate community monitoring programs for threatened species and communities, via private/public landholders where surveys are undertaken as part of this project.

This report describes the outcomes of the field-based surveys in priority areas and discusses recommendation for management.

2.2 Project Deliverables

The deliverables and schedule of deliverables for the *Cool Country Koala project* (Northern section) was as follows (Table 1). The present document is the report (referred below as "Koala Management Plan") including the methods and results of the field work, as well as recommendations for future work.

Table 1: Project Schedule

MONTH	ACTION	DELIVERABLES
MAY	• Shortlisted survey sites based on the NT KRS • Collated GIS information • Identified stakeholders (with NT LLS input) • Started developing network • Organised trip to Northern Tablelands, including gatherings	• List of criteria for shortlistings • List of stakeholders, organisations, emails • Gathering locations, dates, times • Media release for advertising the gatherings (with NT LLS input)
JUNE	• Trip to the Northern Tablelands • Workshops with NT LLS • Community gatherings	• Draft work plan with survey timetable, finalised with NT LLS • Capacity-building outputs e.g. number of gatherings, number of NGOs and other groups participating, number of members present at the gatherings
JULY	• Determined final sites • Organised field trip • Maintained network • Summarised outcomes of gatherings	• Final work plan • Final list of survey sites in priority areas
AUGUST-DECEMBER	• Field surveys • Informal meetings with community	• Progress report
JANUARY-MAY (2017)	• Analysis • Writing • Trip to Northern Tablelands to deliver outcomes talks	• Final report • “Koala Management Plan” • Spatial data • Leaflet • Capacity-building output (post outcome talks)

3. Methodology

3.1 Priority Survey Area / Survey Site locations

Based on the Scope of Work for the present project, one of the goals of the Northern Tablelands *Cool Country Koala project* was to ground-truth NT LLS modelling of koala habitat.

However, the MaxEnt modelling (by Envirofactor / the University of Queensland) of koala distribution based on historical data (Museum, Atlas of Living Australia, Community surveys by DEHP) concluded that the dataset was too biased towards human presence (urban areas and roads) to produce useful maps (Hawes et al. 2016).

As a result, priority areas for surveys were taken from the *Northern Tablelands Koala Recovery Strategy* (layer provided by NT LLS, Figure 1). The priority areas were determined by a panel of experts gathered by NT LLS in 2016.

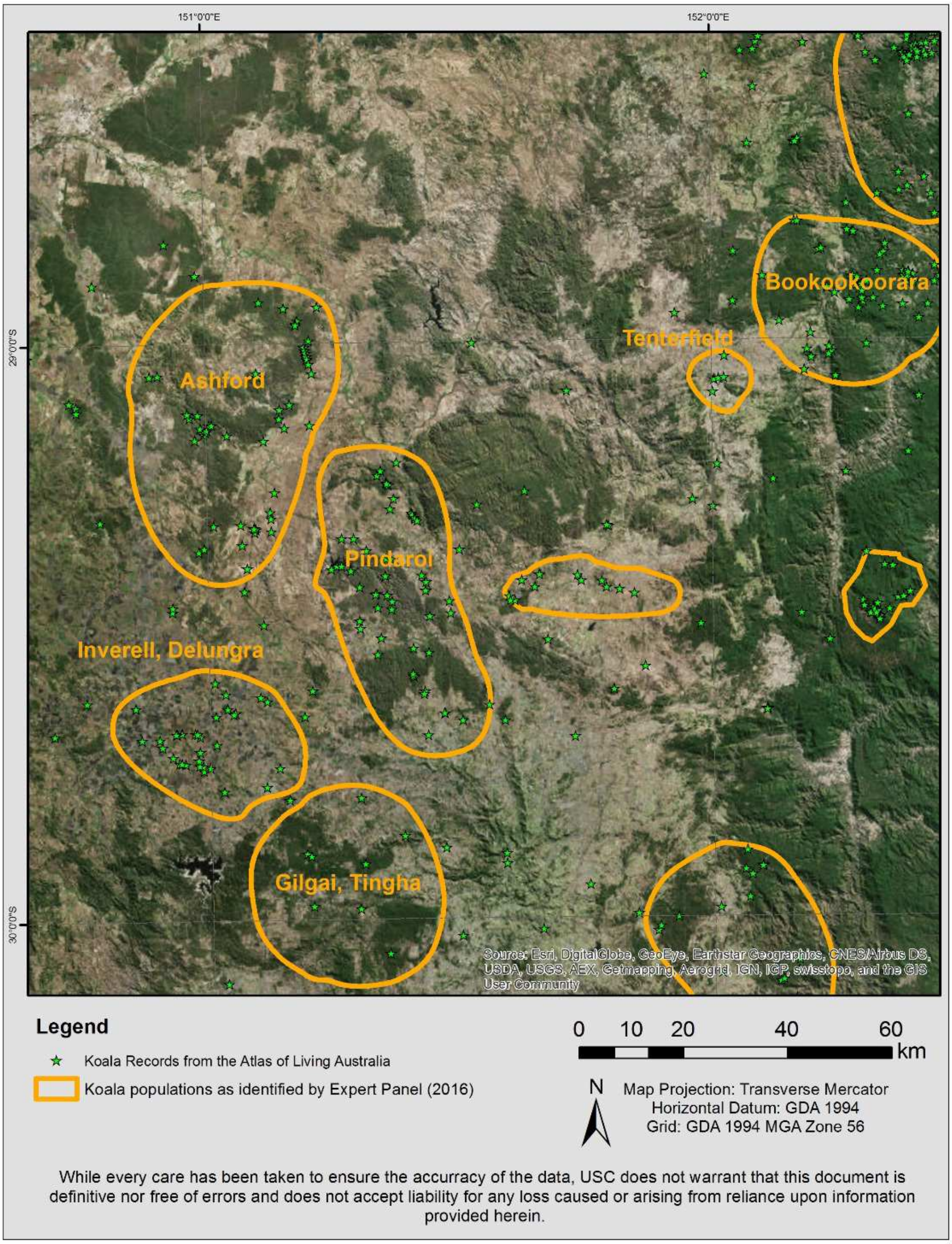

Figure 1: Priority areas in the Northern Section of the NT were taken from the *Northern Tablelands Koala Recovery Strategy*

A desktop study of the Northern Tablelands was conducted using ArcGIS 10.5 (ESRI 2016) to select survey sites within the priority areas identified in the NT KRS. This involved overlaying shapefiles of vegetation, soils, key fauna habitats, land parcels and land tenures in ArcGIS.

Following the desktop study, a Reference Committee workshop was held on the Northern Tablelands with NT LLS and other relevant stakeholders identified by NT LLS to discuss the identified priority geographic areas and prioritise the shortlisted sample sites. The priority areas were divided between the Northern (USC) and Southern (Stringybark Ecological) field work teams. This report only contains the findings of the Northern section.

In parallel with the Reference Committee workshop, a series of community workshops ("Cool Country Koala Field Day") were held on the Northern Tablelands with schools, environment groups and other community groups to introduce the USC detection dogs and maximise the opportunities for more stakeholders to become involved in the project, in particular to gain access to private properties.

Within the Northern area, two priority zones were targeted: the Ashford area and the Delungra / Inverell area. Survey sites were generated within these two priority areas as explained below.

Using Arc Map 10.5, the koala habitat envelope (KHE) layer provided by *Spatial Solutions* was clipped to accessible public property (National Parks, Reserves and Trading Stock Routes). Within this accessible KHE, potential survey point locations were generated using the fishnet tool, where a grid size of 500 m was selected based on koala home range size and to avoid spatial autocorrelation that would result from sampling within the same home range (Ellis et al. 2002, Rhodes et al. 2009). To ensure randomness in potential survey site generation, a random start coordinate was incorporated into the fishnet analysis. Each potential survey point was then assigned the KHE priority attribute corresponding to its location. These KHE priority attribute values range from zero to eight, which represent lowest to highest priority respectively. In-field survey effort was then concentrated on potential sites with the highest KHE priority attribute values. In addition, to ensure representativeness, some low priority sites were also surveyed.

Private properties outside priority areas were also included in the surveys as engagement with Landowners and capacity building for future NT LLS projects were important in this project.

Accessible sites were finalised within the priority areas in consultation with the Northern Tablelands Local Land Services and community stakeholders. Sites were excluded if 1080 baiting was known to have occurred in the area and risk was deemed too high.

3.2 Field Methods

3.2.1 Koala Surveys

Direct observation of animals is time-consuming, particularly for koalas, which have a cryptic nature, occur in low densities, and have large home ranges (Tyre et al. 2001, Kéry 2002). Locating secondary evidence of animals (fur, scats, feathers, tracks, etc.) is a common technique for establishing species occurrence across large areas because secondary evidence indicates species presence (Putman 1984, Wilson and Delahay 2001). The best method to confirm koala presence and habitat utilisation is to use detection dogs specifically trained on the odour of koala scats. USC has proven (and published in the peer-review Journal from Nature, "Scientific Reports,") that the detection dog method surpasses human-only teams in both accuracy and efficiency (Cristescu et al. 2015).

Most of the survey effort in this project involved the deployment of a trained detection dog (Figure 2). Two detection dogs named Maya and Baxter, both Border Collie crosses, were used for the koala scat surveys. Three dog handlers conducted the surveys, Daniel Nugent (DN), Russell Miller (RM), both Research Assistants with the University of the Sunshine Coast and Dr Romane Cristescu (RC). The dog handler was accompanied by Dr Laura Simmons (LS), the botanist in charge of flora data collection for all surveys.

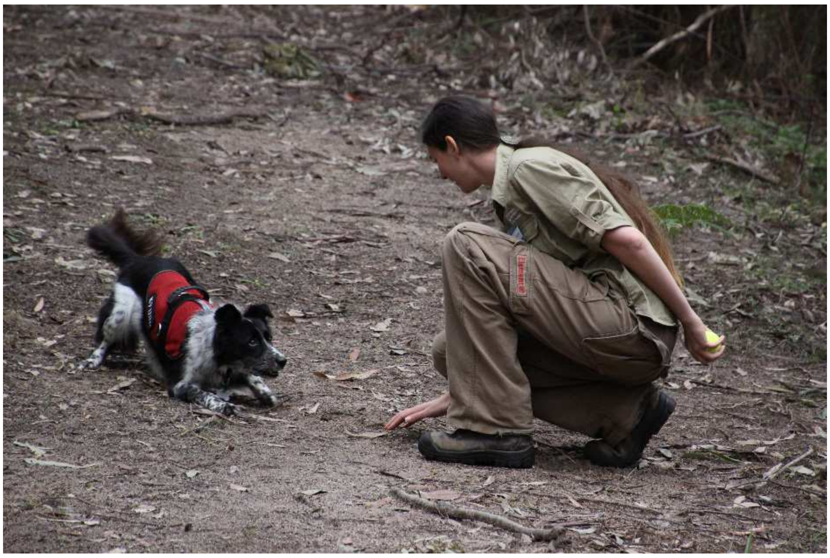

Figure 2: Detection dog Maya waiting to be rewarded after successfully indicating on koala scats (NT LLS "Cool Koala Project Field Day")

Upon arrival at the survey sites and prior to the dog deployment, site information was recorded including location name and survey unique identifying number, and site photos captured. A visual search was performed for the presence of wild dog scats at each site. Any ecological characteristics that might have influenced the detectability and decay of scats were recorded (e.g. wet areas will increase decay rates; therefore, scats will be detectable for a shorter amount of time. Fire also decreases scat survival time).

The dog was then fitted with a GPS collar, motivated with a tennis ball and given the command to search. The GPS tracking of the dog enables us to quantify the survey effort at each site. The dog was rewarded at the end of a survey in which no detections were made, with a planted "reward" koala scat, to ensure a high level of dog enthusiasm during subsequent searches was maintained.

Survey Type 1: Systematic koala scat survey

The survey protocol followed the Koala Rapid Assessment Method (KRAM), which was adapted for use with a detection dog as per Cristescu et al. (2015). At each survey site, 30 trees with a diameter at breast height of more than 10 cm were searched for the presence of koala scats using the detection dog. The trees were centred around the random survey point.

Typical koala scats (Figure 3) have the following characteristics (Triggs 1996):

- symmetrical and bullet-shaped (not jelly-bean shaped);
- generally about 1.5 cm long by 0.5 cm wide (adult koala scat size);
- even-sized and especially fine particles;
- absence of insect parts (koalas do not eat insects); and
- very compact.

Figure 3: Koala scats

When scats were found, the number of scats within a one square meter quadrat, their age category (Table 2) and their size (based on scat width, Figure 4) were recorded as well as their GPS coordinates (GDA94). When only one size of scat and age class (see classification below) is present, the tree is considered less used than when scats of different age classes (indicative of repetitive visits) and sizes (indicative of different individuals) are present. Age of scats allowed us to classify sites as recently used or not.

Fresh scats (Figure 5) that were found on sites were collected in plastic tubes and stored in an esky with an ice brick in the field. Once the research team returned to base, the scats were stored in a freezer to maintain their freshness. These scats were collected in case future research into genetic diversity and health status of the koalas in NT was to happen (scats are currently stored at USC).

Table 2: Scat age categories

Scat Age Categories	Characteristics
1	Fresh (covered in mucus: wet or dry and shiny)
2	Medium fresh (no shine, smells when broken)
3	Old (no shine, no smell)

Figure 4: Scats of different widths

Figure 5: Fresh scats (category 1)

All trees that were searched were identified to species level to determine what tree species were used by koalas compared to all the tree species present.

If the systematic koala scat survey was positive (i.e. koala scats were detected at the site) the site plant community type (PCT, see flora surveys below) was confirmed to be used by koalas and the team proceeded to the next survey site scheduled. If the systematic koala scat survey was negative, a second systematic survey was conducted. If the second koala scat survey was positive, the team proceeded to the next site. If the second koala scat survey was negative, a casual survey was conducted. The second and third surveys were conducted approximately 100 metres apart within the same PCT to allow a thorough assessment of koala presence in that particular PCT (i.e. to decrease the risk of false negative results).

Survey Type 2: Casual koala scat survey

The casual surveys, in contrast to systematic surveys, cannot be compared in space and time, nor do they give insight into utilisation rates of the habitat. The casual surveys are however an excellent and fast way to determine whether koalas are present at a specific site. This method is indeed designed to maximise the chance of detecting koala presence in the minimum amount of time. In this project, casual surveys were used 1) to decrease the risk of false negative in PCT or 2) to increase coverage.

In the casual surveys, the dog is not constrained by the handler to check 30 trees, and can follow its nose roaming over an area of up to two hectares within an approximate 30-minute timeframe, or until the handler deems the search to have covered the site thoroughly. The search duration is usually less than 30 minutes, and can be as short as a couple of minutes if koala scats are detected. The start point of the survey can be determined by the handler, on site, and rely on the handler's assessment of the potential for the area to be used by koalas (this increases the chances of finding koala scats but also increases bias); or can be random.

The same scat details (age and size of scats) recorded for systematic surveys were recorded for casual surveys. Only the specific trees with koala scats underneath were recorded in casual surveys.

Survey Type 3: Incidental koala / koala scat surveys

Researchers conducting the surveys are always on the lookout for incidental, or opportunistic, spotting of koalas and koala scats. These can happen while on foot or in the car, moving between survey sites; or thanks to information passed on to USC researchers from members of the public, property owners or passers-by. The public is always considered as a source of knowledge and individuals are questioned on koala presence, past and present, whenever possible.

When koala scats were located during incidental surveys, the same scats information were recorded and, as previously mentioned, any fresh koala scats were collected for potential future analysis in the laboratory. Tree species was again recorded.

When koalas were located during incidental (as well as systematic or casual) surveys, they were observed with binoculars to try to ascertain: 1) koala sex; 2) external signs of *Chlamydia pecorum* infection (Polkinghorne et al. 2013), often referred to as pink eyes (for ocular infection/conjunctivitis) and wet or stained rump (for urinary tract infection); and 3) presence of a joey (pouch or back young).

3.2.2 Flora Surveys

Flora surveys were conducted in conjunction with the systematic koala scat surveys (Survey Type 1), to match the vegetation to a *Plant Community Type* (PCT). This was to allow the data to be compared to existing datasets and models that use PCT as the vegetation classification.

Upon arrival at the survey sites and prior to the dog deployment, site information was recorded including location name, survey unique identifying number (identical to koala survey), tenure, owner, soil texture and colour and soil origin. A temporary 20 m x 20 m square plot was established at the location of the random point or at a compass bearing and number of paces from a random number table. The coordinates of the North-East corner of the plot was recorded with a GPS (GDA94) and site reference photos were taken.

Within the plot, the following information was recorded:

- identity of all tree species;
- number of adults and seedlings of each species,
- percentage foliage cover of overstorey species (total, not by species);
- dominant shrubs (>1m tall) – minimum of 3;
- groundcover shrubs (<1m) – minimum of 3;
- groundcover grasses – minimum 3;
- exotic plants (all strata);
- linear length of coarse woody debris with small end diameter >10cm;
- percentage cover of bare ground; and
- the number of trees with DBH > or < 50cm.

A threat assessment was conducted over the whole area of the koala scat survey, including the area of the 20 m x 20 m quadrat. This included recording the presence or absence and the intensity of the threats to koalas and their habitat, including:

- Grazing frequency, which was classified as:
    - Recent: fresh dung;
    - Not recent: dry dung;
    - Old: other signs (tracks, etc.).

- Grazing intensity, which had the following categories:
    - None,
    - Light: noticeably grazed but with grass coverage,
    - Severe: little grass coverage or grazed extremely low.
- Tiger pear *Opuntia aurantiacea* intensity:
    - None,
    - Light: rare in frequency,
    - Severe: occasional to common.
- Weeds preventing regeneration of overstorey intensity:
    - None,
    - Light: rare to occasional,
    - Severe: thicket.
- Tree dieback intensity:
    - None,
    - Light: rare to occasional,
    - Severe: common.

The presence of other koala threats such as signs of feral animals, proximity to major roads, presence of threatened species, recent disturbance, wild dogs, fire or any other matters relevant to the project.

Upon return from the field, the coordinates of survey sites from each flora survey were overlaid with a digital elevation model for New South Wales in ArcGIS. Altitude, slope and aspect were extracted for each site location using standard ArcGIS geoprocessing tools.

3.3 Health and Safety

A Job Safety Analysis was completed. Maya and Baxter have both been professionally trained so as not to pose a threat to wildlife. The wellbeing of the dogs is ensured by Animal Ethics approvals (USC: AN/A/14/91). Maya and Baxter are regularly treated against ticks and are regularly checked, as well as both being insured in the event of a snake bite. Surveys were conducted only after it was confirmed that no known wild dog baiting occurred in the areas to be surveyed, and the dog wore a muzzle. The dogs were thoroughly brushed before entering the area so that no weed propagules were introduced. The handler was always in view of the dog and controlled the movements of the dog by voice, which means the risk of the dog escaping and getting lost or injured was remote.

Surveys were conducted under valid wildlife and scientific research permits (OEH permits number SL101741 under the SCIENTIFIC LICENCE NATIONAL PARKS & WILDLIFE ACT, 1974, Section 132c ; Forest permit – Research number HF54891 delivered by Forestry Corporation NSW).

3.4 Data Analysis

All data collected in the field were compiled in two master spreadsheets (part of the raw data given to NT LLS as a deliverable in this project) in Excel (Microsoft Office Professional Plus 2013).

The Koala master spreadsheet contains tabs on:

- The unique site information (one line per koala survey): includes date, site name (naming convention is N (for Northern area of the Northern Tablelands) then year (two digit), month, day, survey number for the day), time, location, site coordinates (Easting/Northing, in UTM 56 GDA94), type of survey (systematic, casual, incidental), past koala sightings (from engagement with the community), koala sighted during the survey, koala and wild dog scat detection, activity level, freshest scat found at each site, as well as some notes.
- The tree information (one line per tree surveyed): added in this tab are each tree species searched as part of this project, whether scats were found under each tree, age of scats, size of scats (one size or multiple sizes), whether scats were found within a one meter radius around the tree trunk, coordinates and any notes.
- Several tabs that present calculations used in this report.

The Flora master spreadsheet contains tabs on:

- Site data: for each flora site, general information including date, site name (note that the site name matches the koala survey site where it was performed), whether koala presence was associated with this PCT (calculated based on one, two or three koala surveys at the PCT site), whether past koala sightings were associated with this PCT (from engagement with the community), coordinates of the flora plot, tree size in the overstorey layer (number of trees larger or smaller than 50 cm Diameter at Breast Height), percent foliage cover, percent of bare ground, fallen logs, grazing frequency and intensity, presence of Tiger pear, whether the density of weeds was considered high enough to prevent native vegetation natural regrowth, dieback, any other threats noticed on site, as well as elevation, aspect, slope and soil data.
- Species overstorey: gives a count of the number of individual adult trees and seedlings for each species and at each site for overstorey species.
- Species midstorey: gives the presence or absence for each species and at each site for midstorey species.
- Species - Native groundcover: gives the presence or absence for each species and at each site for ground species
- Species - Groundcover Grasses: gives the presence or absence for each species and at each site for grass species.

- Species - Exotic Plants: gives the presence or absence for each introduced species at each site (all stratum included).
- Several tabs that present calculations used in this report.

The habitat utilisation was described in terms of activity level (Phillips and Callaghan 2011), which is calculated by dividing the number of trees with scats by the total number of trees searched at the site (30) for each site where systematic surveys were performed.

Strike rate for each tree species was also calculated by dividing the number of trees with koala scats by the total number of trees of that same species at all positive sites (Phillips and Hopkins 2008). This provides a measure of tree species use, which can be considered an indicator that koalas are actively selecting particular tree species.

Historical sightings from all known koala databases were plotted on maps of the Northern Tablelands and compared with the locations of positive scat searches during the study. This enabled us to examine changes in koala habitat use on the Northern Tablelands. We compared our study with historical koala sightings to identify sites where koalas previously occurred and are no longer present, as well as sites where koalas have not been recorded in the past but where scats were found in the study.

The flora data were used to determine PCT at each locations where systematic koala surveys were performed. From this, we were able to link koala presence (past and current) to PCT. The flora surveys also allowed us to map some potential threats to koalas (e.g. weeds, dieback, grazing).

All results were mapped in ArcGIS 10.5, all graphs were produce using JMP 12.1.0.

To investigate the impact of threats (grazing frequency, grazing intensity, presence of weeds, dieback and wild dogs) and vegetation structure and site characteristics (trees with DBH > 50 cm, projective foliage coverage, elevation, aspect, slope), on koala presence, we built models of the response variable koala presence / absence with all variables fitted as fixed effects. The generalised linear models were built and analysed in R version 3.2.0 (R Development Core Team 2015) using the logit link for the binomial error family.

To investigate whether there was an effect of tree species on the presence of koalas, we fitted a cumulative link mixed model for koala presence / absence with tree species as a fixed effect, and site as a random effect. The data included all tree species at all sites (for casual and systematic surveys), the response variable was whether koala presence was detected at the site. This was done using the ordinal package in R and a probit link function.

Further to this, we investigated whether, in positive sites, koalas were preferentially using certain species of trees. To do this, we fitted the proportion of times koala scat was found under each species at each site in a binomial general linear mixed model. Tree species was included as a fixed effect and site was included as a random effect. We accounted for the distribution of tree species at each site by including the proportional representation of that species as a fixed effect. The data included all tree species at all positive sites (for casual and systematic surveys), the response variable was whether koala scats were detected under each tree. This model was fitted using lme4 package in R.

4. Research Outcomes

4.1 Summary of Surveys

Field surveys occurred on the following dates: 19th June; 19th-31st August; and 13th November-10th December. A total of 267 koala surveys were performed, including 166 systematic, 88 casuals and 13 incidental surveys.

A total of 104 flora surveys were conducted, for a species list of 37 overstorey species (Figure 6), 35 midstorey species, 124 ground species with an additional 50 grasses, and 56 introduced species.

We encountered 26 PCT (see description in Appendix 1). For PCT positive for koala presence, koala signs were detected at 73.1% during the first systematic survey, 25.0% during the second systematic survey and only 1.9% during the third survey (casual). This indicates that false negative rates should be minimal.

While interpreting the results from this project, the reader should keep in mind that an intense rain event occurred during the surveys (delaying most of the field work until after the rain / flooding receded, in November 2016). Intense rain is known to affect scat persistence, both by washing scats away and by increasing their decay (Cristescu et al. 2012). During field work, rain was noted as an influencing factor at 41% of the sites (i.e. recent rain / flooding signs were present). Fire is also a factor that can increase scat decay; signs of fire, however, were never encountered in this project.

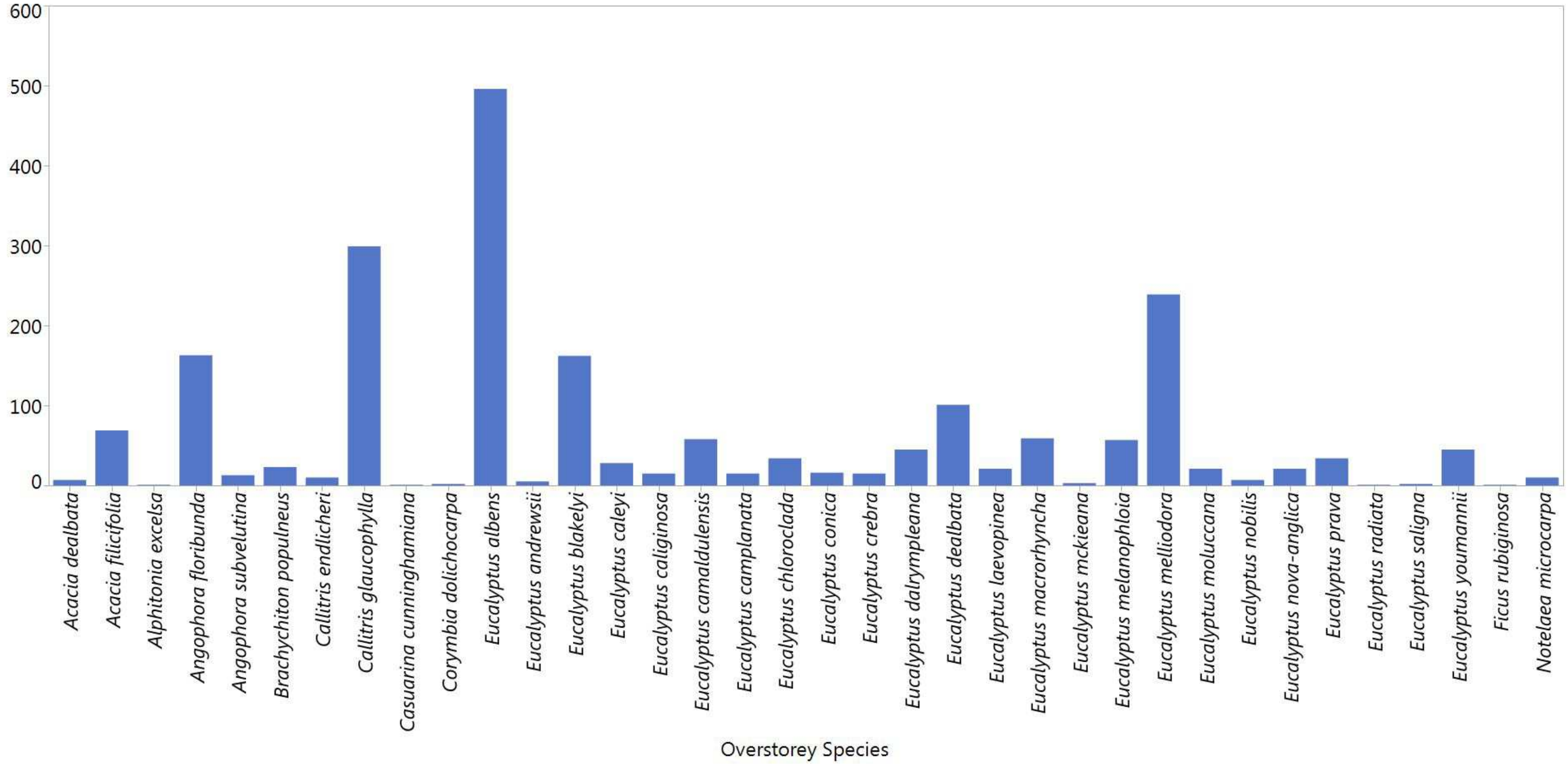

Figure 6: Total number of individuals for all overstorey species encountered in 104 flora surveys

4.2 Presence / Absence of Koalas in Priority Areas and Comparison to Historical Records

We detected koala presence at 81 of our 267 surveys (30.3%, SD = 46.1, see Figure 7). Koala presence in the Ashford priority area was very low (1.3%, as only one site had koala scats in 74 surveys, Figure 8). The Ashford priority area was surveyed before the large rain event, therefore higher decay rate could not have been the cause of the low detection rate.

Contrary to the Ashford priority area, the Inverell / Delungra priority area had a large number of sites positive for koala presence (54.4%, or 62 positive sites in 114 surveys, Figure 9). This area was surveyed after the rain event so presence may in fact be underestimated.

The tree species and the presence of scats under these trees was ascertained for 5136 trees (this encompasses all types of surveys, i.e. systematic, casual and incidental surveys), with 368 trees being positive for scats (7.2%, SD = 25.8).

When we were on private properties, or if a member of the public was encountered during a survey, we enquired whether koalas had been sighted in the past at the survey site. We recorded past koala sightings at 29 sites. We could then compare areas where koalas had historically been present to where they are currently found (Figure 10). From this and records from the Atlas of Living Australia (Figure 11), it seems that the Ashford area has seen a large decline in koala presence. There has been no koala sighting reported in the Ashford priority area since 2010 (Figure 11).

Koala presence was also confirmed in other priority areas that were not specifically targeted by this project, but that were visited on occasions due to the presence of landowners participating in the project. Pindaroi and Bookookoorara priority areas had confirmed koala presence. No koala presence was detected in the Gilgai / Tingha priority area, however there was only six sites surveyed.

An area that was not previously identified as a priority area is the area to the West of priority area “North east of Tenterfield” (see blue box in Figure 7), where six in eight surveys were positive for koala presence.

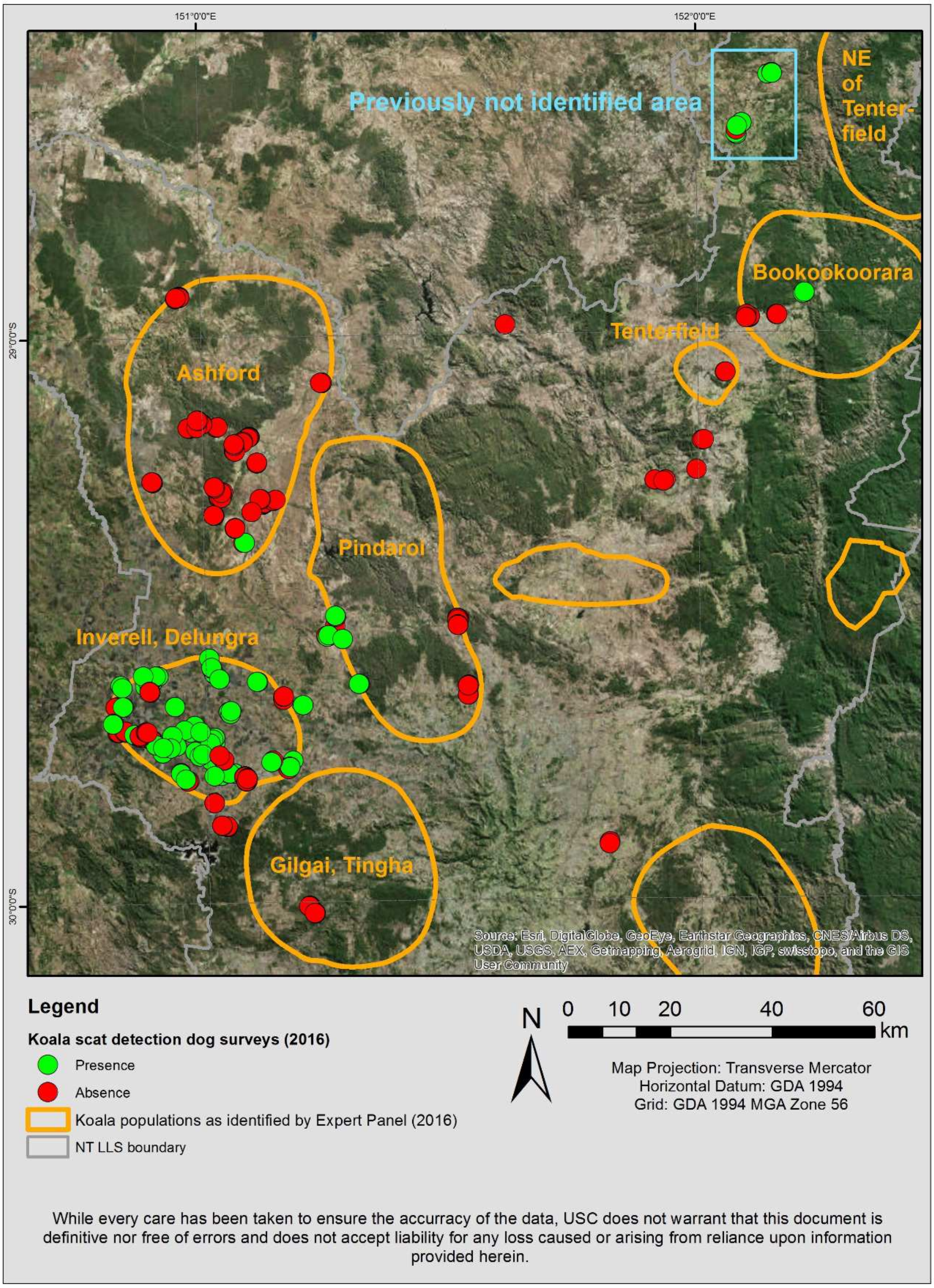

Figure 7: Koala survey sites where koala presence (scats or live animal) or absence was recorded

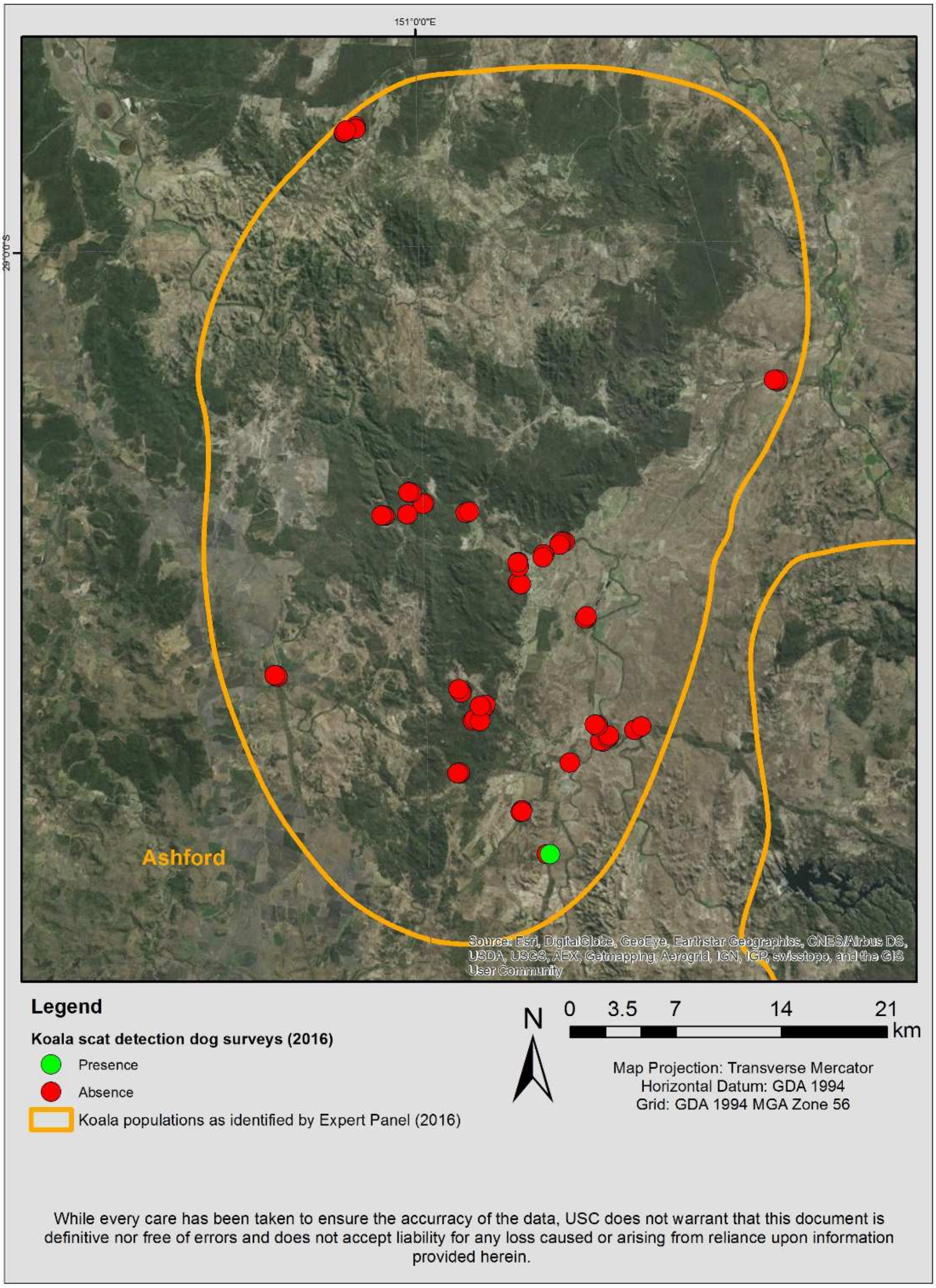

Figure 8: Koala sites where koala presence (scats or live animal) or absence was recorded in the Ashford area

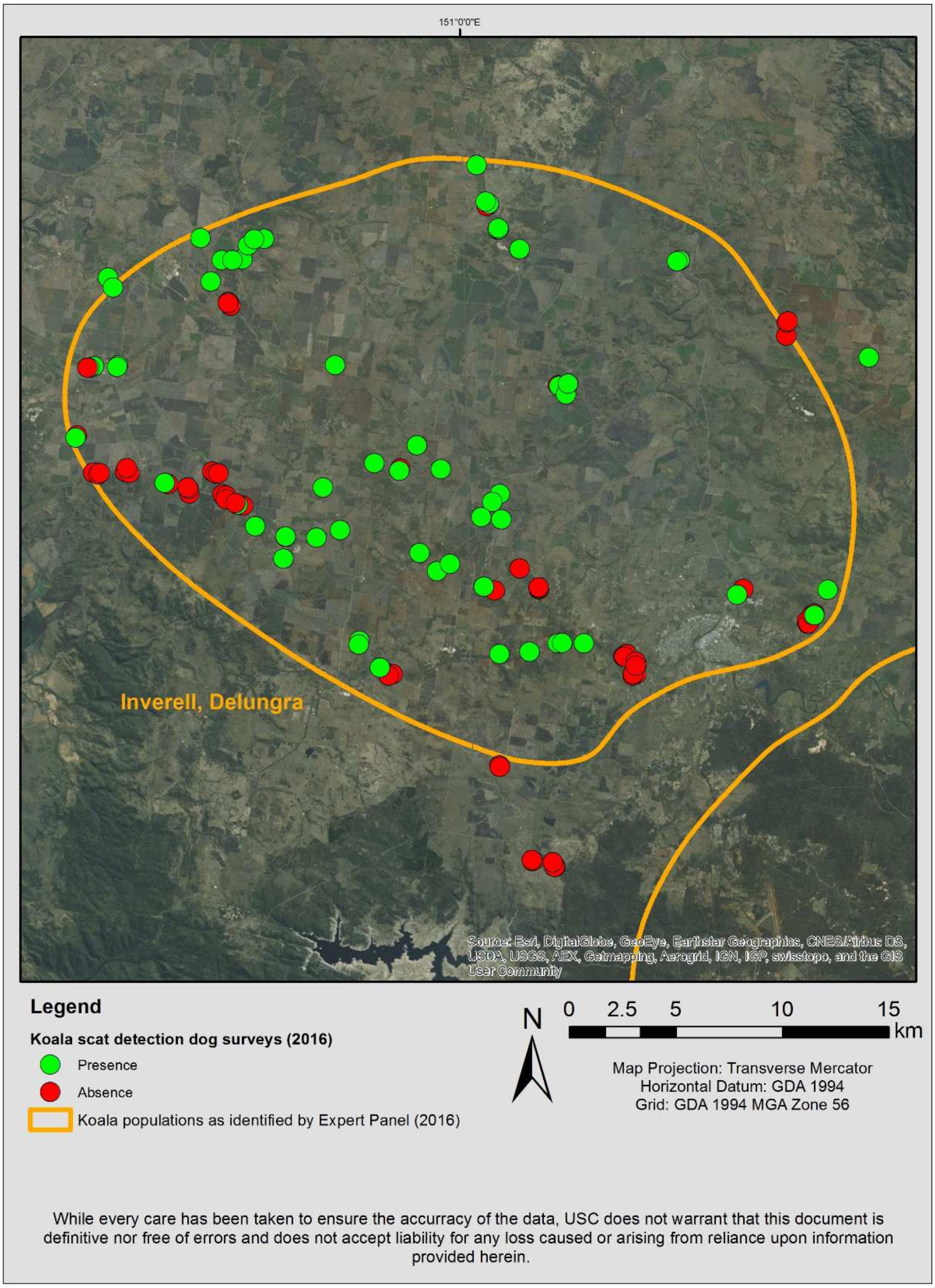

Figure 9: Koala sites where koala presence (scats or live animal) or absence was recorded, in the Inverell / Delungra area

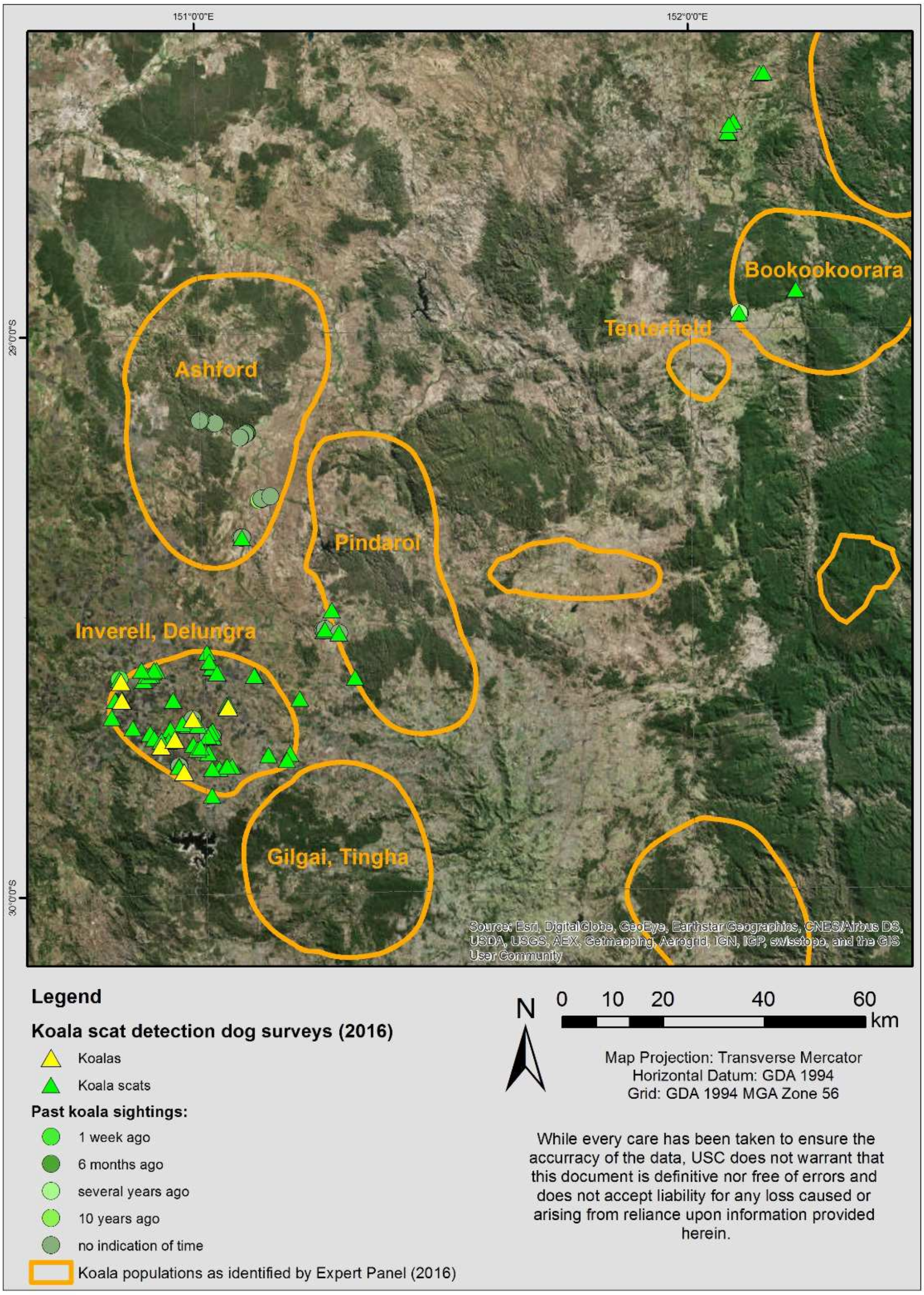

Figure 10: Koala presence recorded as part of this survey from field work and community engagement (i.e.: past koala sightings)

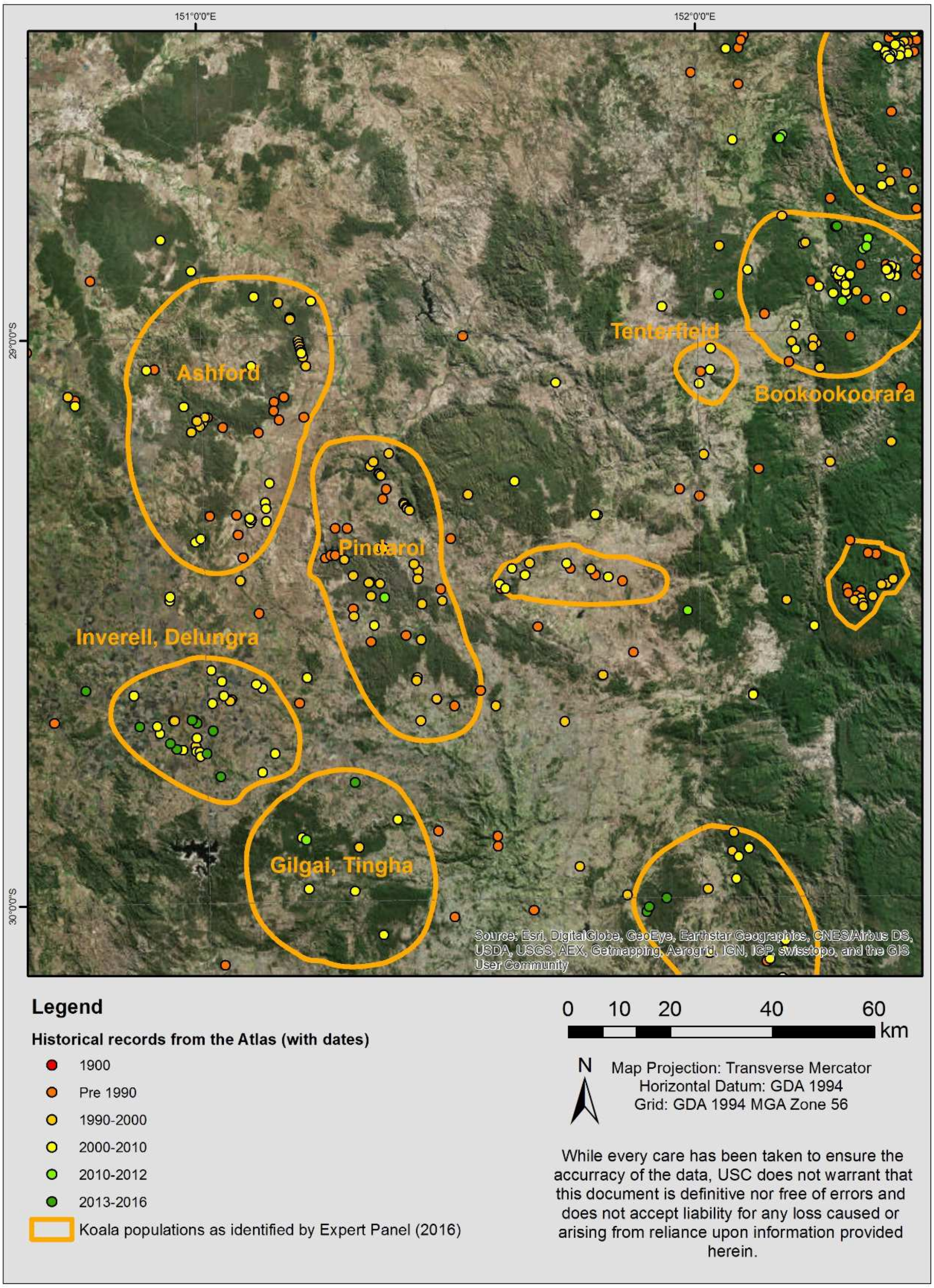

Figure 11: Historical data on koala presence from the Atlas of Living Australia (records with no date have been excluded)

We recorded koalas at eight sites (two systematic, two casual and four incidental sites) for a total of 16 individual animals (see example of two females with back young in Figure 12). One site had two females with back young (four koalas), five sites had one female with a back young and two sites had one adult koala (one female, one sex unknown). It is interesting to note that most animals were females and that most females had back young. Even though the sample size is small, this is a positive sign for the breeding status of the population.

Figure 12: Female koalas with back young

4.3 Activity Levels

During systematic surveys, 4980 trees were systematically searched for the presence of koala scats. Of these, 315 were found to have scats, therefore the average activity level was 6.3% (SD = 24.3).

Activity levels however differed greatly between sites (0 to 70.0%, Figure 13) and particularly, as seen above, between areas (activity level averages: Ashford 0.0% vs. Inverell / Delungra 8.3%, SD = 15.5, Figure 14).

For comparison, in a survey we conducted in the Noosa Council, Queensland, systematic surveys (N = 207) had between 0% and 36.7% activity level, for an average across all sites of 3.1% (note that site selection method in the Noosa Council differed, unpublished data).

The average activity level for positive sites (i.e. sites with koala signs) was 21.0% (SD = 17.7) for the whole project and 29.6% (SD = 18.1) in the Inverell / Delungra area.

At the regional level, the northern part of the Northern Tablelands would be classified in low to medium use of habitat available (see Table 3 from Phillips and Callaghan (2011)). The Inverell / Delungra area would be classified medium to high use.

Table 3: Table extracted from Phillips and Callaghan (2011) showing Activity Levels for positive sites in different surveys (East coast includes: Campbelltown, Port Stephens and Noosa ; Western plains comprises of Pilliga and Walgett)

Activity category	Low use	Medium (normal) use	High use
Area (density)			
East Coast (low)	-	≥ 3.33% but ≤ 12.59%	> 12.59%
East Coast (med – high)	< 22.52%	≥ 22.52% but ≤ 32.84%	> 32.84%
Western Plains (med – high)	< 35.84%	≥ 35.84% but ≤ 46.72%	> 46.72%

Note that for 301 scat detections, we recorded whether the scats were within a one meter radius of the trunk (where most human searches focus), which they were 79.4% of the time. This should be taken into consideration when comparing Activity Levels that are calculated using only a one meter radius search.

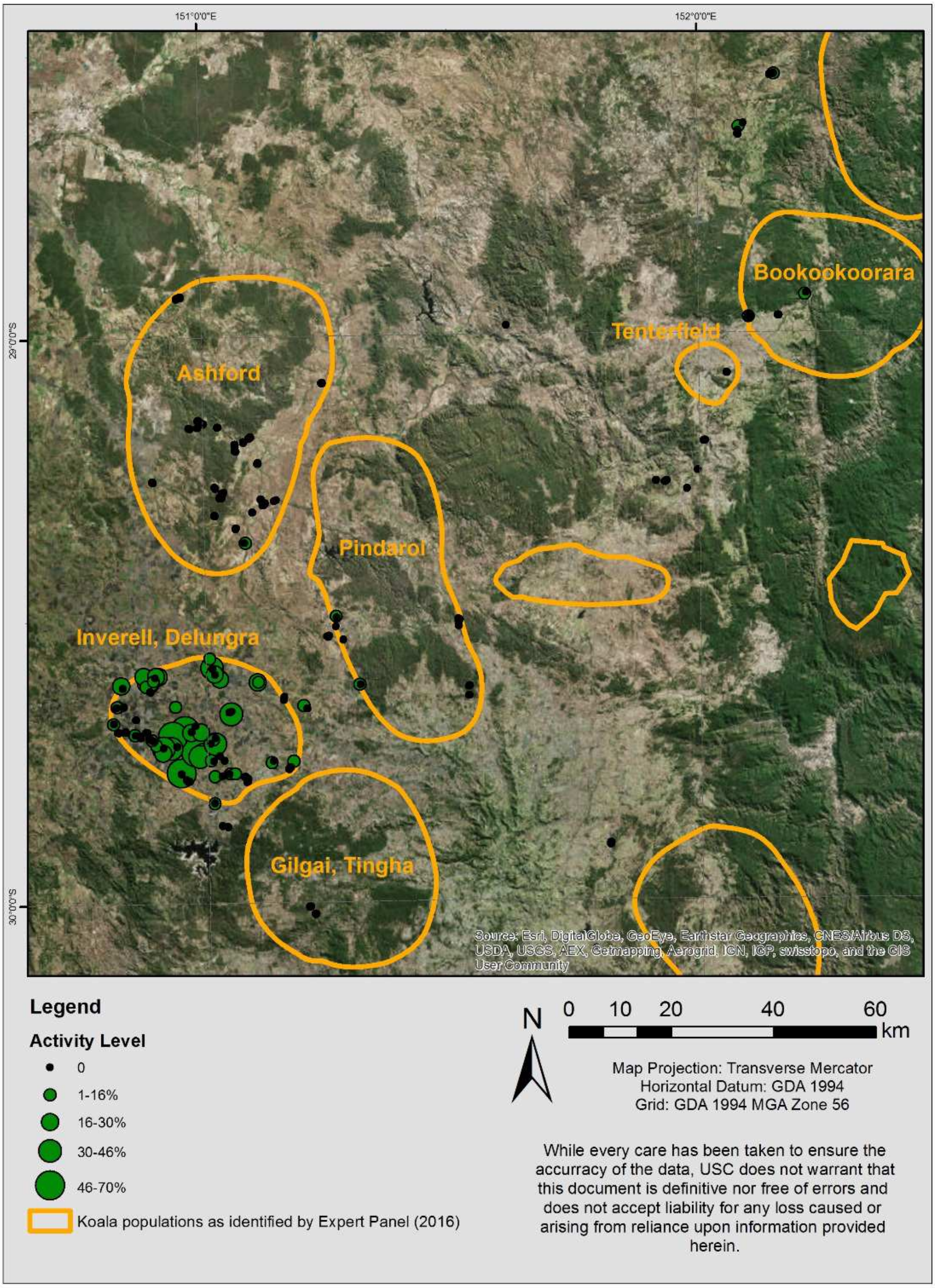

Figure 13: Activity level (percent of trees with koala scats in 30 trees checked during systematic surveys)

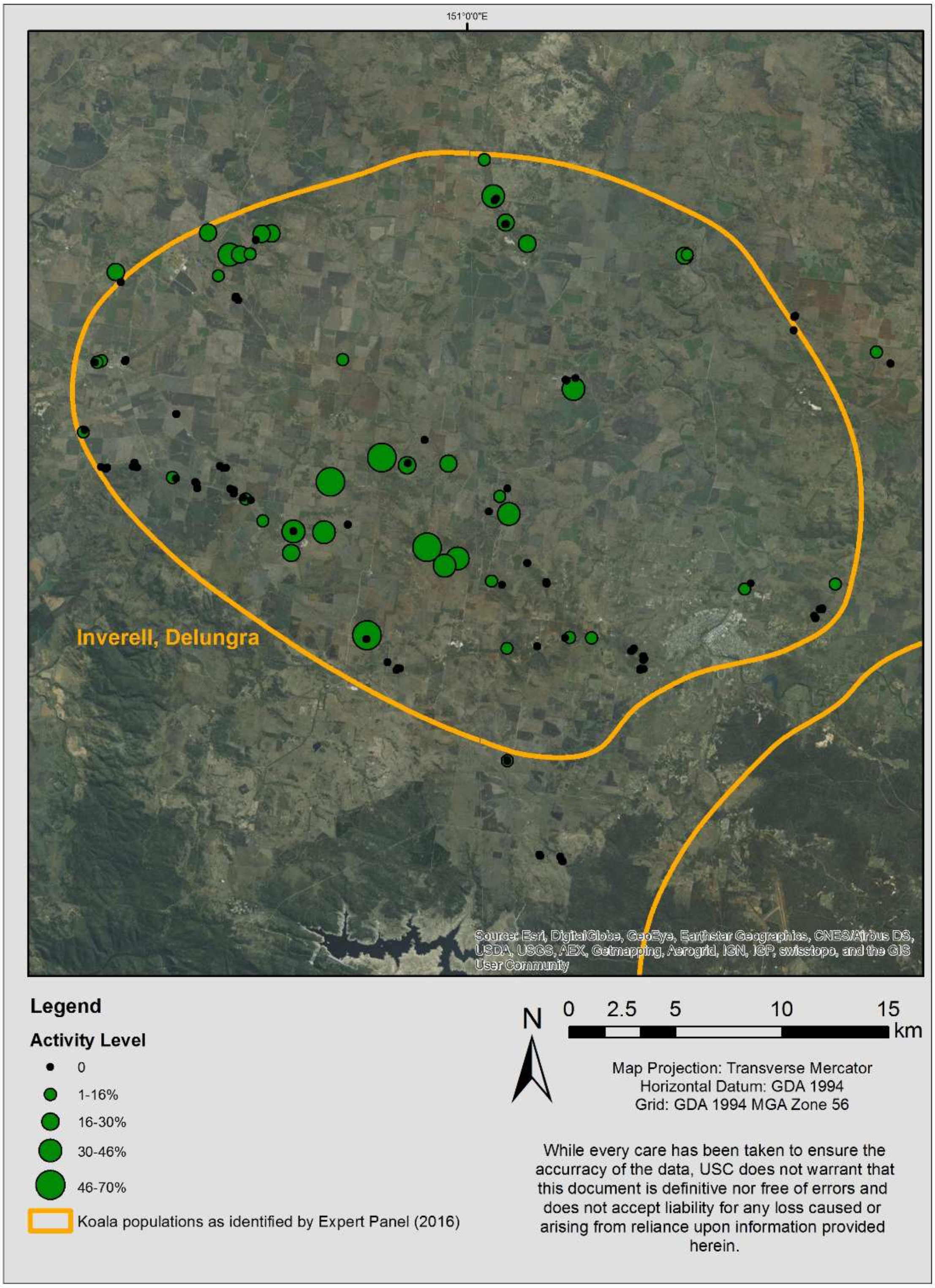

Figure 14: Activity level for the Inverell / Delungra priority area (percent of trees with koala scats in 30 trees checked during systematic surveys)

4.4 Scat Age, Size and Density

Scat age was recorded because fresh scats indicate recent use (< one month) of the area by koalas, whereas old scats can be several months to several years old (Figures 15 and 16 (Rhodes et al. 2011a)). In positive sites, the freshest scats found were: fresh scats for 18.6% of the sites, medium fresh scats for 41.4% of the sites, and old scats for 40.0% of the sites.

We recorded scats of more than one size in quadrats (indicative of different koala individuals using the same tree) at 13.8% of the trees. This needs to be considered a minimum number of trees used by more than one koala as it is based only on differences of koala scat sizes, therefore on differences in koala sizes.

Density of scats ranged from 1 to 58 scats / m^2, with an average of 6.7 scats / m^2 (SD = 8.9). Average number of scats was lower for NT than previous USC projects in Gympie and Fraser Councils (note that the methods used for site selection differed, Table 4). This difference might be a consequence of the large rain event that may have increased scat decay rate.

Table 4: Scat density in this project compared to two projects in Queensland (USC, unpublished data)

	NT	Gympie	Fraser
Max	58	56	60
Average	6.7	14.9	10.2
SD	8.9	12.4	11.0

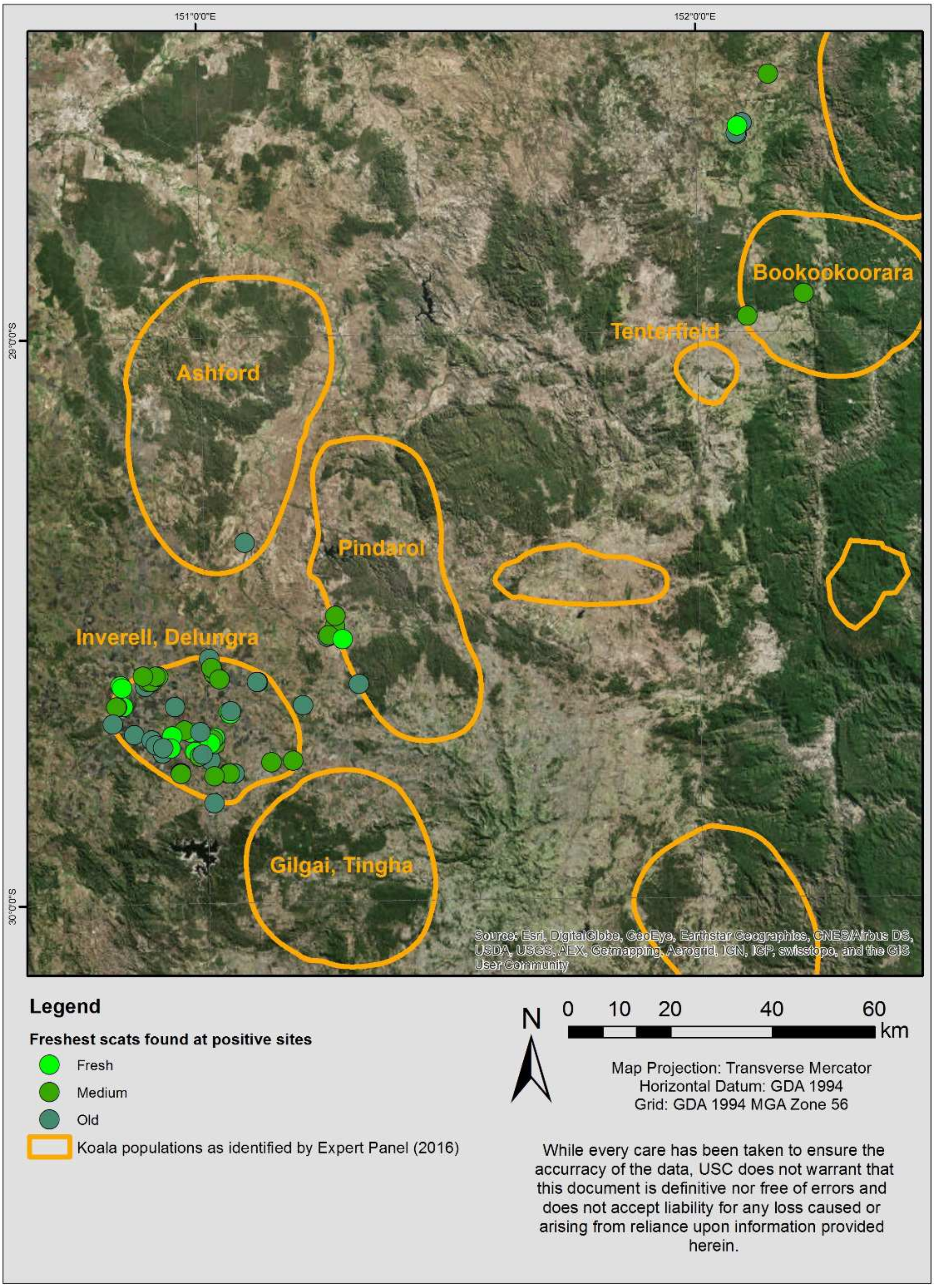

Figure 15: Age of the freshest scats detected at each site with koala presence for the whole study area

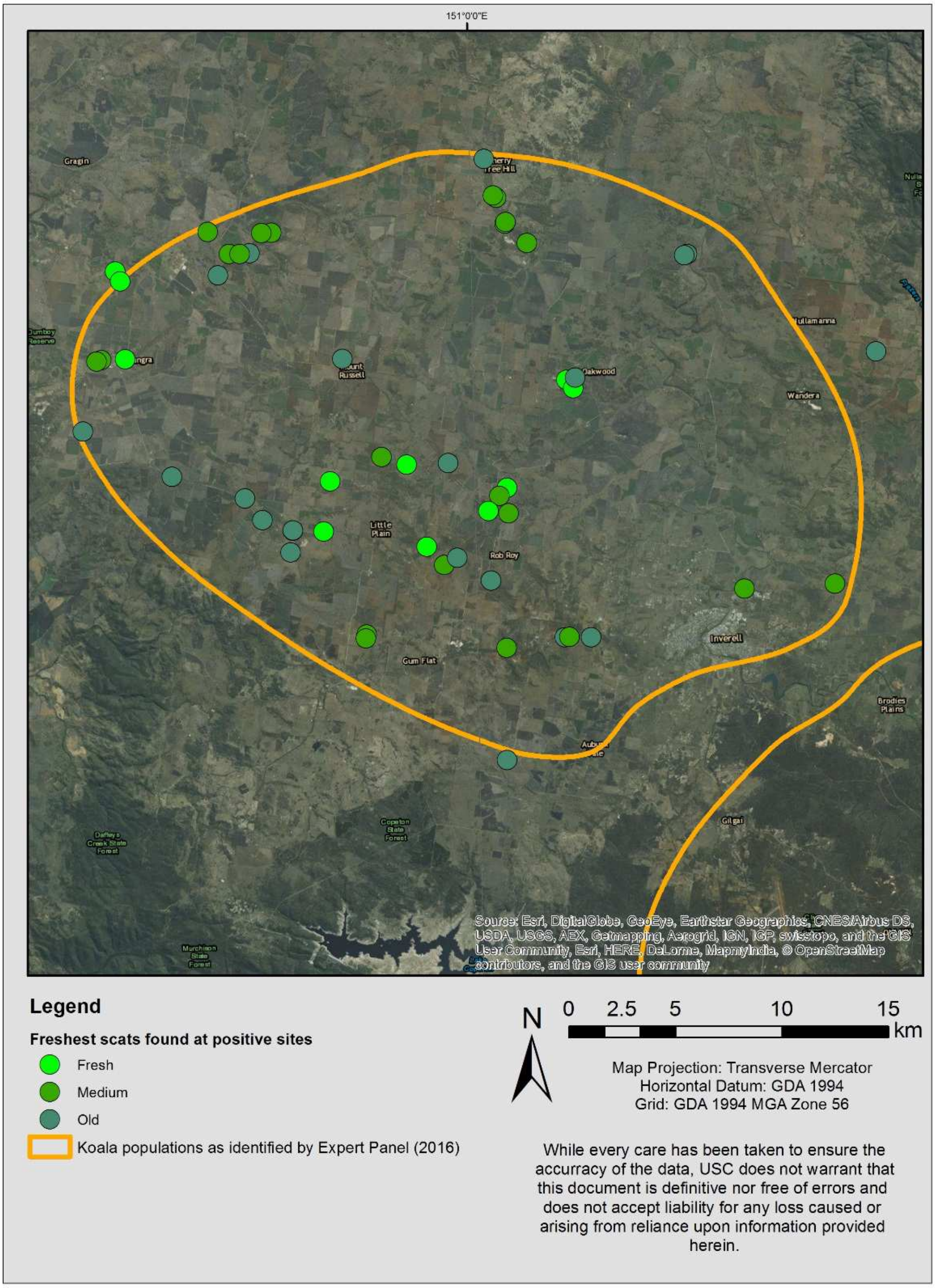

Figure 16: Age of the freshest scats detected at each site with koala presence, Inverell / Delungra priority area

4.5 Tree and Plant Community Type Use

4.5.1 Tree Use Across All Surveys

During the koala surveys, we identified the species of 362 trees with koala scat. Altogether, 18 individual species were recorded as being used by koalas (Table 5). Tree species commonly used by koalas during this project included: *Eucalytpus blakelyi*, *Eucalyptus melliodora*, *Eucalyptus albens*, *Angophora floribunda*, *Eucalyptus camaldulensis* and *Eucalyptus moluccana.*

It is worth noting that the presence of koala scats under a tree does not ascertain whether koalas used that tree for feeding (Melzer et al. 2014). This is because koalas sit in trees all day long but only feed for a small amount of time throughout the day, therefore their droppings can, for instance, be found under trees selected for shelter (for example, for thermoregulation (Briscoe et al. 2014)). A common example of this is the use of native pine trees, *Callitris sp.*, which are favoured by koalas during the day (probably for their shady canopy) but rarely eaten (Cristescu et al. 2011).

Table 5: Tree species found with koala scats present, across all koala surveys (systematic, casual and incidental surveys)

Tree species	Number of trees with scats
Eucalytpus blakelyi	111
Eucalyptus melliodora	101
Eucalyptus albens	62
Angophora floribunda	25
Eucalyptus camaldulensis	11
Eucalyptus moluccana	11
Eucalyptus caliginosa	9
Eucalyptus deanei	8
Eucalyptus dealbata	7
Eucalyptus laevopinea	4
Eucalyptus amplifolia	3
Eucalyptus campanulata	2
Eucalyptus macroryncha	2
Eucalyptus williamsiana	2
Callitris glaucophylla	1
Eucalyptus melanophloia	1
Eucalyptus radiata	1
Eucalyptus sideroxylon	1

Figure 17 describes the tree species composition, across all systematic surveys (i.e. regardless of whether sites had koala presence or absence) divided between sites with presence or absence of koala scats. This gives us an understanding of whether koala presence is more often associated with specific tree species. For instance, *Eucalytpus blakelyi* and *Eucalyptus melliodora* are more often found at sites with koala presence than sites without.

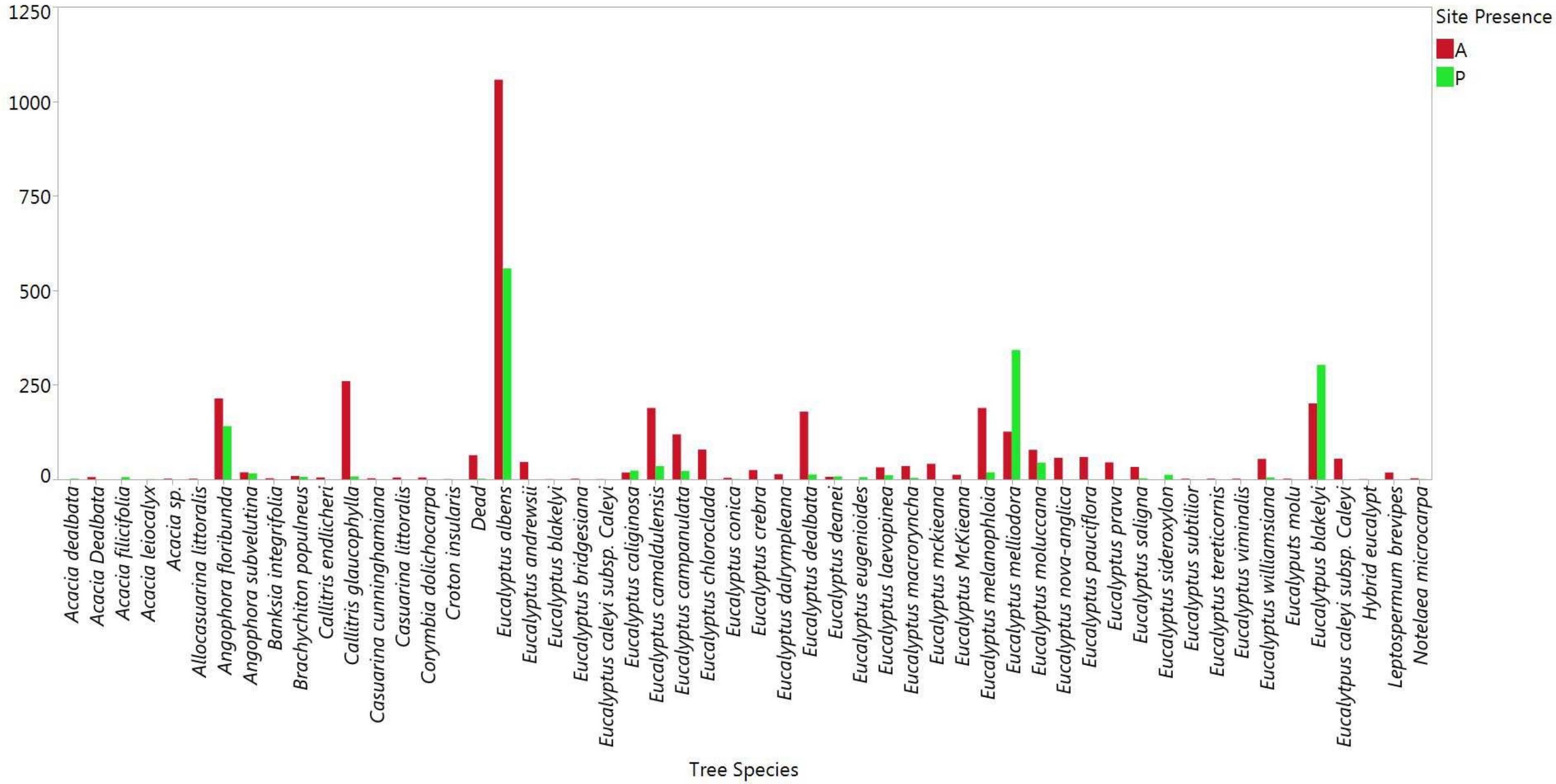

Figure 17: Number of individual trees, divided between sites with presence or absence of koala scats, per tree species, for all systematic sites

We specifically tested through our models whether these species of trees were statistically significantly associated with koala presence. The model had koala presence as the response variable (binary variable: 0 or 1), and the explanatory variable was the specific tree species at these sites (with site as a random effect, and taking into account the proportion of trees at each site). The result was that no particular tree species explained koala presence (the model fitted the data poorly).

Because of the poor fit, we also ran a model using a different approach. First we excluded rare species (i.e. all species representing less than 1% of the trees encountered) as these had no statistical power. For the remaining species, we pooled presence / absence per species to generate a proportion of times a species was found at positive or negative sites. We ran this binomial model with tree species as the explanatory variable. This model was a better fit, however it no longer accounted for species co-occurrence (no random effect). The results showed that two species were more often associated with koala presence: *Eucalyptus melliodora* and *Eucalytpus blakelyi* (Table 6).

Table 6: List of the tree species present at koala survey sites (for all tree species > 1%), and statistical results showing that two tree species were significantly positively associated with koala presence (positive estimates and P-values < 0.05)

Tree.species	Estimate	Std. Error	Pr(>|z|)	Significance
(Intercept)	-0.42	0.11	0.00	***
Callitris glaucophylla	-3.06	0.38	0.00	***
Eucalyptus albens	-0.22	0.12	0.07	.
Eucalyptus camaldulensis	-1.27	0.21	0.00	***
Eucalyptus campanulata	-1.27	0.26	0.00	***
Eucalyptus chloroclada	NA			
Eucalyptus dealbata	-2.21	0.31	0.00	***
Eucalyptus McKieana	NA			
Eucalyptus melanophloia	-1.88	0.26	0.00	***
Eucalyptus melliodora	**1.42**	**0.15**	**0.00**	***
Eucalyptus moluccana	-0.16	0.22	0.48	
Eucalyptus nova-anglica	NA			
Eucalyptus pauciflora	NA			
Eucalyptus prava	NA			
Eucalyptus williamsiana	-1.96	0.48	0.00	***
Eucalytpus blakelyi	**0.83**	**0.14**	**0.00**	***
Eucalytpus caleyi subsp. Caleyi	NA			

NA: Species never present at positive koala sites

4.5.1 Tree Use at Positive Survey Sites

Systematic koala surveys, for which 30 trees are checked, allowed us to calculate the strike rate (number of trees with scats / total number of trees) at positive sites for each available tree species (Phillips and Hopkins 2008). This enabled us to classify tree species that were more actively used by koalas (Table 7 and Figure 18).

Strike rates calculated for small sample sizes need to be treated with caution until a trend can be ascertained for a larger number of trees (e.g. *Eucalyptus dealbata*, *Eucalyptus macroryncha*, *Eucalyptus williamsiana*, *Eucalyptus deanei*, *Eucalyptus caliginosa*), nonetheless, the following species can be classified as trees more commonly used by koalas, in decreasing order: *Eucalytpus blakelyi*, *Eucalyptus camaldulensis*, *Eucalyptus melliodora*, *Angophora floribunda* and *Eucalyptus albens.*

Table 7: Strike rates of tree species (calculated for systematic, positive, koala surveys)

Tree species	Presence	Absence	Strike Rate
Eucalyptus dealbata	7	6	53.8%
Eucalyptus macroryncha	2	2	50.0%
Eucalyptus williamsiana	2	3	40.0%
Eucalyptus deanei	3	5	37.5%
Eucalyptus caliginosa	8	15	34.8%
Eucalytpus blakelyi	100	201	33.2%
Eucalyptus camaldulensis	11	24	31.4%
Eucalyptus melliodora	95	247	27.8%
Eucalyptus laevopinea	3	8	27.3%
Angophora floribunda	22	119	15.6%
Eucalyptus moluccana	6	38	13.6%
Callitris glaucophylla	1	7	12.5%
Eucalyptus albens	53	505	9.5%
Eucalyptus melanophloia	1	18	5.3%
Eucalyptus campanulata	1	21	4.5%
Acacia dealbata	0	2	0.0%
Acacia filicifolia	0	6	0.0%
Acacia leiocalyx	0	1	0.0%
Angophora subvelutina	0	16	0.0%
Brachychiton populneus	0	7	0.0%
Eucalyptus conica	0	1	0.0%
Eucalyptus eugenioides	0	6	0.0%
Eucalyptus saligna	0	3	0.0%
Eucalyptus sideroxylon	0	12	0.0%
Notelaea microcarpa	0	1	0.0%

One of our models tested whether some tree species were actively selected at sites where koalas were present (i.e. used more than expected by chance only). We did not find any particular tree species that was used more than expected at sites where koalas were present (Table 8).

Table 8: List of the tree species present at sites where koala scats were detected, and statistical results showing that no tree species was significantly more used than chance would predict (no P-values < 0.05)

Tree species	*z*	*P*
Acacia dealbata		NA
Acacia filicifolia		NA
Acacia leiocalyx		NA
Angophora floribunda	0.03	0.27
Angophora subvelutina		NA
Brachychiton populneus		NA
Callitris glaucophylla	0.05	0.32
Eucalyptus albens	-0.30	0.58
Eucalyptus caliginosa	0.06	0.29
Eucalyptus camaldulensis	-0.09	0.12
Eucalyptus campanulata	0.01	0.18
Eucalyptus conica		NA
Eucalyptus dealbata	0.04	0.15
Eucalyptus deanei	-0.01	0.19
Eucalyptus eugenioides		NA
Eucalyptus laevopinea	0.06	0.22
Eucalyptus macrorыncha	0.08	0.26
Eucalyptus melanophloia	0.16	0.22
Eucalyptus melliodora	0.06	0.29
Eucalyptus moluccana	0.09	0.51
Eucalyptus saligna		NA
Eucalyptus sideroxylon		NA
Eucalyptus williamsiana	-0.07	0.27
Eucalytpus blakelyi	0.07	0.23
Notelaea microcarpa		NA

NA are those species which are not used at all

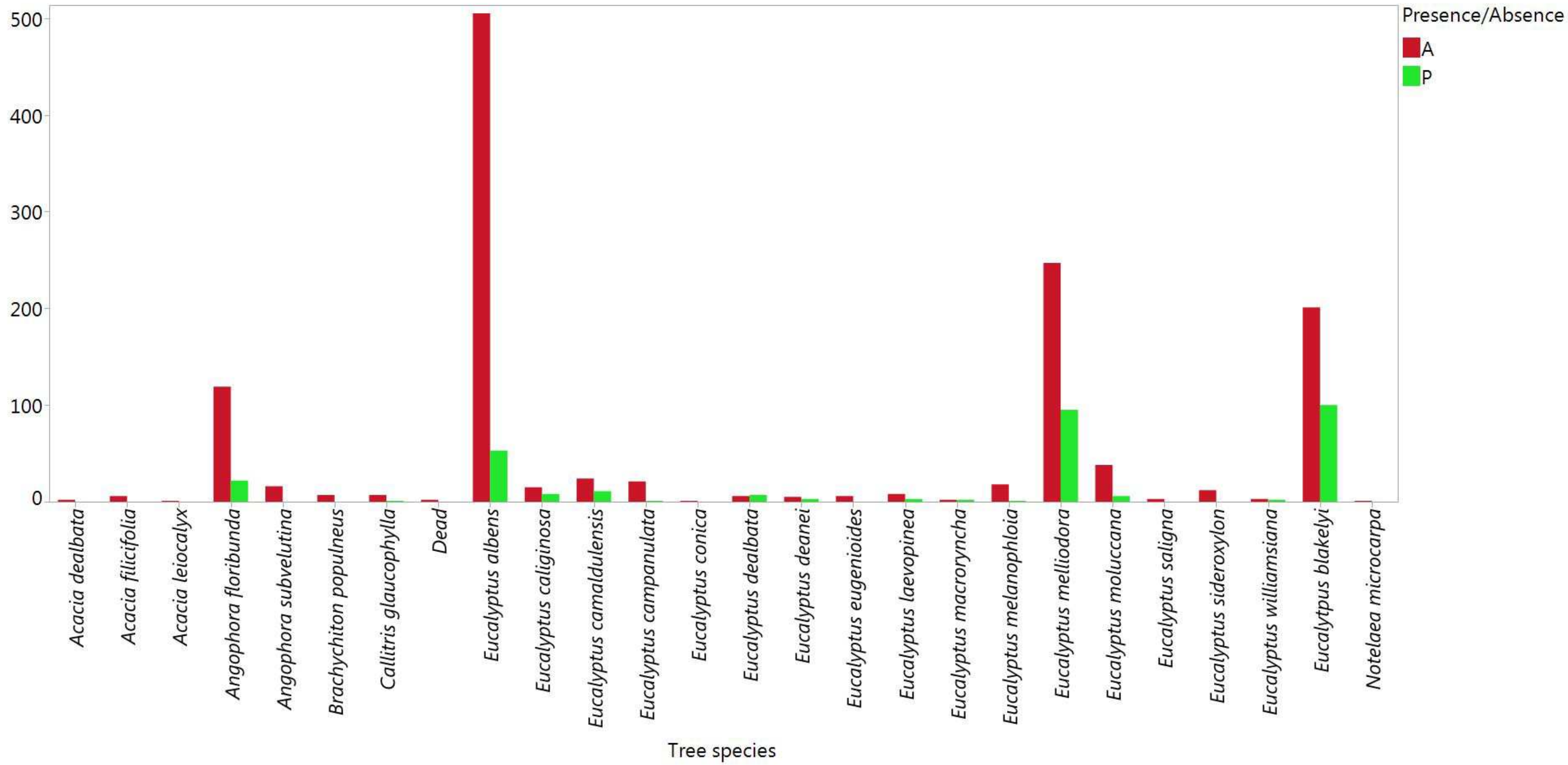

Figure 18: Number of individual trees with presence or absence of scats, per tree species, for all positive systematic sites (used to calculate strike rates)

4.5.1 Plant Community Type Use Across All Surveys

From both flora and koala surveys, we calculated the plant community types (PCT) that were used by koalas either currently (from one, two or three koala surveys conducted in the PCT) or in the past (from community engagement, see Figure 19). In this project, Blakely's Red Gum - Yellow Box grassy tall woodland (PCT = 599) was always utilised by koalas, while White Box grassy woodland (PCT = 590) was used more frequently than not. Other PCTs had a low number of replicates per PCT, so negative results should be treated with caution, however the following PCTs were found with koala presence: 78 (3 sites), 591 (2 sites) and one site with koala presence in the following: 505, 510, 516, 528, 567, 577, 594, 734, 992 and 993 (see description in Appendix 1).

The number of PCT encountered was high, and the number of replicates per PCT was generally low, therefore we could not use modelling to statistically test the significance of any association between koala presence and PCT.

The koala activity level was calculated per PCT (Table 9). Again for PCTs with low number of replicate surveys, these results should be viewed with caution. However, PCT 590 and 599 showed high level of activity with a high number of replicates. Other PCTs that could see high intensity of use by koalas (but would need to be confirmed by additional surveys) are Tumbledown Red Gum - White Cypress Pine - Blakely's Red Gum shrubby forest (PCT 577) and Mugga Ironbark - Blakely's Red Gum open forest (PCT 528).

Table 9: Average activity levels per PCT (note that standard deviation cannot be calculated for PCT with only one survey)

PCT	Average Activity Level	Standard deviation	Total count
577	60%		1
528	57%		1
590	22%	18	15
599	21%	16	21
591	20%	14	2
516	17%		1
78	15%	13	3
734	13%		1
505	10%		1
993	10%		1
510	7%		1
567	3%		1
992	3%		1

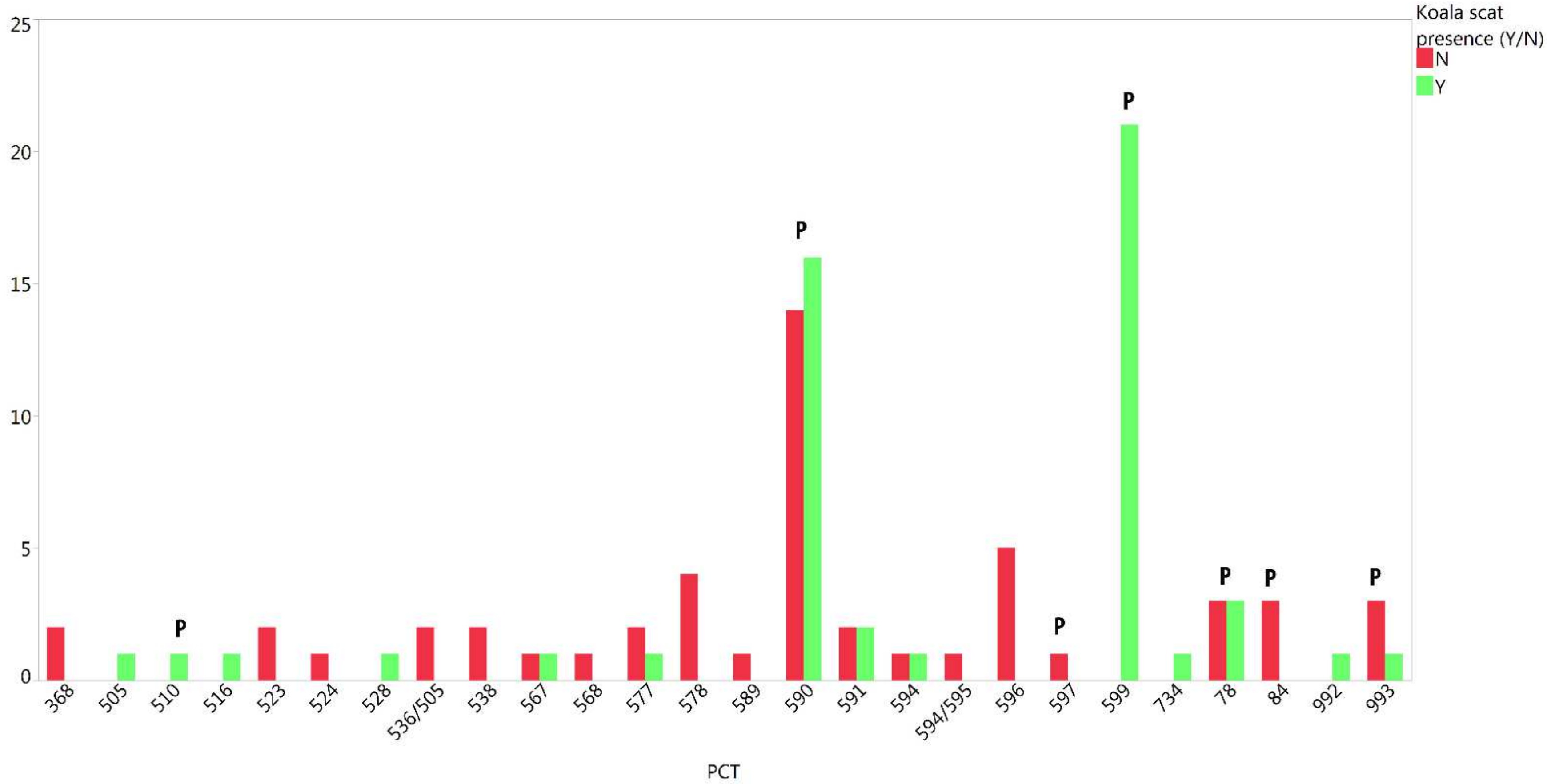

Figure 19: Plant community types (PCT) where koala presence was found during this project or in the past (noted as "P", information gathered from discussions with the community during field work)

4.6 Vegetation Structure / Site Characteristics and Koala Use

Our models did not detect any significant association between the variables describing vegetation structure (i.e. trees with DBH > 50cm, projective foliage coverage) and site characteristics (elevation, aspect, slope, Figure 20) at each site and whether koalas were present.

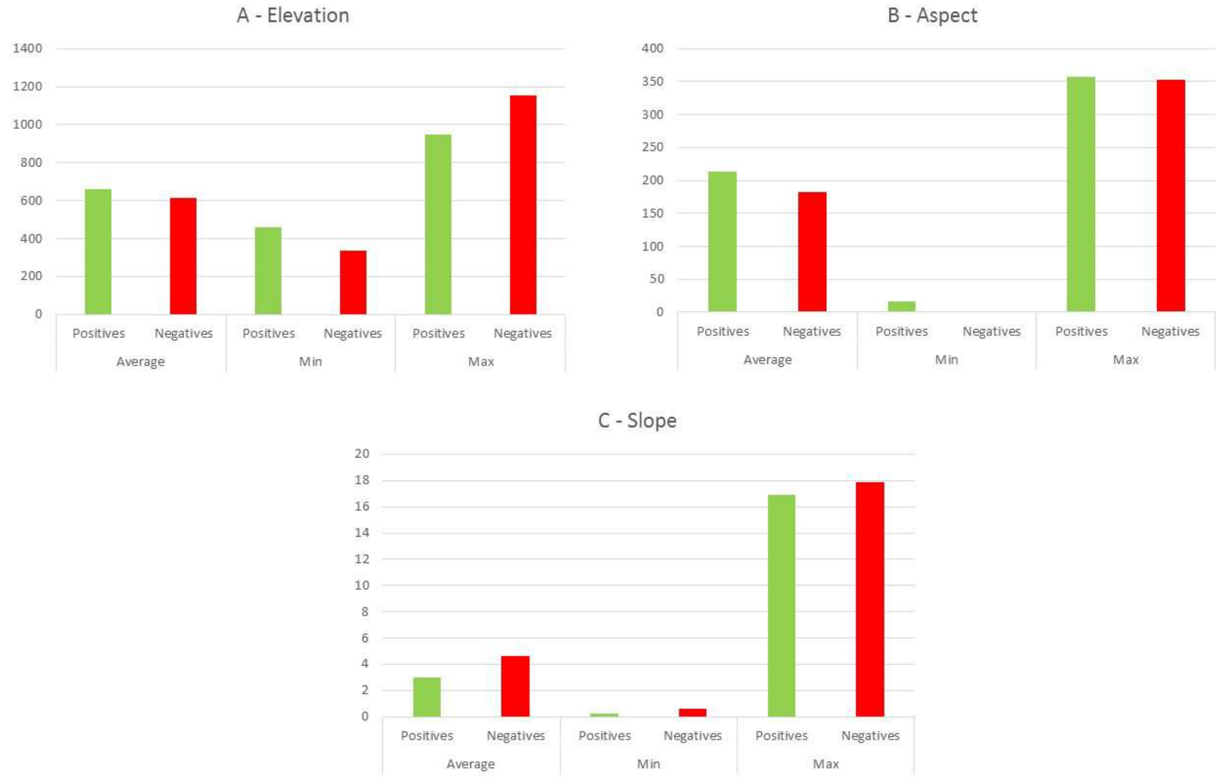

Figure 20: Average, minimum and maximum values for across sites positives or negatives for koala presence, for A – Elevation, B - Aspect and C - Slope

4.7 Threats to Koalas on Site

4.7.1 Wild Dogs

Wild dog scats were found at 19 koala survey sites, four sites had domestic dogs present and one had dog footprints (Figure 21). Therefore in total, 9.4% of the sites surveyed had dog presence. This is a relatively low number, however:

- Sites were selected to avoid baiting areas. It could be that baiting occurs where dogs are problematic, therefore we might have excluded areas of high dog presence. Alternatively, baiting might keep dogs at a low density level. It might be of interest to map baiting and relate this information to koala presence.
- Low presence is not necessarily linked to low impact, as unpublished data from the Moreton Bay Railway Link have shown one dog can cause high koala mortality (Jon Hanger, Endeavour Veterinary and Ecology, personal communication).

The actual threat (and not dog density) of wild (and domestic) dog predation is difficult to quantify in koala populations.

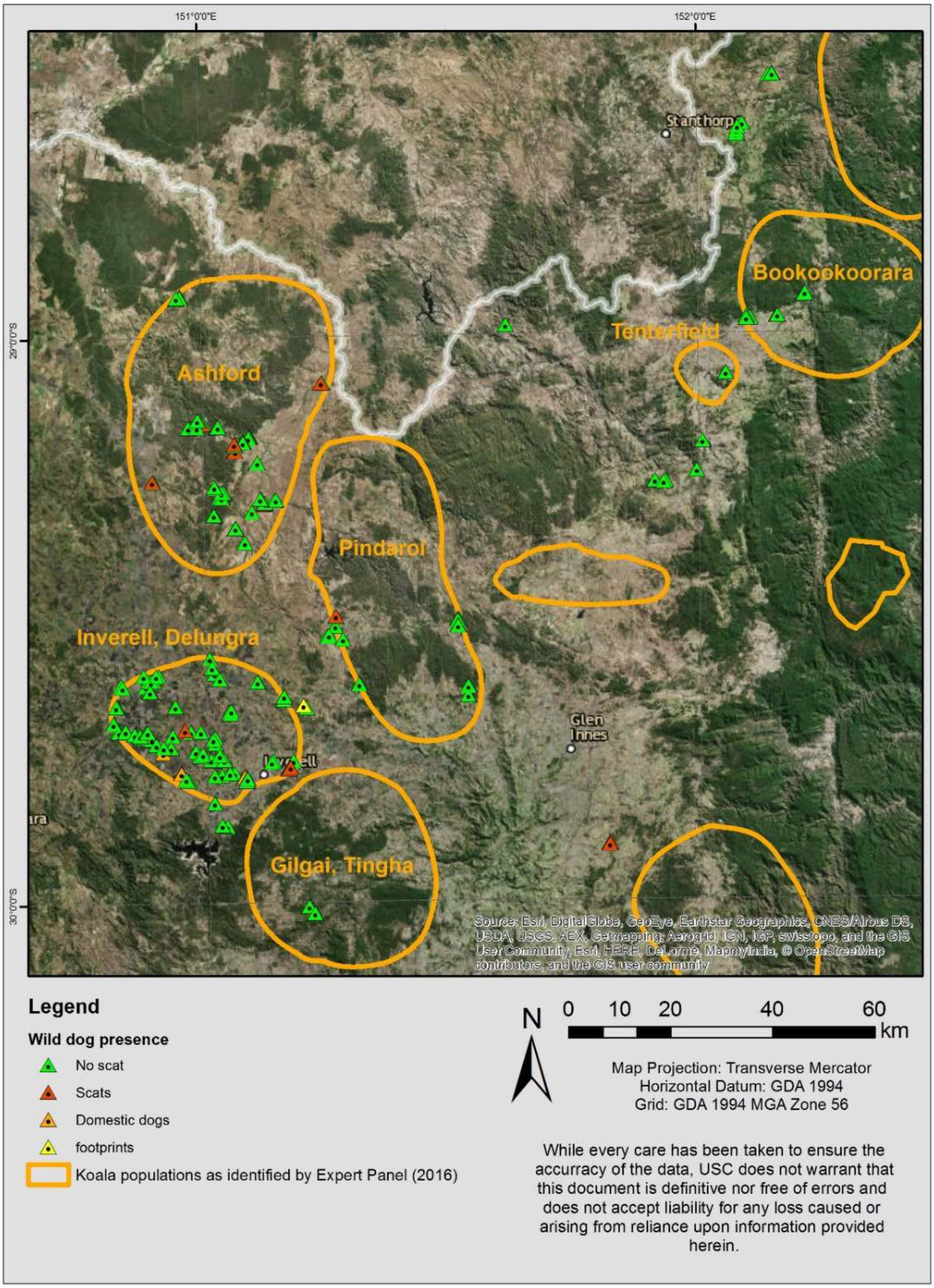

Figure 21: Sites where dog presence was detected

4.7.2 Grazing

Grazing frequency and intensity was recorded at the flora sites (Figure 22). Grazing was present at most sites (94.2%) and was often recent (< 1 year: 49.0% ; between 1 to 3 years: 27.9% ; > 3years: 9.6%, Figure 23). However, grazing intensity was classified as light for the majority of sites (only 4.1% of sites moderate and 7.1% of sites classified as severe, Figure 24).

Figure 22: Grazing classified as severe (site N160822_03 in Tumbledown, Ashford)

Grazing can prevent regrowth of native trees and shrubs and influence fire regimes (Liedloff et al. 2001). Cattle are also known to deliberately trample koalas (Rosie Booth, Australia Zoo Wildlife Hospital, personal communication).

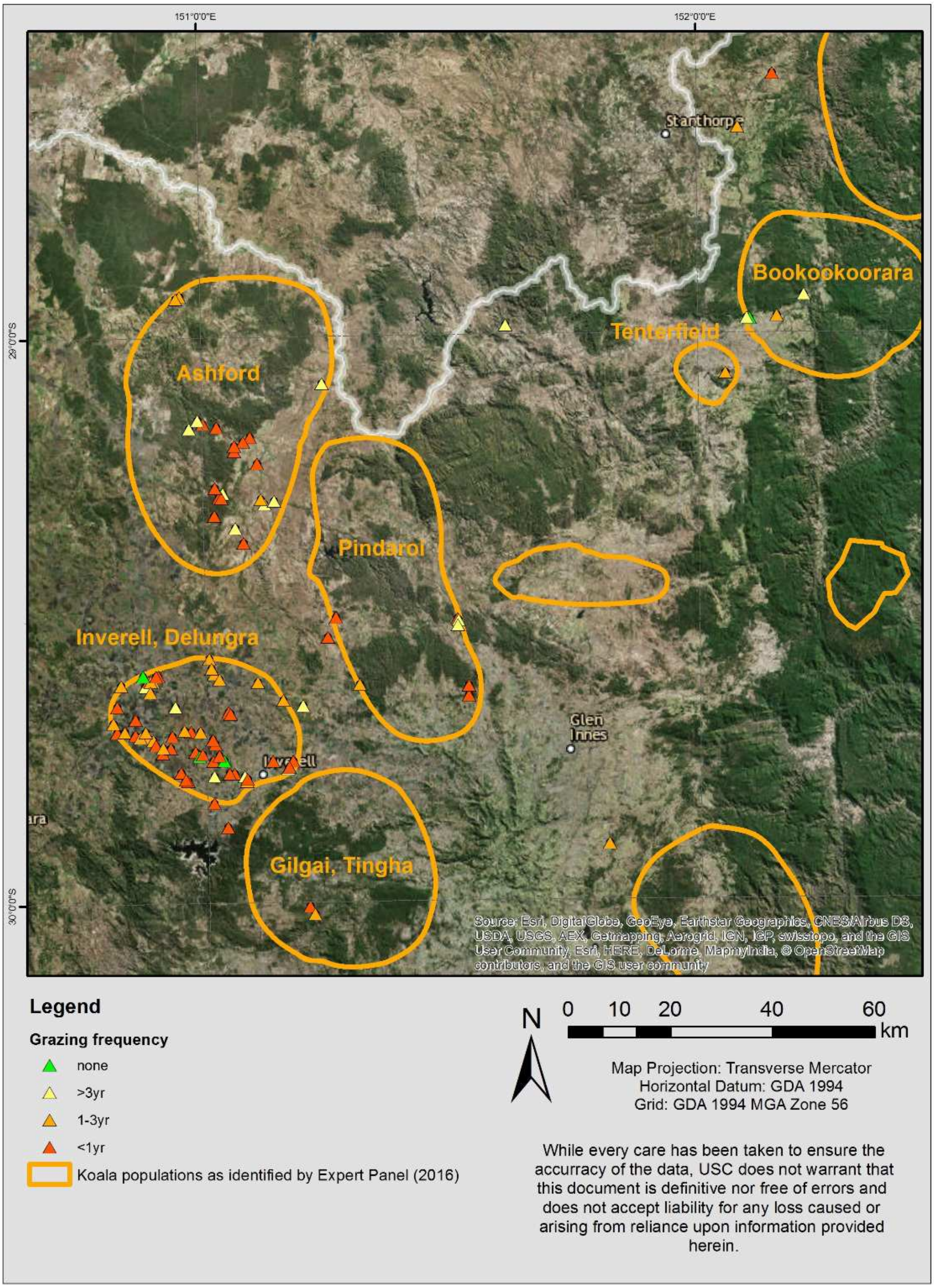

Figure 23: Grazing frequency (estimated number of years since grazing)

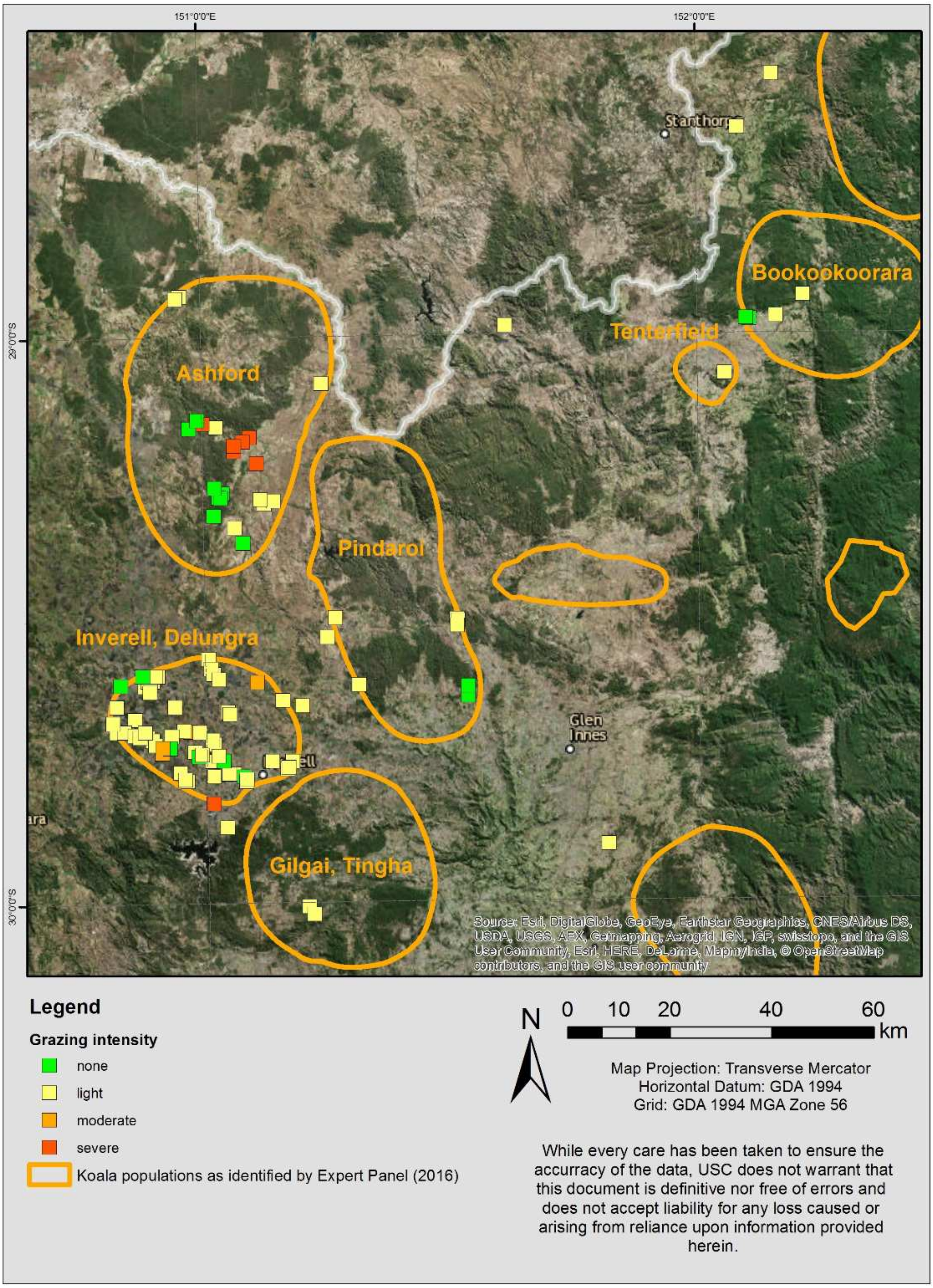

Figure 24: Grazing intensity classified from none to severe

Koala scat presence by level of frequency and intensity of grazing are given in Figures 25 and 26.

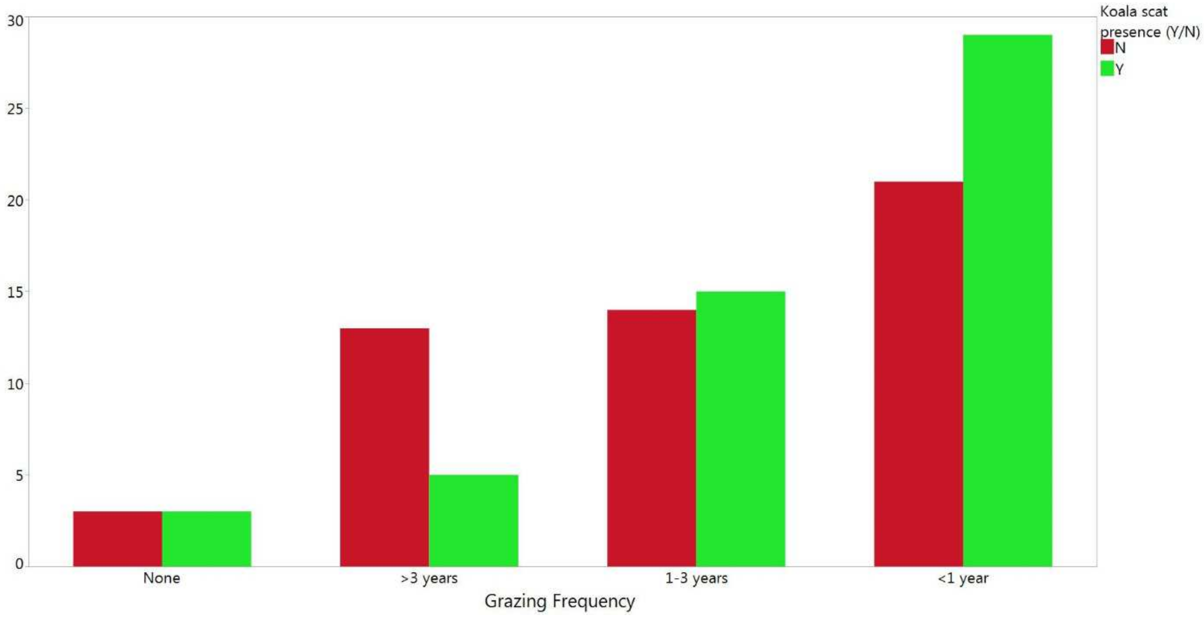

Figure 25: Number of sites with koala presence or absence per grazing frequency level (None = no grazing, then estimated number of years since grazing from more than three years to less than a year)

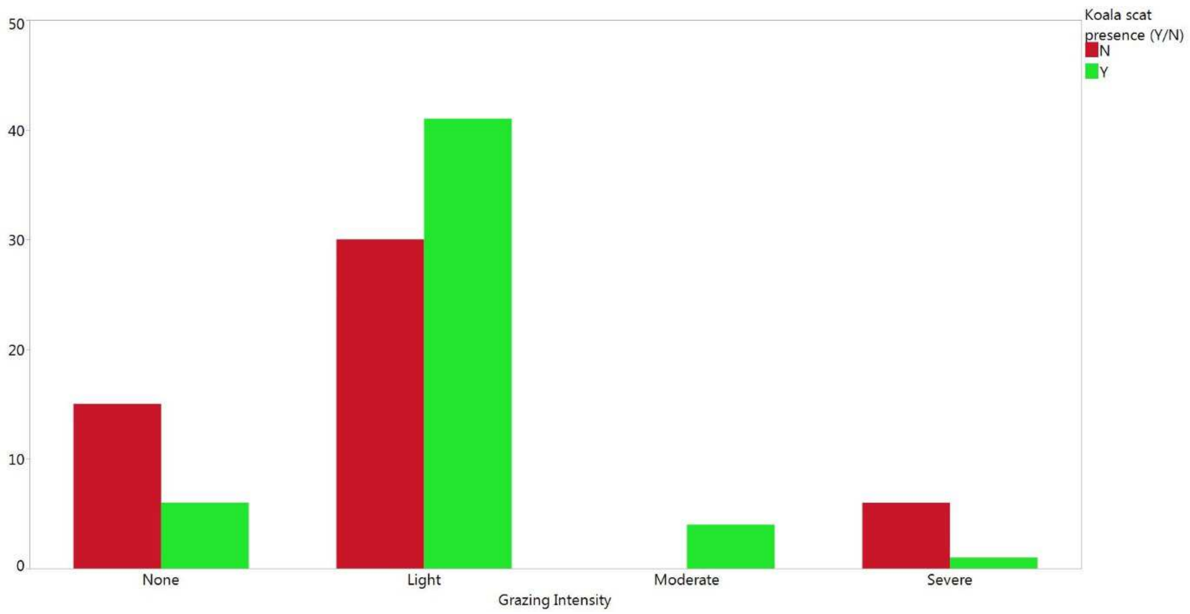

Figure 26: Number of sites with koala presence or absence per grazing intensity level, classified from none to severe

4.7.3 Weeds

To our knowledge, there is no research on how weeds impact koalas, however there is potential that weeds could:

- prevent regrowth of native trees and shrubs,
- increase a fire hazard,
- prevent tree climbing (e.g. cat's claw creeper *Macfadyena unguis-cati*),
- disable a koala (entanglement).

Most flora sites had more than one introduced species, or weed, present (92.3%), and up to 13 species. Weeds identified in the flora plots are given in Figure 27, the more common being: *Hyparrhenia hirta*, *Eragrostis curvala*, *Petrorhagia dubia* and *Medicago polymorpha*. However, the density of weeds were rarely considered to be high enough as to prevent regrowth (weed density was classified as moderate at two sites, and severe at 6 sites, see Figure 28).

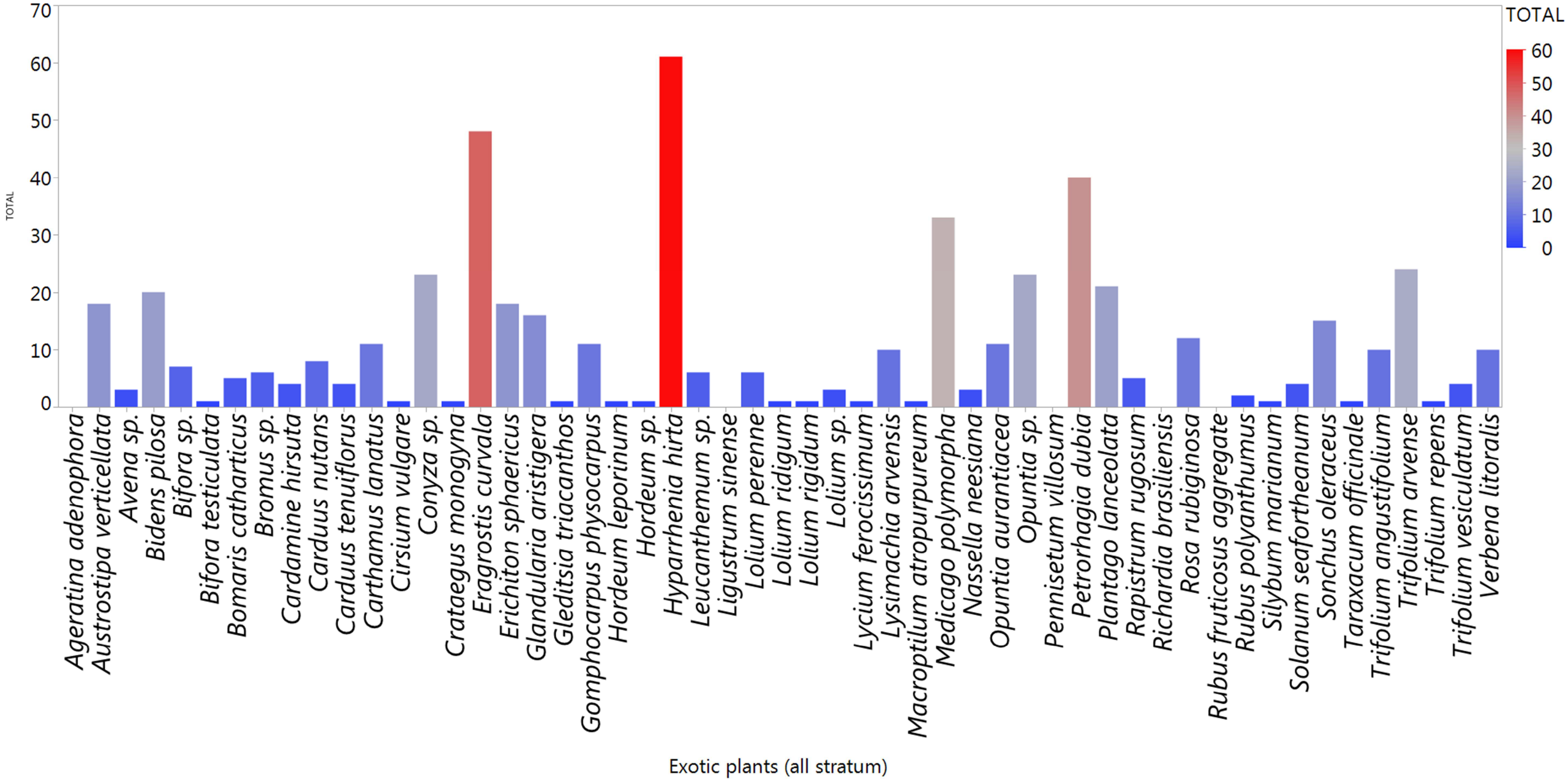

Figure 27: Total number of sites with each weed, showing the more frequent weeds in red

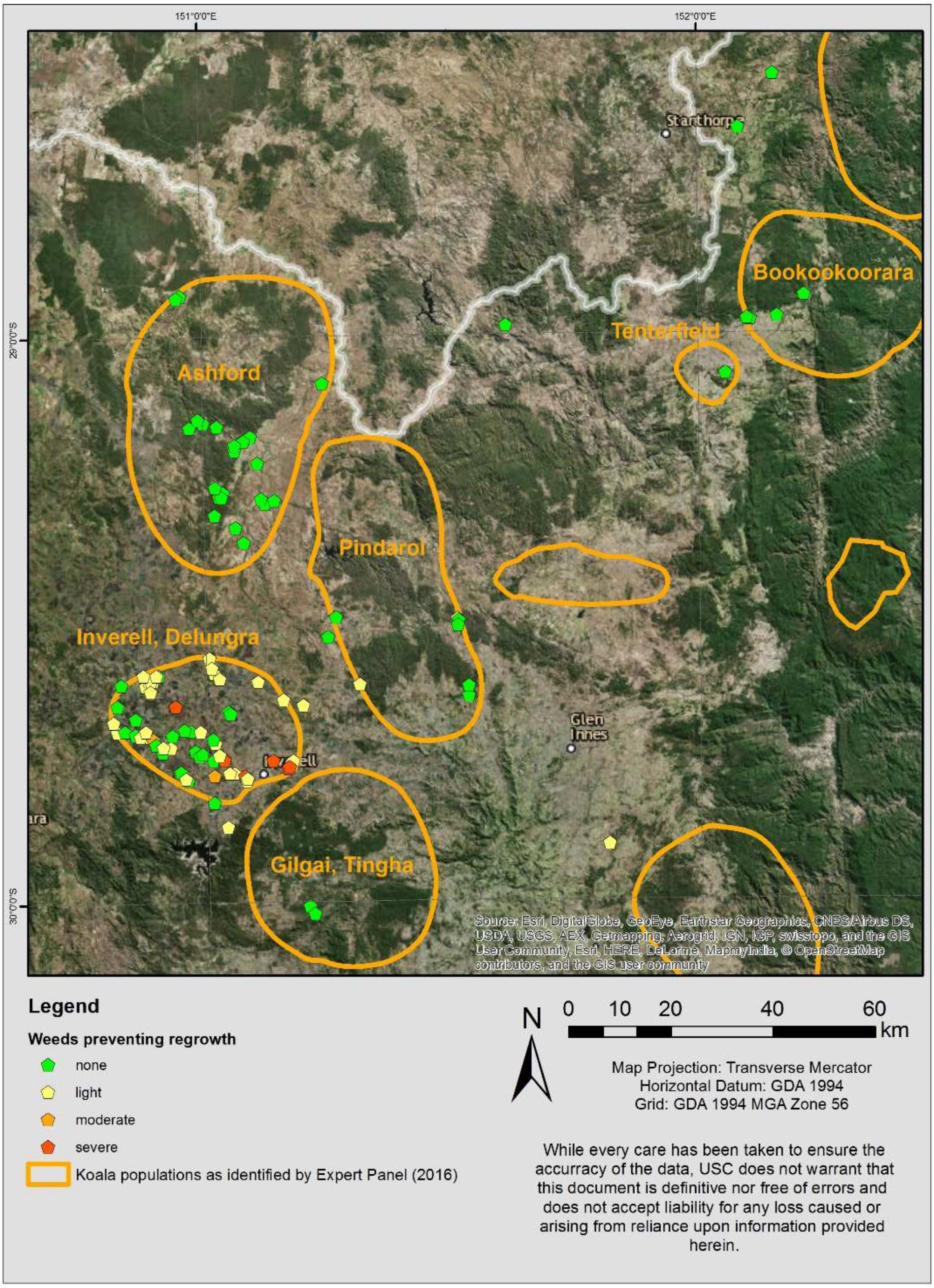

Figure 28: Weeds considered of density high enough to prevent native plants regrowth (from weed density not considered to prevent regrowth to severely preventing regrowth)

4.7.4 Dieback

Dieback was encountered in seven sites only, and it was classified as light (Figure 29). No moderate and no severe dieback was recorded during the surveys.

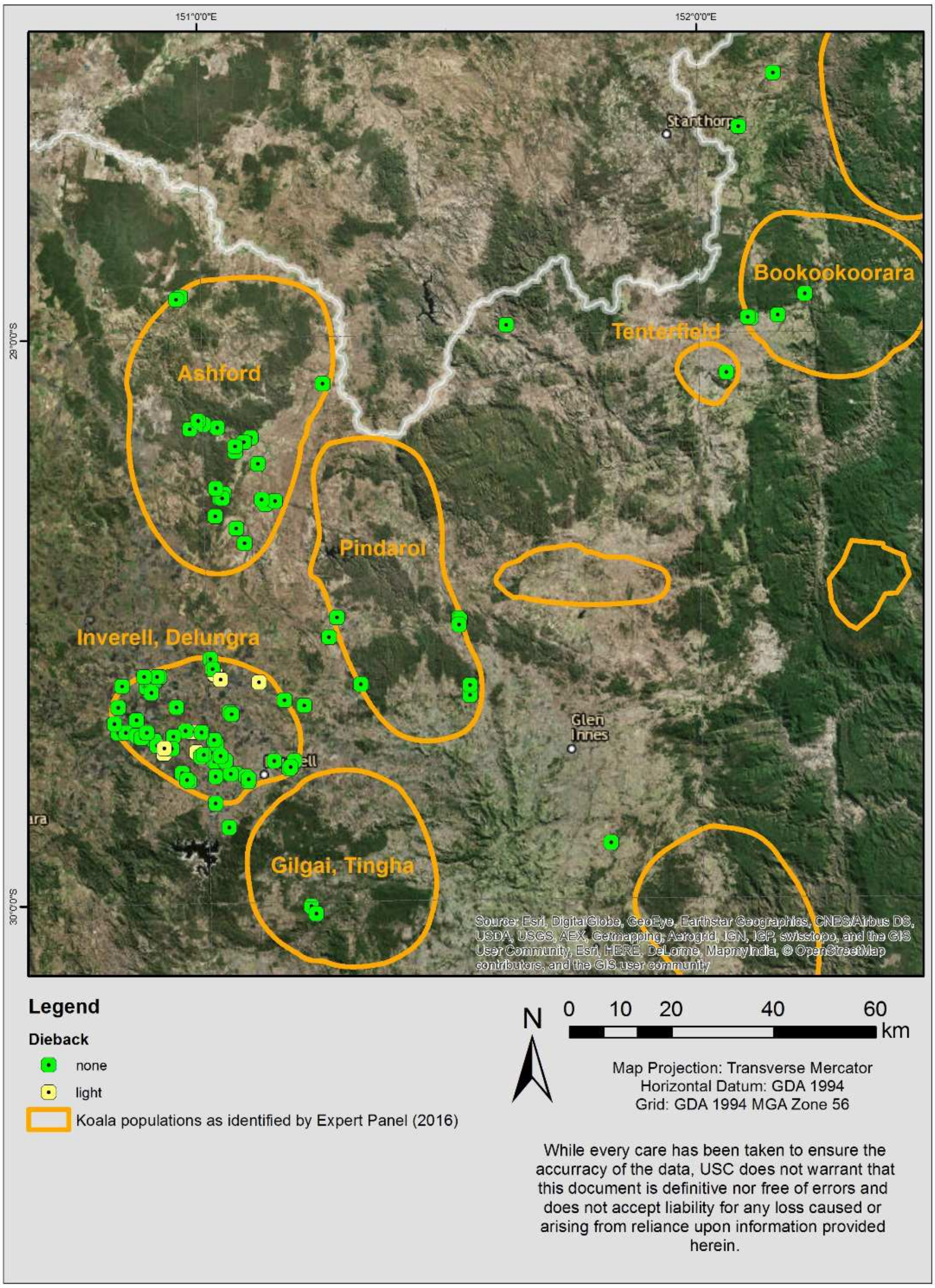

Figure 29: Dieback

4.7.5 Presence of Chlamydia in Survey Area

Of the 16 individual koalas (including nine adults) we observed, none presented external signs of *Chlamydiosis* (conjunctivitis and / or coloured rump signalling a urinary tract infection, Figure 30). Although this is a small sample size, in a similar survey (same methodology) in Queensland the USC team identified six koalas out of 12 with external signs of *Chlamydiosis*.

Figure 30: Example of a clean (healthy) koala rump in NT

4.8 Ground-truthing the Northern Tablelands KRS Habitat Model and Tree Species List

4.8.1 Priority Areas

The present surveys focused mostly on confirming koala presence in areas recognised as potentially sustaining koala populations by NT experts in the NT KRS (Hawes et al. 2016). The two main areas of interest presented contrasting outcomes: the Ashford priority area yielded very low koala presence whereas the Delungra / Inverell priority area was confirmed as a koala hotspot.

It has to be noted that none of the threats measured in this project could explain the different outcomes between the Ashford and the Delungra / Inverell priority areas (based on a model of koala presence / absence as a function of the following threats: grazing frequency, grazing intensity, presence of weeds, dieback and wild dogs).

Additionally, an area that was not previously identified as a priority area but would be worth further investigation is the area to the West of priority area “North east of Tenterfield” (refer to Figure 7).

4.8.2 Habitat Model

The NT KRS also attempted to model koala distribution in the NT. However, the results were considered biased:

“Many areas with woody vegetation on the Northern Tablelands have no observations, while numerous observations are found within cleared areas in the centre of the project area. This is likely to reflect the fact that koalas in these regions are more easily observed due to a more open overstorey canopy, and as a result of having to spend greater lengths of time on the ground in order to access highly scattered/patchy food/shelter resources and mates. It is also likely that koalas in these areas suffer higher rates of disease and therefore again spend longer periods of time on the ground making them more visible. The cleared central tablelands area also supports a greater density of human settlement, consequently there is a bigger population of potential observers to report koalas (Hawes et al. 2016).”

The above paragraph presents valid points. However, when the USC team searched for scats (not koalas) in random locations (thus removing the biases described above) both in Ashford and Delungra / Inverell areas, koala scats were more often found in the Delungra / Inverell area than in the Ashford area, despite the fact that the Delungra / Inverell area has less woody coverage and is more impacted by human activities (agriculture in particular, see Figures 8, 9, and paragraph below “4.8 Connectivity and fragmentation of the priority areas”). Therefore it seems, in this instance at least, that there are other factors at play rather than only biased observations.

Both Ashford and Delungra / Inverell areas were identified as potential priority areas for sustaining koala populations, but showed very different results in terms of koala presence during our field work. This underlines that field work (or ground truthing) is necessary to ascertain current koala distribution in the NT.

4.8.3 Food Trees

Potential food and habitat tree species were identified in the *Koalas on the Northern Tablelands Literature Review* as part of the NT KRS.

We compared, in Table 10, the tree species that had been used by koalas in this project to the tree species list (Inverell and Tenterfield merged) from the NT KRS:

- 10 species were found used in this project but not in the NT KRS,
- 21 species were given in the NT KRS but not confirmed by this project (it is expected that the list of trees confirmed to be used by koalas in the NT will increase with more field work),
- 8 were identified in both.

Interestingly, four of the five top species found in this study (*Eucalytpus blakelyi*, *Eucalyptus melliodora*, *Eucalyptus albens*, *Eucalyptus camaldulensis*) were correctly identified in the NT KRS.

Table 10: Comparison of tree species used by koalas, as identified in this project and in the NT KRS

Tree species	Species identified in this project	Species identified for Inverell and Tenterfield in the NT KRS
Acacia spp		yes
Allocasuarina spp		yes
Angophora floribunda	yes	
Callitris glaucophylla	yes	yes
Casuarina cunninghamiana		yes
Eucalyptus acaciiformis		yes
Eucalyptus albens	yes	yes
Eucalyptus amplifolia	yes	
Eucalyptus banksii		yes
Eucalytpus blakelyi	yes	yes
Eucalyptus bridgesiana		yes
Eucalyptus caliginosa	yes	
Eucalyptus camaldulensis	yes	yes
Eucalyptus campanulata	yes	
Eucalyptus chloroclada		yes
Eucalyptus conica		yes
Eucalyptus dalrympleana ssp heptantha		yes
Eucalyptus dealbata	yes	yes
Eucalyptus deanei	yes	
Eucalyptus laevopinea	yes	yes
Eucalyptus macroryncha	yes	
Eucalyptus melanophloia	yes	
Eucalyptus melliodora	yes	yes
Eucalyptus microcorys		yes
Eucalyptus moluccana	yes	yes
Eucalyptus nobilis		yes
Eucalyptus notabilis		yes
Eucalyptus nova-anglica		yes

Tree species	Species identified in this project	Species identified for Inverell and Tenterfield in the NT KRS
Eucalyptus obliqua		yes
Eucalyptus pauciflora ssp pauciflora		yes
Eucalyptus prava		yes
Eucalyptus propinqua		yes
Eucalyptus radiata	yes	
Eucalyptus retinens		yes
Eucalyptus rubida		yes
Eucalyptus sideroxylon	yes	
Eucalyptus stellulata		yes
Eucalyptus viminalis ssp viminalis		yes
Eucalyptus williamsiana	yes	

4.9 Connectivity and Fragmentation of the Priority Areas

In the Inverell / Delungra priority area, the remaining native vegetation is very patchy (Figure 31), as most of the area (72.5%, Table 11) is agricultural landscape, and classified as 0 in PCT (non-native coverage / disturbed area / cultivated land). Despite the high degree of human modification of the landscape, koalas are still present and their activity level is high.

Table 11: Area and percent of remnant plant community types (PCT) in the Inverell/Delungra priority area

Plant community types		Area (ha)	Percent
PCT 0	Non-native coverage/disturbed area/cultivated land	54719.1	72.5%
PCT 84	River Oak - Rough-barked Apple - red gum - box riparian tall woodland	324.6	0.4%
PCT 505	Black Cypress Pine - Tumbledown Red Gum - Narrow-leaved Ironbark - Stringybark She Oak open forest	15.3	0.0%
PCT 510	Blakely's Red Gum - Yellow Box grassy woodland	26.3	0.0%
PCT 516	Grey Box grassy woodland or open forest	194.8	0.3%
PCT 528	Mugga Ironbark - Blakely's Red Gum open forest	73.9	0.1%
PCT 590	White Box grassy woodland	10378.0	13.7%
PCT 599	Blakely's Red Gum - Yellow Box grassy tall woodland	2103.3	2.8%
	Other remnant PCT	7648.7	10.1%
Remnant PCTs confirmed to be used by koalas in this project		13116.1	17.4%
Total remnant		20764.8	27.5%

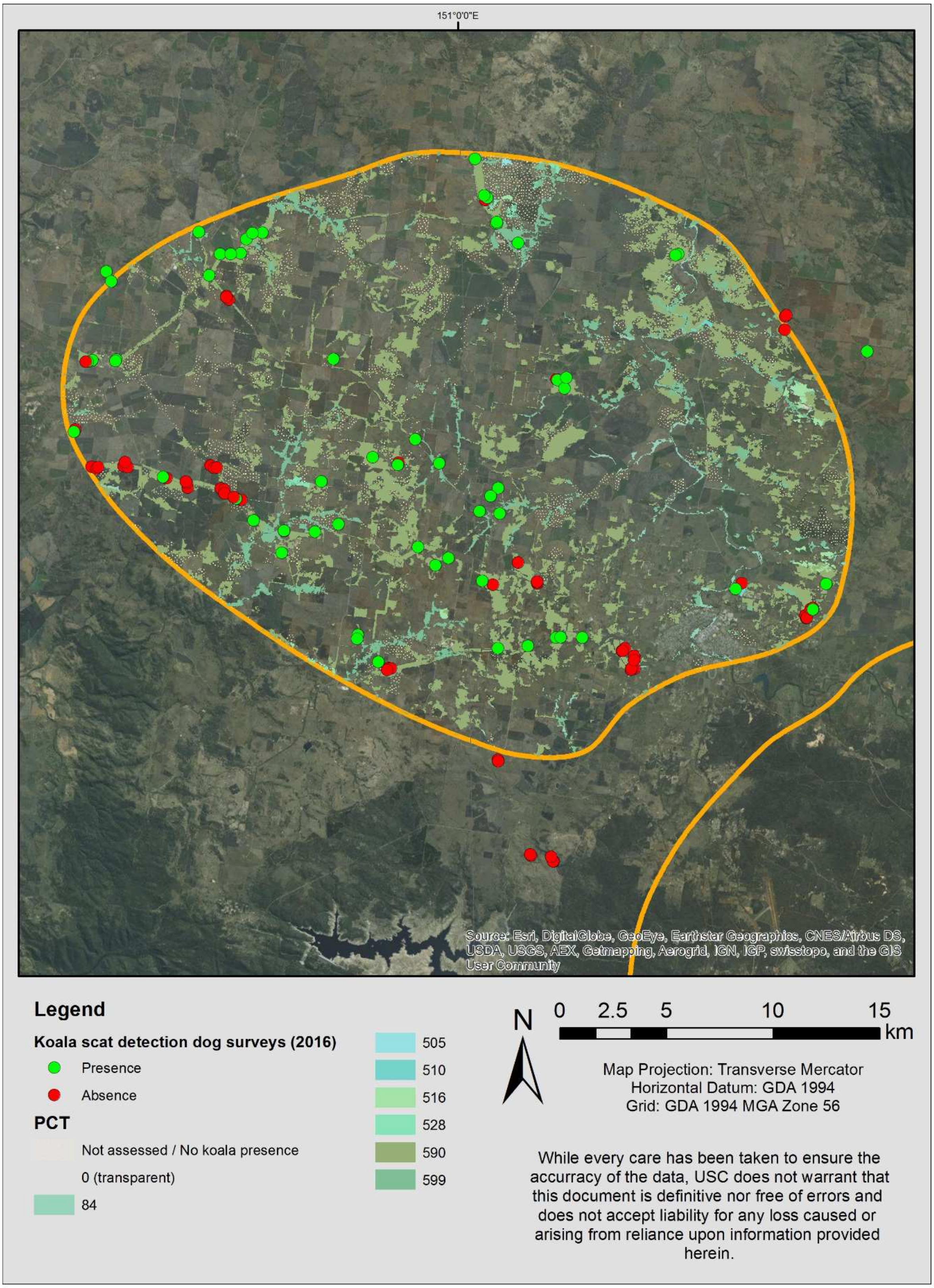

Figure 31: Koala habitat within the Inverell / Delungra priority area based on PCT where koalas are present (refer to Figure 19)

In contrast, the Ashford priority area, despite having low koala presence, has a high proportion of remnant plant community types (90.3%), with low fragmentation (Figure 32).

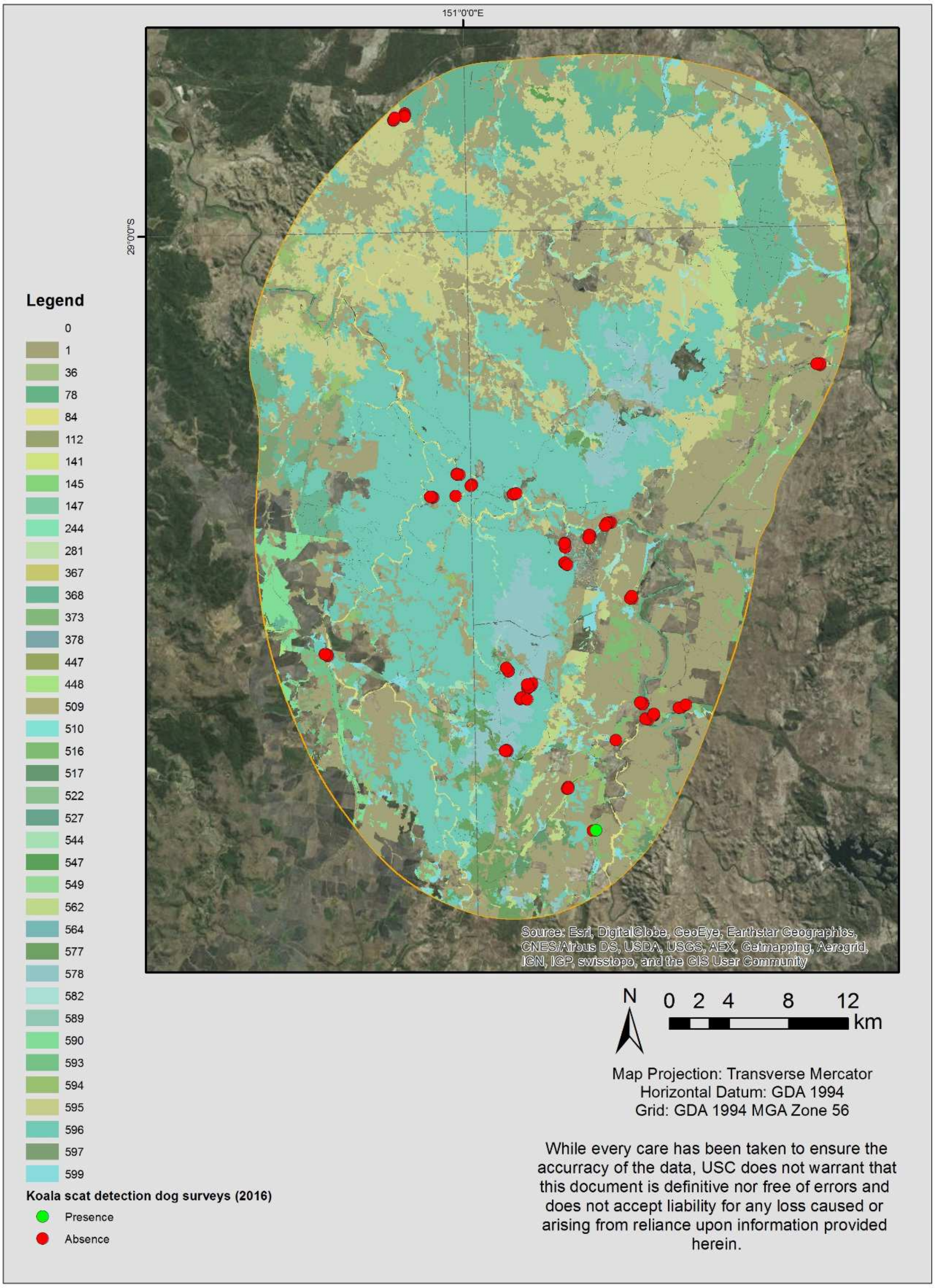

Figure 32: Plant community types in the Ashford priority zone show low fragmentation

5. Recommendations

5.1 Summary of Threats to the Survival of the Koala

Threats to koala populations have been well-documented throughout their geographic range and include the following (Obendorf 1983, Martin and Handasyde 1999, Dique et al. 2003, Rhodes et al. 2011b, Denner and Young 2013, Burton and Tribe 2016, McAlpine et al. 2017):

- habitat loss, fragmentation and degradation (including dieback, grazing and weed incursion);
- vehicle strike;
- disease;
- predation (including wild and domestic dog attack); and
- extreme weather events (bushfires, droughts, heatwaves).

Although the general threats are known, what is lacking and generally difficult to ascertain is the relative importance of these threats across the landscape.

As discussed in Section 4, some areas of the Northern section of the Northern Tablelands appears to experience relatively high levels of koala activity, particularly in the Inverell / Delungra priority area. In comparison, Ashford priority area experienced very low koala activity and, based on historical records and community engagement, it appears that this area has seen a large decline in koala presence, possibly since 2010 (see Figure 11). None of the threats measured in this project were able to explain this difference.

This study has found evidence that predators such as domestic and wild dogs occur within the priority areas on the Northern Tablelands, although the threat of dog predation is difficult to quantify in koala populations. This is because the density of dogs does not necessarily represent the level of threat. In a research project in Moreton Bay Railway Link, where 500 koalas were radiotracked for up to five years, it is thought that one individual was responsible for most of the mortalities attributed to dog attacks (124 koalas killed, Jon Hanger, personal communication).

Tree dieback and grazing activity were light at the majority of survey sites. It has to be noted that dieback can be spatially limited, and therefore easily missed in the field (Andrew Davidson, personal communication).

Most sites had at least one species of weed, or introduced species, present. However, the impact of these infestations on koalas is unlikely to be significant because the infestations were rarely considered high enough to prevent regrowth. Personal observations from the USC team also seems to indicate that presence of weed does not always prevent koalas using sites (unpublished data).

Although only a small number of individual koalas were observed during the study, none presented external signs of poor health or disease (i.e. *Chlamydiosis*).

Our models of koala presence / absence as a function of threats (grazing frequency, grazing intensity, presence of weeds, dieback and wild dogs), showed that no threat was significantly associated with the absence of koala (all P-values > 0.5).

As such, the general recommendations (see "Recommended Management Actions") of this study are more based on the perceived conservation status and threats to koalas on the Northern Tablelands, which has been inferred from known koala threats, rather than on threatening processes observed / quantified during this project.

The recommendations were developed in conjunction with other similar documents produced for koala conservation in New South Wales, including:

- New South Wales Government 2016. Report of the Independent Review into the Decline of Koala Populations in Key Areas of NSW. NSW Chief Scientist and Engineer. December 2016.
- North West Ecological Services 2016. Gunnedah Koala Conservation Plan for the Landcare and Community Groups, prepared for North West Local Land Services.
- Hawes, W., Hunter, J, Lechner, A. & Ede, A. 2016. Northern Tablelands Koala Recovery Strategy 2015-2025. The Envirofactor Pty Ltd, Inverell.

However, below we give some specific recommendations for the two priority areas surveyed through this project, Inverell / Delungra and Ashford, in addition to the general ones.

5.2 Recommended Actions for the Priority Areas of the Northern Tablelands *Cool Country Koala Project* (Northern Section)

5.2.1 Inverell/Delungra Priority Area

During the *Cool Country Koala Project* (Northern Section), we clearly found the Inverell / Delungra priority area to be a koala hot spot. As a consequence, on-ground actions should be targeted and prioritised in this area where the local population of koalas can be supported and increased immediately.

Recommended actions in the Inverell/Delungra priority area are:

Rehabilitation:

Trees on Farms program and other collaborative initiatives (with Landcare groups for example) should be implemented so that the total amount of available habitat is increased. The Inverell / Delungra priority area is highly fragmented (refer to Figure 31) with a low proportion of remnant (i.e. native) PCT remaining (72.5% is cultivated land, Table 11). Despite this, the area already supports a healthy, breeding koala population. By providing more habitat, we expect that the carrying capacity of the landscape would increase and so would the koala population size.

In addition, the local koala population would benefit from the protection of the remnant habitat.

Engagement:

The community should receive a high level of engagement, such as environmental talks from NT LLS, to increase awareness of the significance of their koala population and promote specific behaviours that strengthen koala conservation efforts.

Particular consideration should be given to the possibility of recruiting a "Koala Champion" in this area to create and support a local Koala Action Group. This group could be in charge of encouraging the community to report koala sightings to the Atlas of Living Australia, maintaining a Facebook page where the community could upload pictures, organising tree planting days and generally raising the profile of koalas in the area.

Road signs:

Travellers should be notified that they are entering a special koala hot spot, so they can decrease their speed and increase their level of vigilance. Signs can be as simple as koala zone signs (preferably ones with a koala on the ground, not in a tree, and with a direct action message, see examples Figure 33) or can be an interactive sign with the speed of the driver or with the number of koalas hit in the region for the year (toll).

Figure 33: Example of simple koala signs that show a koala on the ground and have a suggestive message

Disease

Signs of disease, especially *Chlamydiosis*, should be monitored. This can be achieved by:

- being regularly in touch with the wildlife carers in the area, to inquire whether sick animals have been admitted from this area,
- if a Facebook page is created where members of the public upload their sightings, monitor the pictures for clinical signs of the disease,
- scat monitoring (collection of fresh scats by members of the public and analyses for the presence of Chlamydia).

Monitoring of *Chlamydiosis* would permit an early intervention by the NT LLS and other stakeholders to treat / control the disease in case of an outbreak.

Heat wave

If a heat wave occurs in the area, NT LLS should encourage members of the public to provide water bowls for koalas. Koalas have now been proven to drink water when freely available (Sydney University, unpublished data), and this might be increasing their survival when they are suffering heat stress (North West Ecological Services 2016).

5.2.2 Ashford Priority Area

The Ashford priority area, albeit clearly identified as a potentially significant population based on past records, provided very few signs of koala presence during the 2016 survey. However, no threats recorded during the same survey could explain the population crash which, based on interviews with members of the public during the survey, occurred a few years prior. Anecdotal evidence suggests a heat wave could have been involved (Andrew Davidson, personal communication).

As a consequence, the Ashford area would benefit from a follow up survey based on a questionnaire, for example through a letter drop (Note: this could also be part of USC final community talks). The questionnaire needs to be developed with input from researchers / statisticians with knowledge of community surveys (for example, Dan Lunney, Office of Environment and Heritage NSW, could be approached), so that answers provide quantifiable and robust data.

Areas of interest for the questionnaire:

1. Have you seen a koala in Ashford?

2. Can you circle on the map (provided) where your sighting(s) occurred?

3. How long ago did you see your last koala in Ashford?

4. Is there a moment in time where you saw sick or dead koalas in Ashford?

5. Was there any other change in the environment at the time you noticed sick / dead koalas, or when you stopped seeing koalas in Ashford?

The Ashford priority area, because of the very low koala presence, is not an area where rehabilitation and further work promoting "Trees on Farms" program is considered a priority. In addition, the Ashford priority area presents low fragmentation (90.3% is remnant vegetation).

If the reason(s) for the population crash can be elucidated, directly managing the threats, not habitat rehabilitation, would be the highest priority.

Additionally, the Ashford priority area might present an interesting subject for a student project (Honours for example), where the temperature and precipitation records for the area, from the Bureau of Meteorology, could be data-mined for anomalies. This could be compared to the Atlas of Living Australia records and the questionnaire, to determine whether any specific meteorological event coincides with the koala population crash.

5.3 Recommended Management Actions

5.3.1 On Ground Actions

A. Curb habitat loss, increase habitat extent and connectivity

A1. Decrease / prevent habitat clearing in key areas for koala conservation (see 5.3.4 Research)

A2. Increase the extent of koala habitat by supporting tree planting campaigns and promoting natural regrowth (and associated benefits for the land in general)

A3. Increase the extent of protected koala habitat through: land acquisition, legislative protection and voluntary protection

A4. Engage with neighbouring Councils / State, environment groups and bushcare and habitat rehabilitation groups on koala corridor projects

B. Identify koala road mortality hotspots

B1. Compile available data from all koala Hospitals on road mortality

B2. Interview wildlife rescue teams (e.g. WIRES, Northern Tablelands Wildlife Carers (NTWC)) and local veterinarians

B3. Map koala mortality based on B1. and B2.

B4. Map koala habitat (a first approximation could be by mapping PCT used by koalas from the present surveys, but consider employing an expert to perform a habitat mapping exercise) and underline where koala habitat is divided by roads

B5. Rank koala mortality risk based on B4., as well as road speed and traffic, which influence koala mortality (Jones et al. 2014). B5. is useful as there might be zones of high risk, i.e. where koala habitat is divided by high traffic roads, but that was not picked up by B3. if koalas incidents went unreported)

B6. Use B3. and B5. to establish where new koala infrastructure might be needed (see examples Figure 34). Koalas have been proven to use underpasses (Dexter et al. 2016) although not rope bridges (Goldingay and Taylor 2017). Koala fencing is often used to guide koalas to the underpass (Koala Conservation Unit 2012)

Figure 34: Koala exclusion fencing and fauna underpass with koala furniture. (Pictures from Koala Conservation Unit 2012)

C. Audit and prioritise work on koala infrastructure

C1. Map all current koala infrastructure in the NT (e.g. koala fencing, underpasses, koala signs)

C2. Assess state of all current koala infrastructure in the NT

C3. Prioritise koala infrastructure repairs from C2. and new infrastructure needs from B6.

D. Control predation

D1. Target wild dog control to key areas for koala conservation (see 5.3.4 Research)

E. Improve fire Planning

E1. Review recommendations for control burns in koala habitat

E2. Plan control burns to decrease risks of wild fire in key areas for koala conservation (see 5.3.4 Research)

F. Support Wildlife Carers

F1. Subsidise carers and rescuers (grants)

F2. Organise workshops for carers and rescuers to disseminate knowledge about rescue / care / treatment of koalas

F3. Support carers and rescuers to attend koala conferences to stay updated with latest rescue and rehabilitation research findings (grants)

5.3.2 Legislation and Regulatory Controls

- Develop / support legislation:
  - to protect koala habitat (i.e. Land Clearing laws)
  - to properly offset cleared habitat
  - to decrease carbon emissions, climate change and increase renewable energies (climate change will negatively impact koalas (Adams-Hosking et al. 2011))
  - to control domestic dogs
- Enforce legislation

5.3.3 Community Engagement

- Foster a community that is: informed, engaged, active on the ground for koala conservation
- Promote responsible dog ownership

5.3.4 Research

Koala distribution

- Extend koala presence / absence field surveys to all priority areas and corridors from the NT KRS
- Model koala habitat
- Ground truth the model

- Map genetic connectivity at the landscape level

Koala health

- Map koala health (diseases) at the landscape level
- Map koala genetics (diversity, inbreeding, effective population size…) at the landscape level

Map key areas for koala conservation

- Use koala habitat, health and genetics to rank populations and establish key areas for koala conservation

Koala threats

- Research how climate change will affect NT, map potential climate refuge and investigate connectivity between current koala populations and climate refuges
- Investigate research opportunities to assess the impact of wild dogs, and wild dog baiting, on koala populations
- Investigate research opportunities to assess which weeds (and at what density) impact negatively on koala populations
- Investigate research opportunities to identify and quantify threats across landscape

5.4 Division of Responsibilities

5.4.1 Local Land Services

Loss, modification and fragmentation of habitat

- Organise / promote tree plantings (Trees on Farms program)
- Collaborate with other stakeholders to build a strategic corridor network

Vehicle strike

- Participate (with Councils) in mortality hotspot mapping

Predation by wild or domestic dogs

- Continue implementing 1080 baiting

Intense prescribed burns or wildfires that scorch or burn the tree canopy

- Work with other agencies (especially National Parks) to develop fire regime prescriptions for different plant community types
- Work with other agencies to develop guidelines for implementing control burns in koala habitat

Koala disease

- Support research into koala health mapping

Heat stress through drought and heatwaves / Human-induced climate change

- Support legislation on carbon emission, climate change, renewable energies
- Support research on impact of climate change on koala and mitigation measures

Inadequate support for fauna rehabilitation

- Investigate grant opportunities (with Councils) for wildlife carers / rescuers

Lack of knowledge

Poor understanding of sources of trauma and mortality

- Interview wildlife carers and veterinarians, and mine wildlife Hospital datasets, to quantify disease in koalas coming into care
- Encourage the reporting of dog attacks on koalas

Poor understanding of population distribution and trend

- Facilitate the development of accurate, scientifically-tested koala habitat mapping for the Northern Tablelands
- Monitor koala trends in key areas for koala conservation

Poor understanding of animal movements and use of habitat

- Investigate research opportunities to assess animal movements if this information is required for management
- Extend research into koala Activity Levels (see 4.3 Activity Levels) in different habitats (by including more plant community types for example)

Getting the community engaged in koala conservation

- Distribute educational material to the public about:
    - The importance of koala conservation on private land
    - Rehabilitation programs
    - Koala food and shelter tree species on the Northern Tablelands
    - Reporting koala sightings
    - Reporting sick and injured koalas to wildlife carers
    - Facilitating koala movement across private land and creating "koala-friendly" properties
    - Controlling weeds on private land
    - Options for managing wild dogs on private land
    - Providing watering points for wildlife on private land

  - Opportunities for private conservation initiatives
- Offer expert advice to the public about koala conservation, whenever possible
- Develop and maintain strong relationships between land managers, policymakers, researchers, wildlife carers, veterinarians and other community groups on the Northern Tablelands
- Conduct koala field days to educate and engage the public in koala conservation

In addition:

- Allocate funding to implement these measures
- Monitor and evaluate the effectiveness of these measures

5.4.2 Councils

Loss, modification and fragmentation of habitat

- Modify the planning scheme to require a Koala Plan of Management for development in priority areas where koala scats were located. The KPOM needs to ensure a maintained or improved outcome in terms of extent of koala habitat
- Modify the planning scheme to include assessment of potential barriers to koala movement in the development application process.
- Require koala bridges / overpasses / culverts / ladders to mitigate the impact/s of potential barriers
- Implement a policy for replacement / offset of cleared native vegetation for development impacts that do not require a full impact assessment
- Identify Council land that can be regenerated for koalas as a response to developments that do not have space to plant trees
- Protect Council land that has high koala activity from development
- Connect fragmented habitat patches where koala scats were found on Council land (aiming to increase the abundance and diversity of koala food and shelter trees)
- Rehabilitate degraded koala habitat where koala scats were located on Council land (aiming to increase the abundance and diversity of koala food and shelter trees)
- Conduct an audit of existing fencing within each Council area and identify areas where fencing prevents koalas from accessing food trees
- Prepare a tree replacement policy for Council parks and streets that include more koala food and shelter trees
- Manage weeds on Council land to control weeds that threaten regeneration of trees and shrubs, provide a fire hazard or could disable a koala

Vehicle strike

- Identify koala road and rail mortality hotspots on Council land and target these areas for mitigation measures, such as:
    - Exclusion and guiding fences along roadways and railways
    - Koala bridges, culverts and underpasses
    - Koala ladders
    - Speed limit reductions
    - Koala signage (make it bright or flashing, include local koala death toll)
    - Road markings and traffic calmers
    - Improved street lighting
- Audit the state of existing infrastructure on Council roads

Predation by wild or domestic dogs

- Educate the Public about the impact of domestic dogs on koalas
- Modify the planning scheme to apply domestic dogs control limitations / land covenants on land where koala scats were found
- Enforce domestic dog control
- Investigate the usefulness of workshops on koala aversion training for domestic dogs
- Conduct wild dog trapping and/or baiting on Council reserves

Intense prescribed burns or wildfires that scorch or burn the tree canopy

- Manage fire breaks on Council land to prevent the occurrence of uncontrolled fires

Koala disease

- Support research into koala health mapping

Heat stress through drought and heatwaves / Human-induced climate change

- Support legislation on carbon emission, climate change, renewable energies
- Support research on impact of climate change on koala and mitigation measures

Inadequate support for fauna rehabilitation

- Investigate grant opportunities (with State) for wildlife carers / rescuers
- Issue a levy to ratepayers and developers to assist with expenses of koala carers

Lack of knowledge

Poor understanding of sources of trauma and mortality

- Share Council database
- Encourage the reporting dog attacks on koalas

Poor understanding of population distribution and trend

- Facilitate the development of accurate, scientifically-tested koala habitat mapping for the Northern Tablelands

Poor understanding of animal movements and use of habitat

Getting the community engaged in koala conservation

- Create incentives for landholders to engage in private conservation (e.g. grants, subsidies)
- Offer expert advice to the public regarding koala conservation, whenever possible

In addition:

- Allocate funding to implement these measures
- Monitor and evaluate the effectiveness of these measures

5.4.3 State Government

Loss, modification and fragmentation of habitat

- Strengthen legislative and regulatory controls on vegetation clearing
- Require a Koala Plan of Management for development on State and Crown land in areas known to have/had a resident koala population. The KPOM needs to ensure a maintained or improved outcome in terms of extent of koala habitat
- Include assessment of potential barriers to koala movement in the development application process on State and Crown land and require koala bridges / culverts / overpasses to mitigate the impact of potential barriers
- Formulate a tree replacement / offset policy for small development impacts not requiring a full impact assessment on State and Crown land
- Identify State and Crown land that can be regenerated for koalas as a response to developments that do not have space to plant trees
- Protect State and Crown land that has high koala activity from development
- Connect fragmented habitat patches where koala scats were found on State and Crown land (aiming to increase the abundance and diversity of koala food and shelter trees)
- Rehabilitate degraded koala habitat where koala scats were located on State and Crown land (aiming to increase the abundance and diversity of koala food and shelter trees)
- Prepare a tree replacement policy for State roads that include more koala food and shelter trees
- Manage weeds on State and Crown land, to control weeds that threaten regeneration of trees and shrubs, provide a fire hazard or could disable a koala

Vehicle strike

- Identify koala road and rail mortality hotspots on State and Crown land and target these areas for mitigation measures, such as:
    - Exclusion and guiding fences along roadways and railways
    - Koala bridges, culverts and underpasses
    - Koala ladders
    - Speed limit reductions and enforcement of speed limits
    - Koala signage (make it gory, bright or flashing, include local koala death toll)
    - Road markings and traffic calmers
    - Improved street lighting
    - Evaluation of the design of road and rail networks

Predation by wild or domestic dogs

- Conduct wild dog trapping and/or baiting in State forests and reserves

Intense prescribed burns or wildfires that scorch or burn the tree canopy

- Manage fire breaks on State and Crown land to prevent the occurrence of uncontrolled fires
- Include protection of koalas and their habitat in State Bushfire Risk Management Plans
- Investigate the possibility of detecting / catching koalas ahead of prescribed burns
- Investigate the possibility of detecting / catching and treating injured koalas post prescribed burns

Koala disease

- Support research into koala health mapping

Heat stress through drought and heatwaves

- Investigate the possibility of installing water points on State and Crown land

Human-induced climate change

- Strengthen legislative and regulatory controls on decreasing carbon emissions and promoting renewable energies

Inadequate support for fauna rehabilitation

- Develop grants for wildlife carers (with Councils)
- Subsidise petrol for wildlife rescuers

Lack of knowledge

Poor understanding of sources of trauma and mortality

- Make information about koalas coming into care and their treatment publicly available

Poor understanding of population distribution and trend

- Invest in accurate, scientifically-based koala habitat mapping and allocate funds to Councils to contribute to the mapping

Poor understanding of animal movements and use of habitat

- Invest in accurate, scientifically-based koala habitat use mapping
- Investigate the feasibility, and information gained for management, of koala radio-tracking

Getting the community engaged in koala conservation

- Offer expert advice to the public regarding koala conservation, whenever possible
- Create incentives for Councils to support private conservation (e.g. grants, subsidies)

In addition:

- Allocate funding to implement these measures
- Monitor and evaluate the effectiveness of these measures

5.4.4 Private Landholders

Loss, modification and fragmentation of habitat

- Protect existing and potential koala habitat on private land
- Plant koala food / shelter trees to replace trees that are cleared on private land
- Rehabilitate degraded koala habitat where koala scats were located on private land (aiming to increase the abundance and diversity of koala food and shelter trees)
- Encourage natural regrowth (for example, by fencing creeks)
- Engage in private conservation
- Consider barriers to koala movement on private properties and create “koala-friendly” properties
- Examine fencing and identify areas where this prevents koalas from accessing food trees
- Manage weeds on private land to control weeds that threaten regeneration of trees and shrubs, provide a fire hazard or could disable a koala
- Collaborate with neighbouring properties to create strategic koala corridors

Vehicle strike

- Drive responsibly in koala habitat areas and obey all koala speed signs, traffic markings, etc.
- Have wildlife carers phone number stored in mobile phone / vehicle

Predation by wild or domestic dogs

- Restrain domestic dogs
- Support 1080 baiting

Koala disease

- Know koala signs of disease
- Report signs of disease when logging koala sightings to the Living Atlas database
- Contact wildlife carers when diseased koala is identified

Heat stress through drought and heatwaves

- Deploy water bowls for wildlife during drought and heatwaves
- Participate in water stations on farm program

Human-induced climate change

- Support climate change policies

Inadequate support for fauna rehabilitation

- Take injured / diseased koalas to veterinarians or wildlife carers
- Support wildlife carers

Lack of knowledge

Poor understanding of sources of trauma and mortality

- Report koala attacks and deaths to Council, Wildlife carers or NT LLS
- Report diseased koalas to Council, Wildlife carers or NT LLS

Poor understanding of population distribution and trend

- Report koala sightings to the Living Atlas database and take photos of koalas sighted

Poor understanding of animal movements and use of habitat

- Report koala activity in specific tree species (especially feeding)

Getting the community engaged in koala conservation

- Read educational material distributed by NT LLS
- Liaise with other private landholders, policymakers, researchers, wildlife carers, veterinarians, Landcare groups and other community groups
- Participate in koala field days
- Promote koala conservation via social media and through the community

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Appendix 1: Plant community type (PCT) description for the PCT encountered in the flora surveys, and koala presence

PCT	Koala	Description
0		Non-native coverage/disturbed area/cultivated land
78	**Y**	Red River Gym riparian tall woodland/ open forest wetland in the Nandwar Bioregion and Brigalow Belt South Bioregion (*Eucalyptus camaldulensis* , *Casuarina cunninghamiana* / *Callistemon sieberi* , *Leptospermum polygalifolium* / *Cynodon dactylon* , *Austrostipa verticillata* , *Alternanthera denticulata* , *Commelina cyanea*)
84	**N**	River Oak - Rough-barked Apple - red gum - box riparian tall woodland (wetland) of the Brigalow Belt South Bioregion and Nandewar Bioregion (*Casuarina cunninghamiana* subsp. cunninghamiana , *Angophora floribunda* , *Eucalyptus blakelyi* , *Eucalyptus melliodora* / *Acacia implexa* , *Bursaria spinosa* subsp. spinosa , *Notelaea microcarpa* var. microcarpa , *Callistemon sieberi* / *Microlaena stipoides* var. stipoides , *Austrostipa verticillata* , *Lomandra longifolia* , *Commelina cyanea*)
368	**N**	Smooth-barked Apple - cypress pine - Long-fruited Bloodwood - Dirty Gum shrubby open forest / woodland on sandstone hills in the Warialda to Bonshaw region, Brigalow Belt South Bioregion and Nandewar Bioregion (*Angophora leiocarpa* , *Corymbia dolichocarpa* , *Eucalyptus chloroclada* , *Callitris glaucophylla* / *Jacksonia scoparia* , *Acacia conferta* , *Styphelia triflora* , *Xylomelum cunninghamianum* / *Aristida caput-medusae* , *Myriophyllum caput-medusae* , *Hypericum gramineum* , *Platysace ericoides* , *Pomax umbellata*)
505	**Y**	Black Cypress Pine - Tumbledown Red Gum - Narrow-leaved Ironbark - Stringybark She Oak open forest on acid volcanics of the western New England Tableland Bioregion
510	**Y**	Blakely's Red Gum - Yellow Box grassy woodland of the New England Tableland Bioregion
516	**Y**	Grey Box grassy woodland or open forest of the Nandewar Bioregion and New England Tableland Bioregion
523	**N**	McKies Stringybark - Western New England Blackbutt - Rough-barked Apple open forest of the New England Tableland Bioregion
524	**N**	Mountain Gum - Broad-leaved Stringybark shrubby open forest on granites of the New England Tableland Bioregion
528	**Y**	Mugga Ironbark - Blakely's Red Gum open forest of the Nandewar Bioregion and New England Tableland Bioregion
538	**N**	Rough-barked Apple - Blakely’s Red Gum open forest of the Nandewar Bioregion and western New England Tableland Bioregion

PCT	Koala	Description
567	**Y**	Broad-leaved Stringybark - Yellow Box shrub/grass open forest of the New England Tableland Bioregion
568	**N**	Broad-leaved Stringybark shrub/grass open forest of the New England Tableland Bioregion
577	**Y**	Tumbledown Red Gum - White Cypress Pine - Blakely's Red Gum shrubby forest of northern Nandewar Bioregion
578	**N**	Tumbledown Red Gum - Black Cypress Pine - Caleys Ironbark shrubby open forest of the Nandewar Bioregion and western New England Tableland Bioregion
589	**N**	White Box - White Cypress Pine - Silver-leaved Ironbark grassy woodland on mainly clay loam soils on hills mainly in the Nandewar Bioregion
590	**Y**	White Box grassy woodland on the Inverell basalts mainly in the Nandewar Bioregion
591	**Y**	White Box shrubby open forest on hills mainly in the Nandewar Bioregion
594	**Y**	Silver-leaved Ironbark - White Cypress Pine shrubby open forest of Brigalow Belt South Bioregion and Nandewar Bioregion
596	**N**	Tumbledown Red Gum - White Cypress Pine - Silver-leaved Ironbark shrubby woodland mainly in the northern Nandewar Bioregion
597	**N**	White Box - cypress pine - Silver-leaved Ironbark shrub grass open forest / woodland of the northern Brigalow Belt South Bioregion and Nandewar Bioregion
599	**Y**	Blakely's Red Gum - Yellow Box grassy tall woodland on flats and hills in the Brigalow Belt South Bioregion and Nandewar Bioregion
734	**Y**	Broad-leaved Stringybark - Blakely's Red Gum grassy woodlands of the New England Tableland Bioregion
992	**Y**	New England Blackbutt dry heathy open forest on granites of the eastern New England Tableland Bioregion
993	**Y**	New England Blackbutt grassy open forest of the eastern New England Tableland Bioregion

PCT	Koala	Description
536/505	**N**	Orange Gum - Black Cypress Pine shrubby open forest on acid volcanics of the north western New England Tableland Bioregion/Black Cypress Pine - Tumbledown Red Gum - Narrow-leaved Ironbark - Stringybark She Oak open forest on acid volcanics of the western New England Tableland Bioregion
594/595	**N**	Silver-leaved Ironbark - White Cypress Pine shrubby open forest of Brigalow Belt South Bioregion and Nandewar Bioregion/tea tree shrubby woodland mainly in the northern Nandewar Bioregion

For more details, visit http://www.environment.nsw.gov.au/NSWVCA20PRapp/search/pctsearch.aspx