EUROBODALLA KOALAS PROJECT

BENDETHERA May 2013 SURVEYS and ANALYSIS REPORT

Eurobodalla Koalas project
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EUROBODALLA KOALAS PROJECT - BENDETHERA May 2013 SURVEYS and ANALYSIS – REPORT

Contents

Purpose of the surveys

During 2012 the volunteer Eurobodalla Koalas project completed a pilot study.
Its report was published by Coastwatchers in January 2013 and is accessible via the Coastwatchers website www.coastwatchers.org.au
The study:

- conducted a literature review to ground its activities in ecological theory and glean information on the adaptation of low density koala populations to less than optimum habitat, with a particular emphasis on eucalypt browse species;
- examined vegetation types and produced a digital map for the Eurobodalla Shire in light of the above;
- undertook 21 field plot surveys using the RGBSAT technique, to ground-proof the digital polygons and to search for koala evidence;
- tested the results theoretically and analysed the data using ESRI ArcGIS10 software.

The digital map suggested patches within the Eurobodalla Shire that might have high, medium or low potential to sustain koalas in low density circumstances.

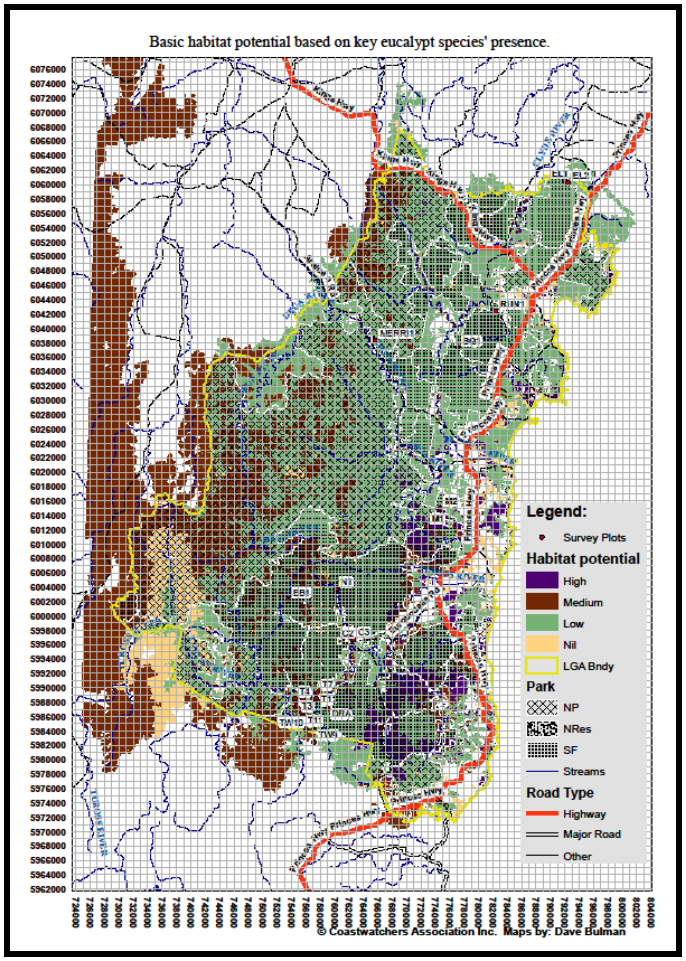
As an extension of this work, the project's 2013 priorities have included:

- testing one of the resulting mapped habitat patches intensively for its potential using the fullest range of factors volunteers can realistically measure over 13 plots [in addition to eucalypt type, factors canvassed in previous research include: (a) size and crown class of trees, foliage cover scales and chemical composition of browse; (b) geology and soil nutrients; (c) altitude, steepness of slope and aspect; (d) distance to viable water source; (e) various disturbance types, eg fire, flood, mining, farming, logging, roadworks, proximity to urban and peri-urban development; (f) size of the patch in relation to known low density home range areas and connectivity corridors for breeding; and, (g) weather history and microclimate];
- analysing the localised patch data in GIS with an improved control for interpreting layers and the content of attribute tables;
- beginning work on a research-based Eurobodalla koala recovery strategy, with a view to this Shire offering a refuge as the species declines in its "core" habitat areas owing to effects like continuing urban/peri-urban development and climate change (*Adams-Hosking & McAlpine, 2013*).

The approx 10 square km patch at Bendethera (around GPS coordinates E 746000 and N 6017000) was selected for the intensive localized study because:

- the pilot study's modeled digital map produced an image of "medium" potential habitat large enough for a home range area
- the patch appeared to have some connectivity through vegetation type to similar quality habitat on the tablelands to the west, where koala populations persist
- the location is at mid-escarpment (altitudes 297 metres at Deua River flat level, to 600 metres at ridgetop level) offering an opportunity to inquire whether the escarpment might be a barrier or a facilitator for breeding connectivity and natural population revival
- although there is no hard evidence except for one nearby Wildlife Atlas record, there is some history of speculation amongst Eurobodalla locals about Bendethera as a place where koalas have lived

- the patch is remote enough from modern development and protected inside the Deua National Park, yet accessible to researchers by four wheel drive vehicle
- the primitive camping conditions allowed for a one-off expedition, which was the most feasible method for a small study with minimal resources



Other background features of the Bendethera survey patch

Exploroz summary description - Bendethera locality

Position DEG -35.94875 149.745834
DMS 35º 56' 55.5" S 149º 44' 45" E
UTM 55 H 6018250mN 747665mE
Altitude 297.09m

Bateman Subregion of the South East Corner Bioregion – overall description of the wider area

Geology

Tightly folded fine grained Ordovician metamorphic rocks with several intrusions of granite. Western margin is a tight synclinal fold in Devonian sandstone and siltstone. Small areas of Tertiary basalt and

quartz sands behind the coastal headlands. Quaternary alluvium on main valley floors and in the estuaries.

Characteristic landforms

Steep hills below the Great escarpment oriented north-south and controlled by rock structure. Lines of hills become lower toward the coast with a slight up turn along the coastal margin. Coastal barrier systems are small and estuarine fills limited.

Typical soils

Mostly texture contrast soils. Red clay subsoils with thin topsoil on metamorphic rocks, deeper coarser grained profiles on granite. Red brown structured loams on basalt and deep siliceous sands with some podsol development on Tertiary sands and coastal dunes.

Vegetation

Hakea, melaleuca, coast rosemary and dwarfed red bloodwood heath on headlands. Red bloodwood and spotted gum forests to 300 m. Yellow stringybark, grey ironbark and woollybutt to 550 m. Brown barrel, black ash, Sydney peppermint, large-fruited red mahogany, Sydney blue gum and monkey gum to 900 m, then snow gum.

Aboriginal history

The Bendethera Conservation Management Plan (*2009*) observes: "The pattern of known occupational sites in the [wider South Coast] area is of larger sites along the rivers and their deep valleys and small, short-stay camps on the high ridges and saddles. It is suggested that Aboriginal people may have set out from these river-side camps, climbing along the tops of ridges to hunt wallabies and possums and venturing into the shady, forested gullies for berries and fern hearts (*Byrne, 1984*). The areas now within DNP, including Bendethera, may have been visited as part of seasonal movements, with large gatherings on the coast in spring and summer and smaller groups hunting, fishing and collecting plant foods in the

forested hinterland in autumn and winter. Intertribal gatherings with groups from further afield to perform ceremonies and trade goods may have taken place at certain times of the year, as ridgelines in the area are likely to have provided routes between the coast and the tablelands….It is recognised that Aboriginal people have a strong attachment through spiritual and cultural links with the whole landscape, and to specific locations within the Bendethera valley."

European settlement

Again the Bendethera Conservation Management Plan observes: "In 1829 the settled area of the colony of New South Wales was divided into nineteen counties. Settlement, including pastoral occupation, was officially forbidden in the area outside the nineteen counties. The boundary of these counties was known as the 'Limits of Location', the southern boundary being the Moruya River (*Goulding & Waters 2005*). The passing of the Robertson Land Acts in 1861 resulted in changing land use patterns, closer settlement and restricted access by Yuin people to many places in their country.

Throughout the 1830s the extent of European settlement steadily grew. Much of the movement of people and stock into the area came down from the tablelands via Braidwood and Araluen while others came by sea. Throughout the nineteenth, and well into the twentieth century, the sea was the focus of south coast settlement with settlers relying on it for the majority of their transport needs (*Goulding & Waters 2005*). It was the discovery of gold in the Deua River at Araluen in 1851 which led to the opening up of the wider region for farming. Farmers were able to make a living by supplying goods to the Araluen miners and later to the miners at Nerrigundah, when gold was discovered there in 1861.

The isolation of Bendethera throughout history has put social constraints on its early European settlers, however this isolation has also engendered a great love for the place. There have never been any immediate adjoining neighbours to the valley. Bendethera was not located far from settlements that existed earlier, however the difficult terrain unsuited for European use isolated the valley and made it, and other Deua Valley holdings, remote pockets in otherwise forested, mountainous country.

It is known that the more accessible inland areas reached via Araluen and coastal areas behind Moruya were taken up earlier than the more remote areas like Bendethera (*Le Maistre 1992*). The Araluen area, around 25kms from Bendethera, was occupied earlier by squatters and after the gold rushes and under the 1861 land legislation, became even more densely settled. The 1861 Acts had an impact on the South Coast with the movement of small scale settlers into the region in the 1860s as the large pastoral leases began to be broken up into small allotments. In the period from 1860 to 1900 a shift occurred over much of the area under consideration from pastoralism to agriculture, intensive grazing and associated activities (ie. cropping and pig raising) as the primary form of European land use.

The historic bridle tracks in the region were first established to provide access to farming properties, such as Bendethera, from the mid-1880s (*NPWS 2000*). When settled in the 1860s, Bendethera had limited access via a bridle track from Moruya, the only way to transport produce to markets. The bridle track from the Deua River to Araluen was used to supply the goldfields area with food grown locally at Bendethera. Other nearby historic properties to the north such as 'Alpine' and 'Canoolie' were also accessible by bridle tracks during this period.

The Bendethera bridle tracks played a large role in opening up the goldfields and Monaro Tablelands to settlement, trade and economic growth in the 1850s and 1860s. These tracks were integral to the development of the Shire and provided an opportunity for the transportation of goods and stock from the tablelands to the coast (*ESC 1997*). As the Deua River Valley lies between Moruya and Krawarree, it was also necessary to build access bridle tracks to link Bendethera with Krawarree and Moruya (*Le Maistre 1992*). It is still possible to identify the bridle

path from Bendethera to Moruya, along which animals were driven up the steep mountain side, eventually to be shipped to Sydney, however the track that we see today is not necessarily the same one that was first used, as the track that is visible was put in by a bulldozer in the late 1960s.

The other main bridle track routes went along the Deua River south to Belowra and then on to Cobargo using the stock routes. This route provided access to land used for cattle grazing on the Deua at Georges Creek junction and to the miners at Nerrigundah. The tracks were regularly used for the transportation of supplies and stock through the area between the coast and tablelands. They continue to be traversed on horse-back and provide a great opportunity to see the scenic South Coast hinterland (*ESC 1997*).

The distance from Moruya and Araluen did not completely isolate the families who lived at Bendethera from the towns. The George and Rankin families, who lived at Bendethera, were active members of the Catholic Church at Moruya. When the George and Rankin families lived at Bendethera the priest from Moruya visited quarterly. Although the railway from Sydney to Nowra was completed in 1893, it was many years before road transportation to Moruya was to become a popular means of travel. At that time, overland communication to districts south of Nowra was still by means of the series of bridle tracks from the tablelands."

Koala history

Records of sightings or population size prior to World War II are non-existent. Only three records since then have been entered on the NSW Wildlife Atlas for the broader part of Deua National Park (stretching from Badja Nature Reserve to the Moruya edge of the Park) that includes Bendethera. *Wildlife Atlas records show one occurrence on a ridge near our altitude 800m Plot B11*. Local speculation about Bendethera as a koala place has occurred, but there is no other hard evidence. The general history of the koala in the whole of the Eurobodalla is of sparse records and probable decline from healthy populations in the mid-19th Century (prior to the full impact of European clearing for farming, and hunting) to a status approaching functional extinction by the late 20th Century. The confirmed occurrences nearest to Bendethera in recent years have been around Nerrigundah (2009) and Wamban Creek (2013), the latter being a tributary of the Deua River just inside Deua NP adjacent to small private holdings and the western edge of Moruya State Forest.

Forest types

Using the SCIVI map descriptors (*Tozer et al, 2010*) the forest types in the patch are:

- Highland Range Sheltered Forest (dominated by E fastigata and E dalrympleana; with Efas classified as a "secondary" potential browse species in the pilot study and Edal not mentioned)
- Batemans Bay Foothills Forest (dominated by E sieberi, E agglomerata and Angophora floribunda; with all of Esie, Eagg and Angflo classified as "supplementary" potential browse species in the pilot study)
- Clyde-Deua Open Forest (containing E muelleriana, E cypellocarpa and E sieberi; with Ecyp classified as "primary", Emue classified as "secondary" and Esie classified as "supplementary" potential browse species in the pilot study)
- Clyde-Deua Ridgetop Forest (dominated by E sieberi and E radiata; with Esie classified as "supplementary" and Erad classified as "secondary" potential browse species in the pilot study)

- South Coast Hinterland Wet Forest (including E cypellocarpa, E muelleriana and E fastigata; with Ecyp classified as “primary”, Emue classified as “secondary” and Efas classified as “secondary” potential browse species in the pilot study)
- Mountain Wet Fern Forest (dominated by E fastigata, classified as a “secondary” potential browse species in the pilot study)
- South Coast River Flat Forest (dominated by E tereticornis, classified as a “primary” potential browse species in the pilot study)

The floristic descriptors for these forest types provide detailed predictions on frequency of occurrence etc amongst species, permitting koala browse-related ground proofing against baseline data. Apart from the dominant or more common species mentioned above, the floristic descriptors also enumerate the other less commonly occurring eucalypts within each forest type. On the other hand, much of the SCIVI vegetation type polygon construction has relied on modeling, so user caution is required in the absence of comprehensive ground-truthing. ***NPWS provided a list of Deua plant species (Appendix 1)***.

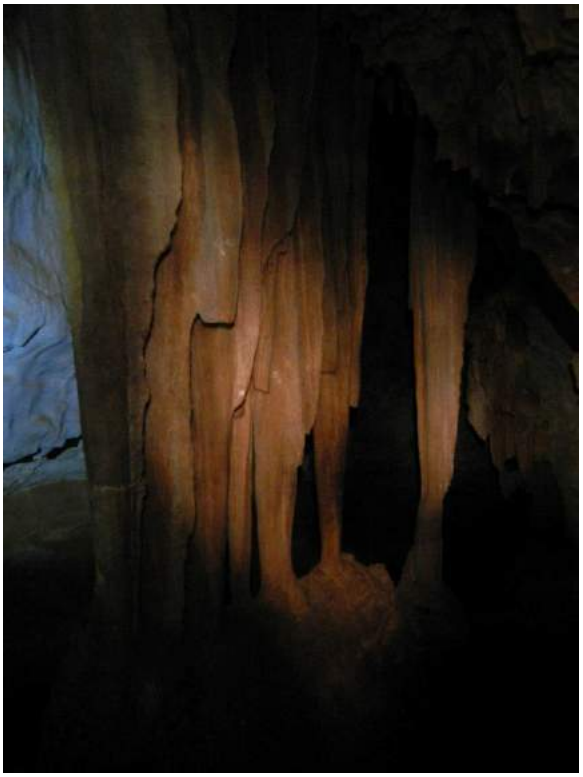
Geology

Koala researchers consider geology and soil type relevant to the quality of habitat. *Norton & Neave (1996)* consider high quality habitat is typically derived from basalt or alluvium, and *Braithwaite (1983)* considers high quality habitat requires high nutrient soils, on flat topography or gullies.

The best available geological map for the Bendethera area is the “Araluen” sheet.

The NSW Red Index describes the general geology for the Deua NP as follows: “The area has a diverse geology. Ordovician sediments outcrop on the Kybeyan Range at the western edge of the area, and in a large band centred on the Deua River. Siluro-Devonian granites are found along Woila Creek and the middle parts of Burra Creek; Devonian sediments along the Minuma Range and Tabletop-Mother Woila

area; and Silurian sediments at Bendethera Caves. Devonian-aged "Comerang" volcanics form the ridges leading to the Deua River, east of Bendethera Caves and at the Mountains of the Moon, near the eastern part of the area. At the eastern edge of the area the sediments of Merrimbula Formation are exposed. Small areas of Quarternary alluvial sediments occur along the Deua River."
The Bendethera Caves are of limestone formed in a shallow sea between 440 and 415 million years ago, containing shell marine animal fossils from the Silurian Period in the Paleozoic Era.



Local advice is the geology around Bendethera can be quite complex. Apparently "the limestone sucks up other minerals", and in the old days the fossickers there were looking for base metals (not gold) on a small scale (*John Butcher, pers comm*). The Bendethera Conservation Management Plan refers to short term mining for silver, lead and zinc "for a year or two" around 1890.

Weather and Climate

BOM weather stations close to Bendethera (including one at Bendethera itself and one called "Snowball") appear to have incomplete records because of their openings and closings. A quick online check of the Snowball station data revealed:

Lat: 35.94° S

Lon: 149.59° E

Weather station opened 1896

Altitude 870m

Historical mean and median rainfall per month compared with 2012, at link
http://www.bom.gov.au/jsp/ncc/cdio/weatherData/av?p_display_type=dataSGraph&p_stn_num=069062&p_nccObsCode=136&p_month=13&p_startYear=2012

Full detailed rainfall data, at link

http://www.bom.gov.au/jsp/ncc/cdio/weatherData/av?p_nccObsCode=136&p_display_type=dailyDataFile&p_stn_num=069062&p_startYear=2012&p_c=-953908371

There is also a station called "Moruya (Plumwood)" [not to be confused with the main Moruya Airport station beside the sea]. This might be at the Plumwood Fire Tower, and if still open as indicated below probably has the best approximations for the Bendethera ridgetops (though possibly not for river bed microclimate). The Plumwood data are:

Station Number: 69145

Opened: 1993

Now: Open

Lat: 35.98° S

Lon: 149.86° E

Elevation: 930 m

Full rainfall data, at link

http://www.bom.gov.au/jsp/ncc/cdio/weatherData/av?p_nccObsCode=139&p_display_type=dataFile&p_stn_num=069145

The "Khan Yunis" (745 m elevation in the Braidwood district) gives mean historical monthly rainfall as 48.3mm in May (the lowest) up to 99.2mm in March (the highest). (*Adams-Hosking concluded highest probability of koala occurrence is between 700mm and 1500mm per annum. Researchers generally accept the upper altitude for koalas as 800m but the Numeralla Gum Reserve population has been said to be at 1000m*).

A snapshot weather forecast for Bendethera in mid-January had temperatures ranging from 15deg minimum to 28deg maximum over three days. (*Adams-Hosking & McAlpine, 2013 argue the highest maximum temperature for koala habitat is 37.7deg and highest probability of occurrence is between 23deg and 26deg, maximum summer temperatures.*)

The Eurobodalla is promoted by the tourism and real estate industries as having the most temperate climate in Australia, but readings at prominent BOM stations like Moruya Airport are not representative of inland and higher altitude localities. The Deua NP NPWS Rangers describe Bendethera as a "frost hollow" in the colder months.

The Eurobodalla Shire Council Bushfire Management Plan describes the general climate for the Shire as follows: "The Eurobodalla Shire is situated on the South Coast of New South Wales, 280km from Sydney, 760km from Melbourne and 150km from Canberra. It is approximately 110km in length and 50km in width.

The climate of the area, can best be described as mesothermal with long dry summers. It is influenced by the Pacific Subtropical and Subpolar Maritime Air Masses as well as the stable dry to very dry Subtropical Continental Air Mass.

Most of the area consists of uninhabited mountains and hills which fall from the rim of the plateau of the Southern Tablelands at about 1000-1100 metres a.s.l. to a narrow coastal lowland where settlement and economic activity are concentrated.

Temperature, humidity, rainfall and wind are all important components of weather that contribute to fire behaviour. All of these factors except for wind are considered in the BKDI (Byram-Keech Drought Index). An analysis of BKDI records for the Southern Region of NSW S.R.B.A (1994) show that relatively high BKDI levels exist along the coastal hinterland during

the summer months.
Dry Winters and Springs are common in the Eurobodalla and August normally receives about 5% of the annual rainfall. Higher monthly rainfall is usually experienced in the months December to April, where 50% of the annual amount is received. Summer thunderstorms with lightning are a regular occurrence.
In the months December to May, winds are generally from the north-east to north-west with strong gusty southerly winds occurring on occasions. These 'southerly busters' have the potential to have a major impact on the control of wildfire situations."

Disturbance

As well as the mining and farming history, bush fire is relevant as a koala habitat disturbance factor. The general history for the Eurobodalla is described in the Eurobodalla Shire Council Bushfire Management Plan as follows: "High intensity bushfires have been a regular phenomena within the Eurobodalla since European settlement. The Eurobodalla has a particularly bad fire history with severe fire seasons occurring every three to seven years. During the last fifty years, at least eleven devastating fires have occurred in the area. The fires of 1939 and 1952 are generally regarded as having been the most widespread, but those of 1927-28, 1953 and 1968, did incalculable damage over more localised areas. (*A local pers. comm. indicates the 1968 fire wiped out the last remaining koalas near Moruya township, at Telegraph Rd, Mogendoura.*)
The fires of 1994, generally started west of urban development and ran into urban development, under strong winds. Although one house and several sheds and fences were destroyed by fire, over 60 homes were ignited and saved, over the two day period. At no stage, did a 'southerly buster' impact on the running fires, otherwise, losses may have been more significant.
This severe fire history, results from the combination of a wide range of factors which include, topography, vehicle access and trafficability, frequent droughts, periods of hot drying winds and large areas of forest, which for the most part, have abundant shrub and herb layers.
Wildfire occurrence is closely related to the rainfall pattern. A large percentage of fires over the years, have been relatively easy to control and a number were allowed to burn out over very large areas. Their origins have generally been in the dry area to the west or on private property adjoining State Forest or Crown Land, the cause in most cases, being illegal burning off, to promote new growth for grazing.
Most of the severe outbreaks, have occurred when fires, which had been burning steadily for a long time, spread rapidly with the advent of conditions of high fire danger. In general, this has occurred when the Spring dry, failed to break, as happened in 1968, or when a wet Spring has been followed by a dry summer, as happened in 1939 and 1952. The most common direction of fire travel is from the west towards the coast, posing a serious threat to coastal settlements.
Apart from this threat to life and property, serious damage can occur to growing stock on the intensively managed coastal forests and may also have a detrimental effect on water catchment values.
Records of ignition locations for the Eurobodalla, come from several agencies and prior to 1975, are incomplete."

NPWS has digital fire records for the Deua National Park, but volunteers were still trying to obtain these at the time of completion of this report.

Topography

The ruggedness of the Bendethera area was considered from the beginning of this exercise as a possible key inhibitor of koala occurrence, or at least of koala movement outside the immediate Deua River

valley. (*Norton & Neave, 1996, cited by Hammond found 90% of koala sightings occurred on slopes of less than 20deg.*)

Measuring the koala habitat factors

Eucalypt type

Recorded at plot scale in the field data sheets, then analysed in GIS in conjunction with SCIVI map polygons and research on potential low density browse species.

Size and crown class of trees, foliage cover scales and chemical composition of browse

Size of individual trees, tree canopy cover and species richness recorded in field datasheets. Chemical composition requires a separate study.

Geology and soil nutrients

Underlying geology checked post-survey. It was found the geological data were not able to be productively overlaid in the GIS exercise. Geology of the plots was metasediment, the usual condition for the Eurobodalla inland surveys. Soil samples were collected for each plot and a couple sent to www.apal.com.au for nutrient content testing. Soil depth and general soil type recorded on field datasheets.

Altitude, steepness of slope, aspect and shade

Altitude, steepness of slope and topographic shading to be overlaid in GIS post-survey. Steepness of slope estimates, aspect and localised shade also recorded on field datasheets.

Distance to viable water source

Deua River is less than or equal to approx 3 km from most plots. GIS map shows watercourses.

Various disturbance types, eg fire, flood, mining, farming, logging, roadworks, proximity to urban and peri-urban development

To be gauged from the area's history (above) and maps. Field datasheets allow for some localised notes.

Size of the patch in relation to known low density home range areas and connectivity corridors for breeding

Gauged from GIS map. This patch was chosen for its apparent suitable size as a home range area for perhaps one breeding association, plus possible connectivity to others.

Weather history and microclimate

BOM records consulted (*above*). Climate profile for the geographic range (Bendethera study patch) generated by ANUCLIM using the 13 plot survey points and compared with a known koala area elsewhere in the NSW South East.

May Expedition and Participants

Report for Coastwatchers Newsletter:

YOUNG PEOPLE HELP KOALA PROJECT GLEAN BENDETHERA DATA

As part of its investigation into the capacity of the Shire's forest habitat to offer home ranges and breeding connectivity, the volunteer Eurobodalla Koalas project undertook a survey expedition to Bendethera from 5th to 12th May.

Supported by the Coastwatchers tax deductible Environment Fund and generous locals Rob Richmond of Mogendoura and Tony Usback of Malua Bay who provided an accommodation base and four-wheel drive vehicles, Coastwatchers member Keith Joliffe (now living in Canberra), Dave Bulman of Bermagui and Surfside resident Mike Kachyckyj camped out for the whole eight sunny autumn days and frosty nights.

Bega's Kahli Beissner and Canberra's Lauren Chockman (*pictured fully enjoying her novice scat identification experience – this one was possum*) alternated for half the week. Kahli hopes to begin a university Honours program next year, researching the suitability of the Deua National Park as a koala refuge. Lauren is involved in community outdoor and scientific volunteering as part of her Duke of Edinburgh Award Gold Challenge.

In the middle of the week the volunteers were joined by a Canberra Grammar School Year 10 outdoor education group who split into two to spend half a day each surveying and half a day learning about Geographic Information Systems from Dave. The boys accepted survey leadership roles with alacrity and were fascinated by the sophisticated digital software the Eurobodalla Koalas project uses for its analysis. The number of survey plots completed, some in terrain Park Rangers thought impossible, was boosted from a planned 10 to an actual 13 by the input of 7 Murrumbidgee Rover Crew members (Belconnen, ACT) on the final weekend. Not only were the Rovers fit, young, enthusiastic and well equipped but included in the group were employees of CSIRO (Chris Malam) and Geoscience Australia (Crew Leader Katy Tomkins) experienced in habitat surveys and GIS modeling.

Although no koala scats were found, an enormous amount of other data was collected on the full range of predictive habitat factors including eucalypt type and size, species richness, canopy cover, the presence of other animals, shade, topographic features, geology, soil, weather and disturbance history.

Lauren, Dave and Keith have now begun the long task of analyzing the material. Keith says “a day in the field generates ten days work in the office” and believes it will be late 2013 before the research team can say if the Bendethera site offers a viable home range. Bendethera was chosen for special, intensive attention because it showed up on last year’s pilot study mapping as a large enough patch for a koala resident group to establish a home range, appeared to have “Medium” browse species potential, is mentioned in local folklore as a past koala place and is in a good position to test whether the escarpment might be a facilitator or a blockage to breeding connectivity between the coast and known populations on the nearby tablelands.

When winter is over, the project volunteers would like to do some more surveys at the Deua catchment’s Wamban Creek closer to Moruya, where the koala roars were recorded and fresh scats found last summer. It is still uncertain whether this animal was a dispersing male or part of a resident group. There are several other spots around the Shire that need surveying also, such as Bodalla State Forest which came up on the 2012 map as having “High” habitat potential.

Keith Joliffe has declared his ambition to begin designing a Eurobodalla Koala Recovery [Strategy] by the end of 2013. Anyone interested in this intriguing work (whether you’d like to help in the bush or in other more sedentary ways) is invited to contact Keith on (phone) or via the Eurobodalla Koalas project *facebook* group accessible through the recently upgraded Coastwatchers website.

Survey plot coordinates and datasheets

Coordinates for plots, and SCIVI veg type polygon codes for each

Plot #	*Easting*	*Northing*	*SCIVI polygon code*
BE #1	**0746021**	**6016942**	**p91**
BE #2	**0746987**	**6016992**	**p89**
BE #3	**0747804**	**6016996**	**p89**
BE #4	**0745990**	**6016008**	**p91**
BE #5	**0746991**	**6015991**	**p66 & adj p89; p91**
BE #6	**0748030**	**6015956**	**p91**
BE #7	**0745000**	**6015000**	**n183**
BE #9	**0747030**	**6014957**	**p91**
BE #10	**0747728**	**6014959**	**p91**
BE #11	**0743302**	**6014368**	**p98**
BE #13	**0749895**	**6016020**	**p98 & very adj p91; e12**
BE #14	**0747604**	**6015690**	**p89**
BE #15	**0746750**	**6018800**	**p91 & very adj p30**

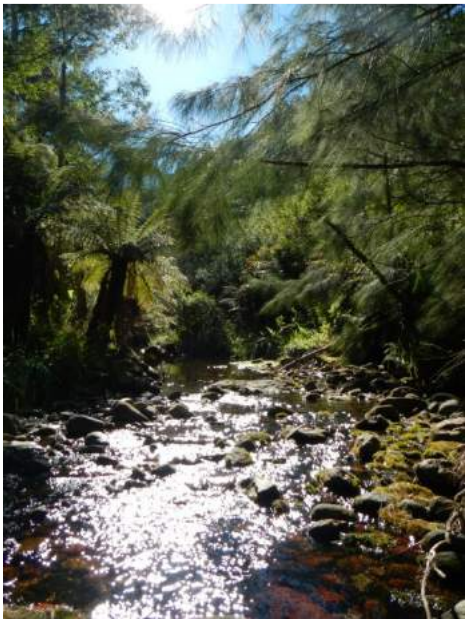
Preplanned locations where surveys were achieved

Other surveyed locations added during the expedition

Relevant SCIVI forest types and codes - Appendix 3, Tozer et al (2010)

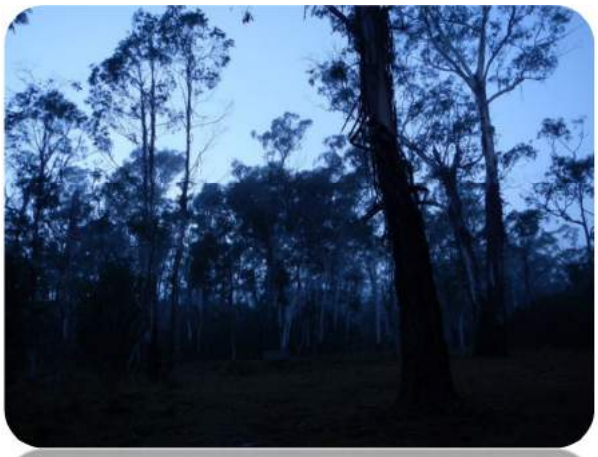
e12

Mountain Wet Fern Forest, Pp 24-27



p30

South Coast River Flat Forest, Pp 279-282



p66

Highland Range Sheltered Forest, Pp 357-361

p89

Batemans Bay Foothills Forest, Pp 396-399

p91

Clyde-Deua Open Forest, Pp 404-407

p98

Clyde-Deua Ridgetop Forest, Pp 411-413

n183

South Coast Hinterland Wet Forest, Pp 193-196

- ***<u>The completed plot datasheets are attached as Appendix 2 (Excel file).</u>***

Post-survey data collection

<u>Browse species and foliage factors</u>

<u>Attached at Appendix 3 is an analysis undertaken by Lauren Chockman.</u> Lauren used the forest types occurring at Bendethera according to the SCIVI polygon codes (above). She extracted from each forest type's floristic descriptor the percentage occurrence of each eucalypt species amongst the total for that forest type. Lauren then arranged these figures according to the "Primary", "Secondary", "Supplementary" and "Suspected" importance of each species as part of the browse mix for local low density koalas, postulated by the *Eurobodalla Koalas project Pilot Study (2013)*.

The only other foliage input was tree canopy cover, collected in the field on the individual plot datasheets (***Appendix 2***).

- *Note the eucalypt ID difficulties recorded on the sheets.*
- *Note Greg Watts' (Deua NP Ranger) remark that the Deua NP Plant Species List shows E radiata and E smithii variants.*

Attached at Appendix 1 is the Deua National Park Plant Species List.

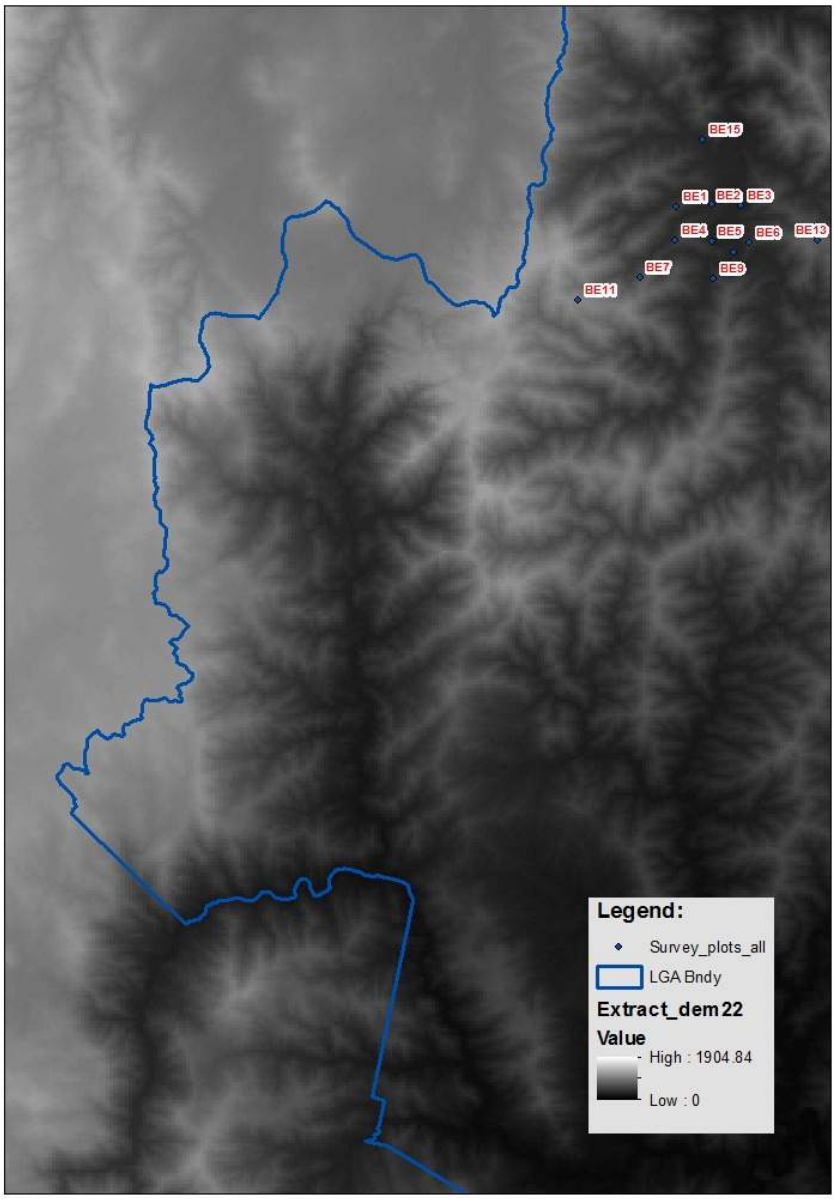
Topography

Dave Bulman produced an elevation map and an aspect map using ArcGIS 10.

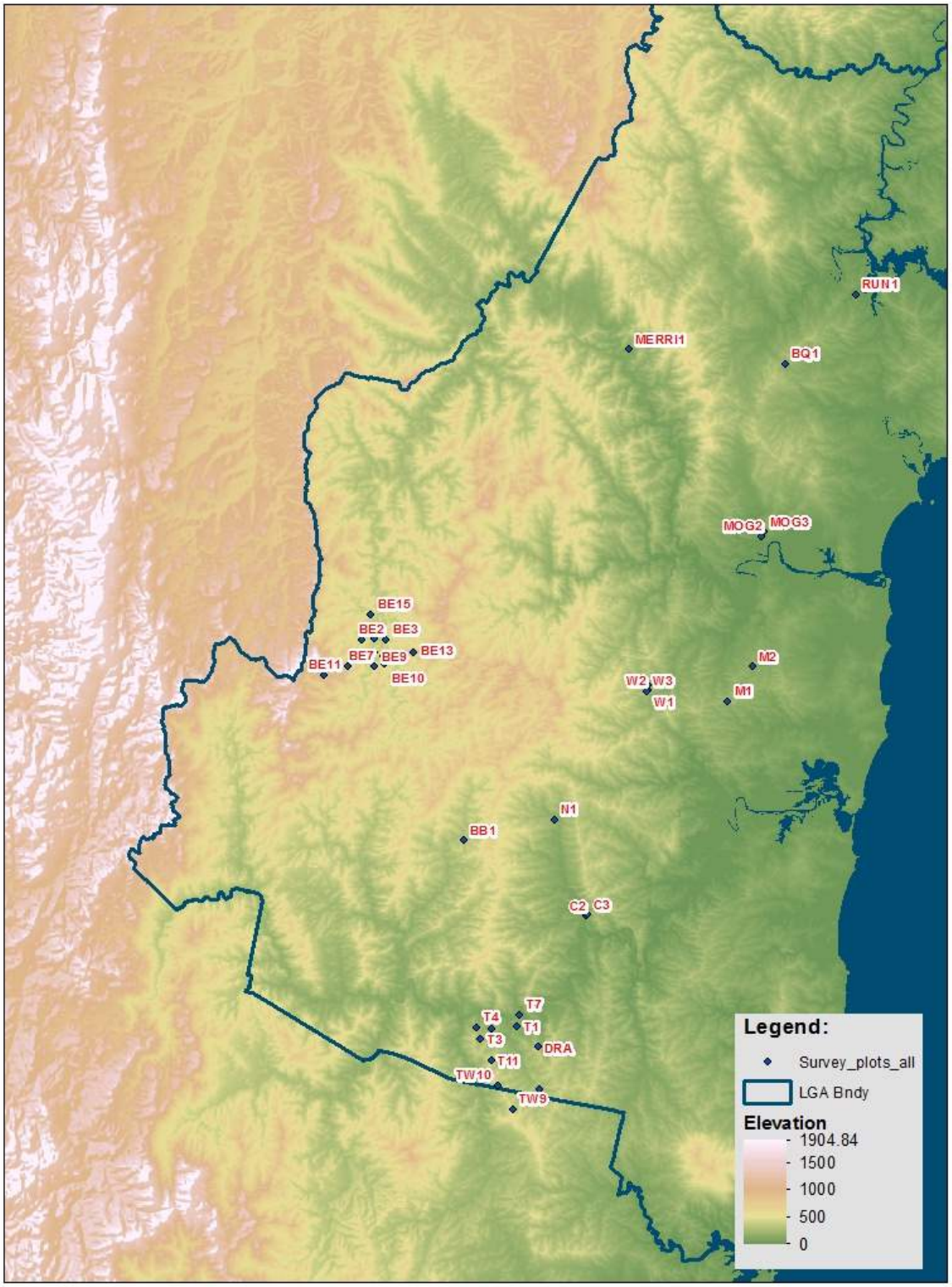
The maps are reproduced below. The GIS files also contain a slope map.

The elevation map was aimed at checking potential topographic pathways through from Bendethera to known koala areas around Badja and Tallaganda/Bredbo, the same places where the previous vegetation type modeled map seemed to suggest a "medium" habitat connection.

Elevation Maps: Bendethera to Tablelands West & South West; Eurobodalla LGA & Tablelands



© Coastwatchers Association Inc. Maps by: Dave Bulman



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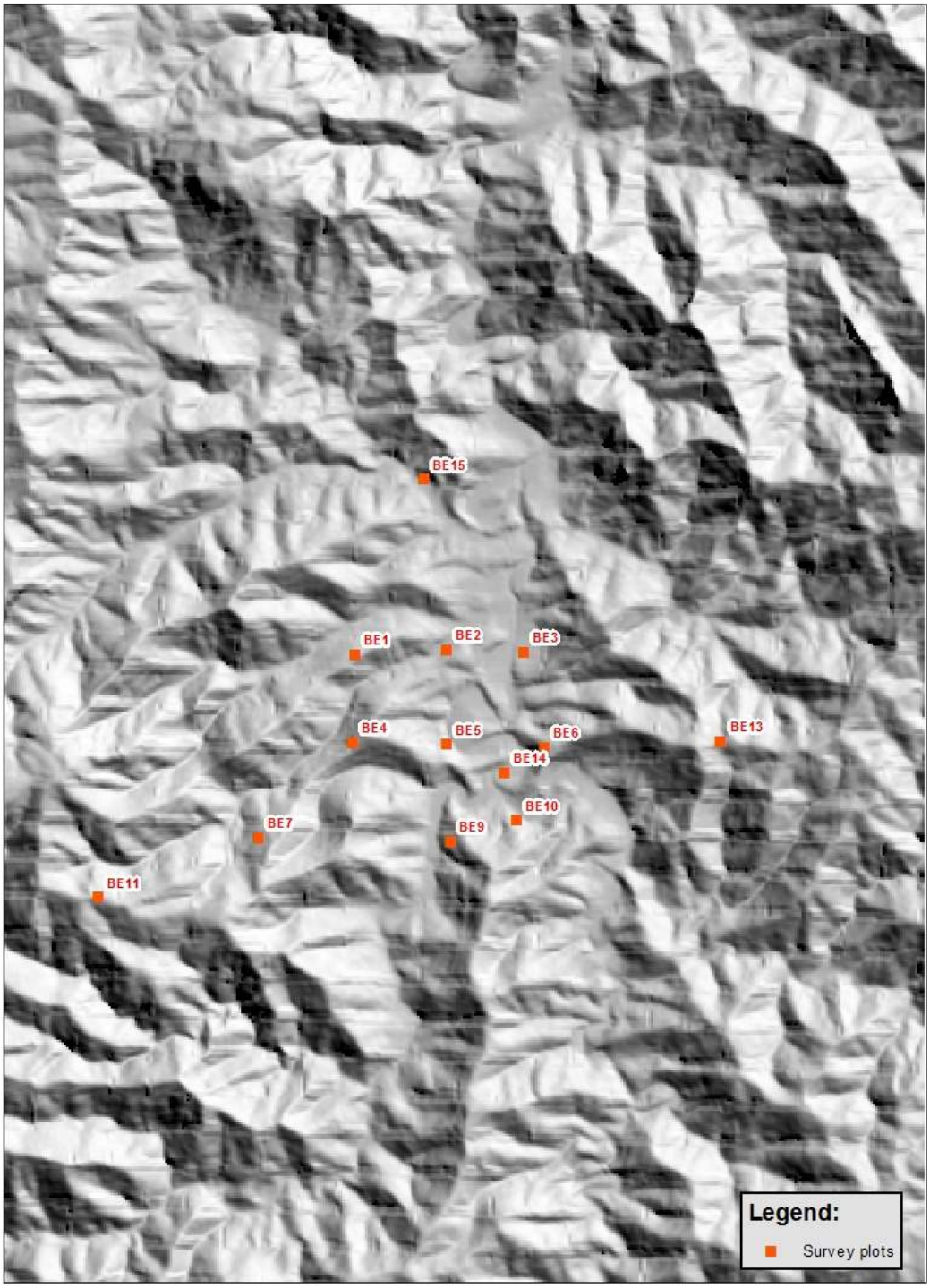
Aspect Map – Bendethera



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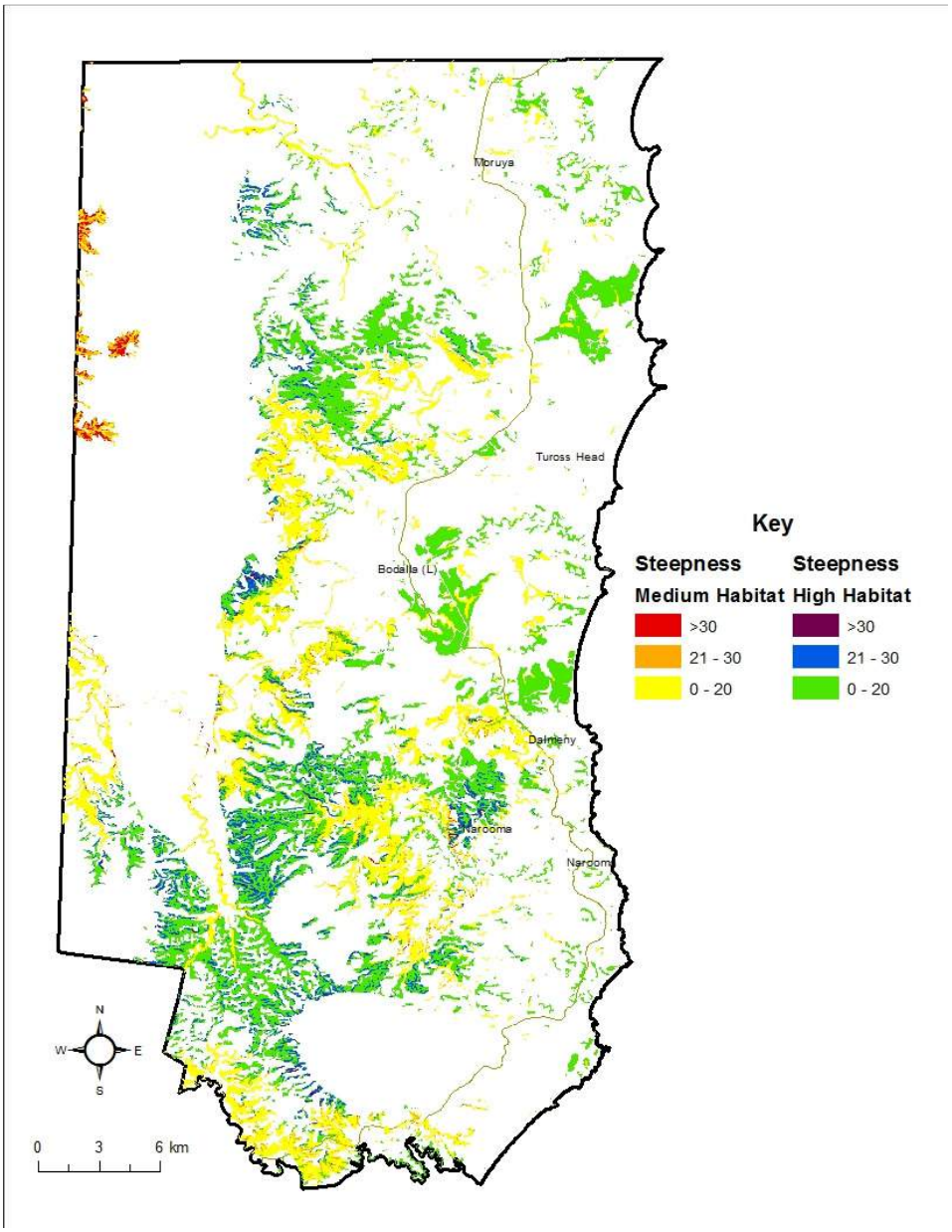
As a side project, Chris Malam began working on a combined slope and vegetation type display (below) for the potential connectivity zone from Bermagui/Sam's Ridge (known populations) northward to Wamban Creek (koala evidence 2012/13). Wamban Creek is a tributary of the lower Deua, closer to Moruya. A future side project might address the potential for the traditional bridle track to offer a koala movement corridor from Bendethera along the Deua River south to Belowra and then on to Cobargo via the old stock routes. This bridle track gave 19th Century Bendethera farmers access to cattle grazing land at Georges Creek Junction, and to the miners at Nerrigundah (known koala area until 1950s and still producing occasional records until 2009).



Soil sample analysis

Two samples were able to be sent for analysis (See ***Results***, below).

Weather

The BOM internet links are given in "***Other background features****…weather & microclimate*, above).
The ANUCLIM exercise produced the data in ***Results***, below.

Results

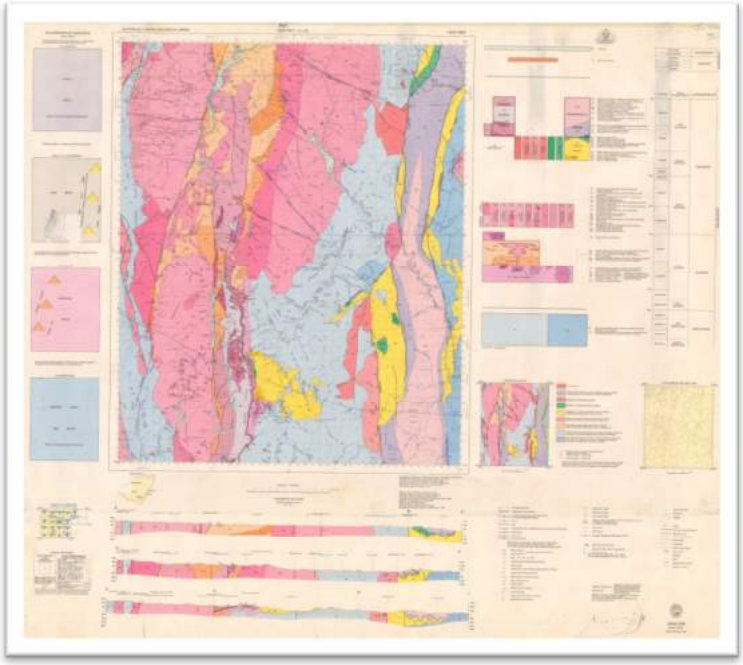
Vegetation Type

Lauren's analysis of the SCIVI polygons' floristic descriptors (***Appendix 3***) showed that numerous potential koala browse species of varying apparent importance would be expected to be scattered thinly amongst each other across the whole Bendethera patch. Greatest concentrations per SCIVI polygon are of pilot study "Primary" *Ecyp* (eg 9.17% in n183 and 12.5% in p98), pilot study "Primary" but disputed by conventional classifications *Eglo* (11.01% and 15%) and pilot study "Supplementary" *Esie* (14.68% and 20%). *Emue*, (pilot study "Secondary") and pilot study "Supplementaries" *Angflo*, *Eagg* and *Acas* are expected in lesser but also notable numbers in the mix for some SCIVI polygons.

By comparison the Bendethera survey datasheets show denser, often dominant concentrations of these species in the smaller scale plots. Some datasheets show dominant *Eagg* (specific Stringybark ID was difficult for the amateur survey volunteers), and one plot each have pilot study "Secondaries" *Erad* and *Eela* dominant. Altitude, slope, aspect, soil (river-flat loam or hillside sandy loam) appeared to play a part in the differences of eucalypt dominance between separate plots.

The survey results for tree canopy cover were "Thin" (7 plots) and "Medium" (6 plots).

Geology



The "Araluen" Geological Sheet

The 13 Bendethera plot datasheets record geology as "Metasediment".
The Quartz content of some ridgeside plots (eg with *E sieberi*) was noted on the datasheets.
According to the layout of the Araluen Geological Sheet, the underlying geology type for Bendethera is "Oa" (Oligocene Alluvium) with one small patch of "Qa" (Quarternary Alluvium), and extends over the whole patch.
Generally the description is "Late Ordovician quartz-rich flysch with tight to isoclinal meridional folding. Axial plane cleavage commonly not well developed." This explains the very steep slopes on ridges (see ***Topography***).
The digital query on the map does not appear to coincide directly with the legend.
Some previous research suggests Devonian intrusions (underpinning fertile soils) are best for koalas.

Soils

The plot datasheets record soil type as "Sandy Loam" (in most cases) and "Loam" (river flat locations).
The laboratory results for the two tested Bendethera plot samples are as follows:

SAMPLE ID Unit	***BE3***	***BE14***
Olsen P mg/kg	2.32	2.74
Exchangeable Ca mg/kg	1018.62	894.00
Exchangeable Ca meq/100g	5.08	4.46
Exchangeable Ca %	60.99	68.54
Exchangeable Mg mg/kg	282.70	202.60
Exchangeable Mg meq/100g	2.33	1.67
Exchangeable Mg %	27.92	25.62

Exchangeable K mg/kg	293.88	118.63
Exchangeable K meq/100g	0.75	0.30
Exchangeable K %	9.02	4.66
Exchangeable Na mg/kg	39.74	17.56
Exchangeable Na meq/100g	0.17	0.08
Exchangeable Na (ESP) %	2.07	1.17
CEC meq/100g	8.33	6.51
Zinc mg/kg	0.87	0.48
Copper mg/kg	0.55	0.59
Manganese mg/kg	237.70	76.80
Iron mg/kg	33.15	91.80
NO3 Nitrate mg/kg	3.17	19.12
NH4 Ammonium mg/kg	40.48	32.19

Weather and Climate

Mean rainfall per month (Plumwood) is approx 50-100mm (annual 976mm), with the highest in December to March.

Mean maximum temperature (Moruya Airport) is highest at 25 degrees in January, and 28 degrees at Khan Yunis.

Advice from Chris Allen was that koalas will adapt to all sorts of climates (eg Styrzleckis with higher rainfall) so a climate profile comparison with other locations used by koalas probably won't tell us anything useful. As mentioned previously Dave Bulman nevertheless made such a comparison with a similar sized koala area further south in the Bega Valley Shire using ANUCLIM and Wildlife Atlas records. Dave concluded that this comparison demonstrated nothing we didn't already know.

The climate profile for the Bendethera study patch itself (13 survey plots) generated by ANUCLIM is as follows:

@(#)bioprofile2

1. Annual Mean Temperature 13.45 1.08 10.67 10.80 12.19 13.26 13.92 14.14 14.27 14.29 14.29 14.29 10.54

2. Mean Diurnal Range(Mean(period max-min)) 12.70 0.36 11.71 11.75 12.22 12.75 12.86 12.91 12.94 12.94 12.94 12.94 11.66

3. Isothermality 2/7 0.50 0.01 0.47 0.47 0.49 0.50 0.50 0.50 0.50 0.50 0.50 0.50 0.47

4. Temperature Seasonality (C of V) 1.52 0.03 1.49 1.49 1.49 1.50 1.51 1.54 1.58 1.58 1.58 1.58 1.49

5. Max Temperature of Warmest Period 26.12 0.87 23.74 23.85 25.00 26.15 26.42 26.64 26.73 26.73 26.73 26.73 23.64

6. Min Temperature of Coldest Period 0.58 0.64 -1.01 -0.93 -0.15 0.36 0.92 1.05 1.13 1.14 1.14 1.14 -1.09

7. Temperature Annual Range (5-6) 25.54 0.30 24.76 24.80 25.20 25.52 25.62 25.75 25.80 25.80 25.80 25.80 24.72

8. Mean Temperature of Wettest Quarter 18.30 1.03 15.64 15.76 17.08 18.09 18.72 18.92 19.05 19.07 19.07 19.07 15.51

9. Mean Temperature of Driest Quarter 8.44 1.15 5.52 5.66 7.13 8.26 8.96 9.19 9.33 9.36 9.36 9.36 5.38

10. Mean Temperature of Warmest Quarter 18.93 1.00 16.34 16.46 17.74 18.72 19.33 19.53 19.65 19.67 19.67 19.67 16.22

11. Mean Temperature of Coldest Quarter 7.80 1.14 4.92 5.06 6.51 7.63 8.32 8.55 8.69 8.72 8.72 8.72 4.79

12. Annual Precipitation 870.21 31.70 850.83 851.31 852.27 855.14 859.94 870.43 955.51 959.89 959.89 959.89 850.35

13. Precipitation of Wettest Period 25.13 0.52 24.63 24.66 24.72 24.83 25.01 25.33 26.19 26.23 26.23 26.23 24.60

14. Precipitation of Driest Period 9.15 0.95 8.73 8.74 8.77 8.84 8.96 9.24 12.15 12.15 12.15 12.15 8.72

15. Precipitation Seasonality(C of V) 24.30 1.60 19.38 19.59 23.59 24.39 24.74 24.97 25.11 25.14 25.14 25.14 19.18

16. Precipitation of Wettest Quarter 270.13 5.54 265.26 265.59 266.23 267.25 268.33 271.41 282.69 283.43 283.43 283.43 264.94

17. Precipitation of Driest Quarter 148.98 12.32 143.43 143.58 143.89 144.81 146.34 149.84 187.04 187.04 187.04 187.04 143.28

18. Precipitation of Warmest Quarter 248.97 4.91 244.19 244.48 245.07 246.09 247.27 249.81 260.79 260.79 260.79 260.79 243.89

19. Precipitation of Coldest Quarter 165.96 11.31 160.35 160.48 160.74 161.52 162.83 164.13 199.50 201.13 201.13 201.13 160.22

20. Annual Mean Radiation 16.06 0.07 15.86 15.87 15.94 16.07 16.08 16.11 16.12 16.12 16.12 16.12 15.85

21. Highest Period Radiation 24.52 0.10 24.29 24.30 24.32 24.50 24.56 24.59 24.63 24.63 24.63 24.63 24.27

22. Lowest Period Radiation 7.12 0.03 7.03 7.04 7.11 7.13 7.13 7.14 7.15 7.15 7.15 7.15 7.03

23. Radiation Seasonality (Cof V) 37.39 0.12 37.30 37.30 37.31 37.33 37.36 37.39 37.78 37.78 37.78 37.78 37.30

24. Radiation of Wettest Quarter 19.45 0.07 19.28 19.29 19.31 19.45 19.47 19.49 19.52 19.52 19.52 19.52 19.27

25. Radiation of Driest Quarter 11.39 0.10 11.10 11.12 11.32 11.41 11.42 11.43 11.44 11.44 11.44 11.44 11.09

26. Radiation of Warmest Quarter 22.38 0.09 22.19 22.19 22.20 22.38 22.40 22.43 22.46 22.47 22.47 22.47 22.18

27. Radiation of Coldest Quarter 9.06 0.06 8.88 8.89 9.01 9.07 9.08 9.09 9.09 9.09 9.09 9.09 8.87

28. Annual Mean Moisture Index 0.81 0.06 0.76 0.76 0.77 0.77 0.80 0.84 0.94 0.95 0.95 0.95 0.76

29. Highest Period Moisture Index 0.98 0.01 0.97 0.97 0.97 0.97 0.98 1.00 1.00 1.00 1.00 1.00 0.97

30. Lowest Period Moisture Index 0.51 0.08 0.45 0.45 0.45 0.46 0.48 0.55 0.72 0.73 0.73 0.73 0.45

31. Moisture Index Seasonality (C of V) 20.52 4.26 9.13 9.65 15.13 20.65 21.95 22.81 23.33 23.43 23.43 23.43 8.61

32. Mean Moisture Index of High Qtr. MI 0.97 0.02 0.95 0.95 0.95 0.96 0.97 0.99 1.00 1.00 1.00 1.00 0.95

33. Mean Moisture Index of Low Qtr. MI 0.56 0.09 0.50 0.50 0.50 0.51 0.53 0.61 0.82 0.82 0.82 0.82 0.49

34. Mean Moisture Index of Warm Qtr. MI 0.56 0.10 0.50 0.50 0.50 0.51 0.53 0.62 0.83 0.85 0.85 0.85 0.49

35. Mean Moisture Index of Cold Qtr. MI 0.96 0.02 0.95 0.95 0.95 0.95 0.96 0.98 1.00 1.00 1.00 1.00 0.95

PARAMETER MEAN S.D. 2.5% 5 % 10 % 25 % 50 % 75 % 90 % 95 % 97.5% MAXIMUM MINIMUM

the time period for this profile is weeks

user input file = C:\Users\coastwatchers\GIS Data\ANUCLIM data\bendeth_ungen2a.txt

Date of this run: 23-08-2013, 10:27

Breeding connectivity with other places

Chris Allen (OEH koala survey specialist for the NSW South East) will make available the coordinates for an area east of the general Cooma populations**.** He has done about 30 plots on granite (as distinct from the usual metasediment for his koala survey geology). There is good evidence of koala presence from the pellet findings. It includes Badja State Forest, which is right on the edge of the escarpment and is one of the areas we're interested in.

The modeled vegetation type map seems to show “medium” potential habitat connectivity from Bendethera to the Tablelands westward.

On the other hand the altitude map seems to indicate the topography is very rugged with no easy access because of the many ridges over 800m or even 1,0000m (yet there are some gullies that might offer a circuitous route and the one Wildlife Atlas record shows a koala at about 800m in this general vicinity).

The GIS slope map shows a very complex subset of steep slopes within the larger areas where the overall slope profile averages significantly less.

Chris Malam's map overlaying steepness of slope on modelled "medium" and "high" potential low density habitat suggests better overall conditions for breeding connectivity between known koala areas at altitudes lower than Bendethera.

Conclusions

Browse species

A combined view of Lauren Chockman's SCIVI polygon analysis (***Appendix 3***) and the Bendethera survey plot datasheets (***Appendix 2***) confirms the eucalypt-based classification "Medium potential habitat" accorded this total patch by the GIS modeling in the *Eurobodalla Koalas project's Pilot Study* (2013). This conclusion needs to be treated cautiously however, because the pilot study's modeling relied not only upon the acknowledged imprecisions of landscape-scale SCIVI polygons but also upon the pilot study's own proposition (yet to be fully tested by OEH data analysis) that certain eucalypt types not previously regarded as important for koalas may in fact support adapting low-density populations in less than optimum conditions. If the pilot study's proposition is correct, then the overall Bendethera patch has a distribution of viable browse if a diverse mix of apparently suitable species is used. If koalas were to use only one or two "Primary" species at Bendethera, they might struggle to find sufficient richness or species density beyond *Eglo*.

Topography

Although Wildlife Atlas records show one occurrence on a ridge near Plot B11 (800m), the ruggedness of terrain between Bendethera and known koala areas on the Tablelands seems to be a significant blockage for breeding movement, as shown by the elevation maps and the complex slope map. For Eurobodalla koala recovery purposes, it is probably better to look at Chris Malam's analysis (slope & habitat quality according to SCIVI vegetation type modelling) between Bermagui/Sams Ridge & Wamban. Easiest breeding movement in the Deua catchment might be along the (albeit narrow) river passage itself. On the other hand, South East koala specialist Chris Allen speculates that koalas in this region might be "mountain animals" that have adapted well to steeper slopes and higher altitudes having avoided the worst effects of historical clearing of lower slopes and river flats.

Disturbance

History of farming and mining would have had an impact in the 19th Century, especially if there was also koala hunting. During the survey expedition fire, roadworks and tourism were the most obvious disturbance types, but based on the presence of koalas elsewhere in NSW with these kinds of disturbances, they should not necessarily impact catastrophically on a potential resident koala group.

Geology

The Araluen Geological Sheet does not appear to indicate anything of significance for koala browse, and its descriptions are difficult and confusing to read.

It does explain the origin of the steep slopes, which would be an important issue for migration corridors for breeding connectivity purposes.

The "Metasediment" feature recorded on the datasheets for the plot locations appears consistent with the underlying geology of plots where koalas exist in nearby regions.

There is some consistency with the conclusions of *Norton & Neave (1996)* who consider high quality habitat is typically derived from basalt or alluvium, and *Braithwaite (1983)* who considers high quality habitat requires high nutrient soils, on flat topography or gullies.

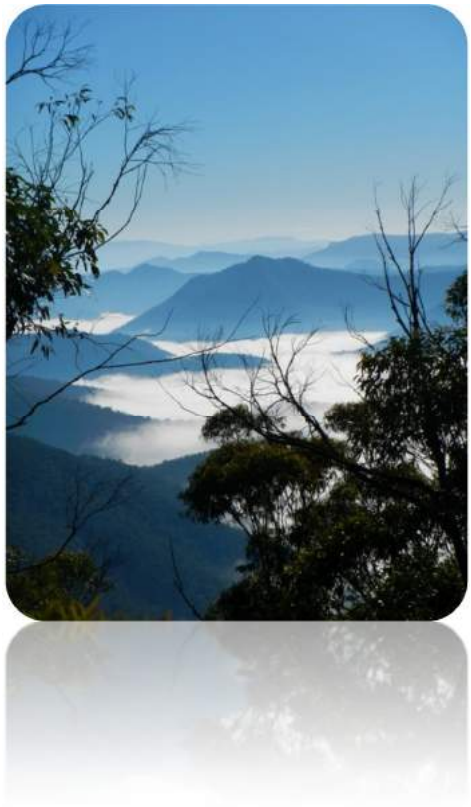
Soils

Whereas the soils on slopes and ridges were deemed "Sandy Loam", those on plots BE3 and BE14 were designated "Loam" on the datasheets (both at river flat level). These appear consistent with the general soil types on plots where koalas exist in nearby regions.

A comparison of the patch results with a brief overview of related research suggested that the Bendethera soils were suited to low density koala presence, and that the levels for key elements (Nitrogen, Magnesium; Potassium) found in the two tested samples were not critically low.

Obtaining precise correlations between soil elements and nutrient uptake appears extremely complex and context-driven, so no stronger conclusions can be drawn from the soil samples without at least an associated analysis of the foliage content on the same plots.

Weather and Climate



Overall the climate appears temperate, tending to cool temperate at higher altitudes near Bendethera. Weather in the broad area appears compatible with viable koala habitat.
The Bendethera temperature and rainfall figures generated by ANUCLIM, match Adams-Hosking's "highest probability of occurrence" parameter well. Highest temperatures do not approach critical maximums for koala survival.

Overall Conclusion

Bendethera is a possible potential home range area but not a terribly attractive one because of the steepness of slope away from the river bed and the low concentrations of certain eucalypt types. On the other hand, the right trees are definitely there when all relevant species suggested by the pilot study are totaled up over the whole patch, the soils and climate are fine, there's possible breeding connectivity along the narrow catchment, and Chris Allen thinks the South East koalas might be adapted mountain animals that were able to survive because they retreated from or were not caught up in the clearing of lowlands for farming.

The disturbance factors, geology, soil, access to water, weather and climate profiles of Bendethera render it feasible as a location for one (isolated) home range for a low density koala breeding association. On the other hand, the patch would present strong obstacles to breeding connectivity with

known contemporary populations because of its topographic surrounds (ie steepness of slope and altitude of ridges outside the narrow river corridor zone).

For natural revival or translocation purposes there appear to be more benign overall conditions at lower altitudes in the Deua National Park and its adjacent State Forest and private tenures. Based on the findings of this volunteer Bendethera exercise and the overall Eurobodalla Koalas project so far, encouraging breeding connectivity between the Deua catchment (eg at Wamban Creek) and areas like Bermagui/Sam's Ridge should take initial priority over connectivity with the Tablelands (eg Badja or Tallaganda via Bendethera). The latter deserves attention later however, when the OEH Palerang survey program is complete.

Appendices

Appendix 1: Deua National Park Plant Species List (courtesy NPWS Narooma)
Appendix 2: Plot Datasheets (Excel file)
Appendix 3: Percentages of eucalypt species per forest type by rated importance as low density browse (Excel file)