A SCIENTIFIC ASSESSMENT OF THE CONSERVATION VALUE OF MONGA AND BUCKENBOWRA STATE FORESTS, NSW, AUSTRALIA – WITH A PARTICULAR EMPHASIS ON ADEQUACY AND REPRESENTATIVENESS

B.G. Mackey, J.A. Stein, J.L. Stein and J. Gilles

The Centre for Resource and Environmental Studies/The Department of Geography, Faculty of Science, The Australian National University



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I. INTRODUCTION AND SUMMARY

Should Monga State Forest remain managed for commercial wood production or should its land tenure change to a conservation reserve? The purpose of this report is to provide a scientific evaluation of the conservation values of Monga and adjacent areas. These evaluations are designed to compliment the analyses being undertaken as part of the Regional Forest Agreement (RFA) for the Southern Region.

In summary, we argue that:

A. There is a strong scientific basis for conversion of Monga and Buckenbowra State Forests to a conservation reserve, this argument hinges, *inter alia*, on consideration of the criteria of Adequacy and Representativeness.

B. Monga has special regional significance as a refugia, particular in relation to the effects of climatic drought.

C. Monga is a high primary productivity landscape in the headwaters of the Mongarlowe River. This section of the river has a very low gradient and a native forest cover. This is regionally significant and critically important in maintaining regional ecological integrity and the long term persistence and population viability of key taxa.

D. The Biodiversity values of Monga and Buckenbowra State Forests are outstanding, in particular as they contains a large number of threatened, vulnerable and otherwise special species and associations.

E. For the purposes of assessing the criterion of Comprehensiveness, Monga State Forest must be considered as part of the tableland ecological domain as defined by critical climatic and hydrological considerations.

II. CONSERVATION CRITERIA

The CAR criteria have been established within the RFA process to provide a set of targets for evaluating the conservation value of forests.

- **Comprehensiveness** – a regional reserve system should contain the agreed to minimum area of the set of forest communities (that is, forest ecosystem types) in the region.

- **Adequacy** – the extent to which the ecological viability and integrity of populations, species and communities is ensured; this criterion can be interpreted in terms of the design, spatial configuration and management of reserves, and the efficacy of protected habitat in relation to population viability.

- **Representativeness** – those sample areas of the forest that are selected for inclusion in reserves should reasonably reflect the diversity found within the recognised forest

communities/ecosystems; for example, the range in understory species composition and site productivity.

Additional RFA conservation criteria relate to:
- the conservation of rare, endangered and threatened plant and animal species
- and targets for old growth forest and wilderness.

Of these three CAR criteria, RFAs throughout Australia have tended to focus on the first criterion, namely, Comprehensiveness, with less emphasis placed on Adequacy and Representativeness. Adequacy, if considered at all, is general restricted to some consideration of habitat size to support minimum viable populations of selected taxa. Representativeness is generally ignored, or not assessed against agreed targets. It is critical that the Southern RFA properly applies all three criteria. This requires an explicit consideration and regional interpretation of Adequacy and Representativeness.

1. Productivity

The habitat of a given species is to varying degrees a function of the flux of energy, carbon, other nutrients, and water through the local ecosystem. An overarching consideration is the fact the biota play a critical role in regulating these local environmental conditions. Human perturbation disrupts these ecological flows such that the environment and hence habitat for a given species is degraded. Gross primary productivity (GPP) is therefore controlled by the environmental conditions determined by the interaction between the physical environment and the biota themselves. However this biotic regulation is constrained by the distribution and availability of the primary environmental resources (heat, light, water and mineral nutrients) as controlled by climatic, topographic and geological factors.

Net primary productivity (NPP) is the net biomass (averaged over a suitable period of time) left after community respiration and decomposition by fungi etc. The residual amount of biomass determines the overall level of organic material available for herbivores (especially invertebrates) and carnivores. NPP is stored in various pools within a forest ecosystem. One of these is the volume of commercial wood. However a great deal of biomass is stored in forms that have little or no wood production value. Nonetheless, commercial wood volume is a good index of NPP. This means that locations classified as having a high site quality/productivity for wood production are very likely to have a high NPP, and hence are very likely to be places that have high overall biological productivity. Consequence there is an abundance of food and hence larger and/or more viable population levels through the entire food chain. It follows that representation of high productivity sites within a regional reserve system is essential for ensuring the ecological integrity and viability of both common and rare/threatened species and communities. A regional reserve system that lacks high productivity sites is therefore not representative of inter-forest ecosystem variability and cannot claim to be representative or adequate.

2. Catchment hydrology

Forests play a critical role in catchment hydrology, exerting a fundamental control on water flow and quality. All other factors being equal, mature wet sclerophyll forest promotes a regulated base-flow of water out of the catchment, while disturbed and re-growth forest promotes surface flow and rapid pulses of water following rainfall events (Australian State of the Environment 1996). Climatic conditions are also an important factor in determining the overall characteristics of the moisture regime, in particular the annual total, seasonal and year-to-year variation in precipitation.

A wet environment with low seasonality in the moisture regime is particularly significant for taxa that depend on and prefer a persistently wet environment, for example, herptefauna. Such locations can function as regional refugia in that in times of climatic drought they can retain viable populations that act as a source for the re-population of neighbouring landscapes following the return of wetter conditions. These refugia landscapes are therefore regionally significant in contributing to ecological integrity and viability. Also, note that maintaining a regulated flow of water from a forested sub-catchment is also important for fauna and flora associated with downstream ecosystems.

3. Climate change

When considering Adequacy from a regional perspective, we can no longer ignore the reality of accelerated global climate change due to the greenhouse problem. It appears likely that for S.E. NSW within 50 years with a doubling of $C0_2$, annual temperatures will increase between 0.2-2.7^0C, with an increase in hot summer days, an increase in summer and autumn rainfall, a decrease in winter and spring rainfall, and an increase in fire frequencies (Hennessy *et al*. 1998). It is therefore vital that a nature reserve system capture the regional temperature gradients and does so via interconnected areas. This is necessary to promote the movement of flora and fauna as they migrate and in effect 'track' optimum temperatures (Walker and Steffen 1997).

III. STUDY AREA

In order to evaluate the conservation value of Monga State Forest and neighbouring areas in terms of the RFA criteria, we have taken an area defined by the Monga-Buckenbowra Reserve Proposal put forward by The Friends of Mongarlowe River and the South East Forest Alliance. Unfortunately, lack of time and resources prevented alternative reservation options from being examined. Therefore we use this as an indicative reserve boundary to provide a focus for our analyses.

This area covers most of Monga State Forest, including areas both within and outside the Mongarlowe River Valley, as well as most of Buckenbowra State Forest (including Cabbage Tree Creek and Buckenbowra River Catchments), all of Quart Pot State Forest, and a part of Wandera State forest, along with a small area of crown land adjacent to Wandera State Forest and Deua National park. The proposal area covers approximately 26,800 hectares.

Various analyses were undertaken to examine this indicative reserve area according to the RFA criteria, but particularly in relation to Adequacy and Representativeness.

IV. DATA AND METHODS

1. Regional classifications

Questions of comprehensiveness, adequacy and representativeness, require that a given location be given an appropriate regional context. Here we have used the environmental domain method developed by Mackey *et al*. (1988, 1989). This form of analysis has not been substantially used in the RFA process. We believe this is because of a fundamental misunderstanding of the purpose of the methodology. The purpose is to identify landscape pattern in the distribution and delivery of primary environmental resources (heat, light, water and mineral nutrients) that (as discussed above) drive potential biological productivity in terms of gross primary productivity (photosynthesis), rates of respiration and decomposition, vegetation structure, plant carbon allocation strategies, plant physiognomy and phenology, and the subsequent flow-on affects for animal productivity.

The methodology was not developed with the aim of predicting or accounting for species distributions or the taxonomic composition of landscapes! It therefore was explicitly designed to compliment not replace species-based modelling approaches.

Furthermore, recognising that the primary environmental resources vary continuously through space and time, our methodology enables the relative similarity of landscape patterns to be quantified and mapped. Failure to use this information about relative landscape similarity ignores one of the main strengths of the approach.

We therefore generated a terrain classification that was mapped at two levels of similarity. A 250m resolution Digital Elevation Model was used to generate values of elevation, slope and relief for each grid cell. Similarly, a climate classification was generated and mapped at a two levels to show higher and lower order affinities.

The classifications were intersected with land use data (indicating relative biophysical naturalness), the reserve network, and geological coverage from the national geological atlas. A table was produced that showed for each higher order climate and terrain group found within Monga and Buckenbowra, its regional distribution, current land cover and geology. These spatial analyses were undertaken using the ARCINFO Geographic Information System, and additional statistical software, operating on a SUN_UNIX platform.

These analyses can only be considered as indicative for a number of reasons:

- Lack of time and resources prevented an evaluation of lower order (ie. finer resolution) climate and terrain groupings

- We did not have access to the high spatial resolution digital elevation data that is now available for the region; 20-40m is actually the appropriate resolution for terrain analysis; nor did we have time to apply more recent developments in topographic analysis
- We did not have access to the recent land cover data and up-dated geological data that have been generated as part of the CRA.

Hence the climatic analysis was conducted at the correct resolution, but the digital terrain analysis and geological data were too coarse to derive definitive analyses.

2. Bioclim analyses

It is our expert opinion that the BIOCLIM/BIOMAP programs (Nix 1986) remain the best method for modelling the potential climatic domain of species where presence-only data are available. Distribution data were collated and analysed for two important plant species found at Monga, namely, *Eucryphia moorie* and *Telopea mongaensis*. These data were collected from published papers and museum records. The potential climatic domains of these two species were mapped using the 250m resolution gridded climatic data base referred to above.

3. Catchment significance

Data and results from the National Wild Rivers study (Wild Rivers Project 1999) was used to assess the regional catchment and hydrological significance of the indicative reserve.

4. Productivity

Biomass data collected during ANU undergraduate field trips was used to estimate per unit area total carbon as an index of NPP. These data were compared with other estimates of biomass and total carbon from Kioloa State Forest (Jones 1998) and East Gippsland (Gibbons *pers.comm.*).

5. Biophysical characteristics of the indicative reserve

In order to more fully evaluate the conservation value of Monga-Buckenbowra we used a variety of sources to ascertain the area's biological characteristics including:

- published scientific journal articles, reports and books
- research theses published by universities
- personal communications from scientific specialists
- personal field observations of the authors.

V. RESULTS

1. Bioclimate

Fig 1 shows the 99 group climate classification for the region, Fig 2 the 15 group classification, and Fig 3a the dendrogram of the inter-group relations. In all cases, the location of the indicative reserve boundary and Monga State Forest are indicated. The attribute values for the groups are given in Table 1.

At the 99 group level, Monga occupies a distinctive bioclimatic domain. At the 14 group level, it shares affinities to the south, and to an outlier in the north. Monga is clearly part of the tableland - rather than coastal or escarpment - bioclimatic domains.

The regional bioclimatic significance of Monga is also apparent from the maps rainfall Seasonality (Fig 4) and Annual Mean Rain (Fig 5). Monga State Forest occupies an area that is relatively wet and aseasonal, ie. it has high rainfall in both winter and summer. Also note Annual Mean Temperature (Fig 6), and the extraordinary thermal gradient sampled by the indicative reserve proposal – nearly six degrees celsius.

2. Terrain

The 40 group terrain classification is given in Fig 7, the 14 group in Fig 8 and the inter-group relations indicated in the dendrogram in Fig 3b. The attribute values for each group are detailed in Table 2. The classifications highlight the special position of Monga being at nexus of the tableland/escarpment landscapes.

3. Representativeness analysis

Table 3 details the results of intersecting the climate and terrain classifications with geological coverage, land use, and the reserve boundaries. Bioclimatic group 3 corresponds to Monga State Forest, while groups 5 and 8 correspond to Buckenbowra State Forest.

Of particular interest are those terrain classes that are characterised by low slope values - #1, #3, and #4, as these generally have only very small percentages with a natural cover currently found within reserves. Also of note is the poor representation of locations in the "Ordovician-Silurain slate/siltstone" substrate class with natural cover. Note that finer scale maps of geological coverage show that Monga has, *inter alia*, substantial areas of basalt.

Fig 9.1-9.9 show for each bioclimate and terrain group found within the indicative reserve the distribution of natural cover overlaid on geological classes. The dominant bioclimatic group for Monga has affinities with remnant natural cover to the north and south but virtually none remains on the "Ordovician substrate" class dominant under Monga. By comparison, the dominant bioclimatic group for Buckenbowra has more extensive natural land cover remaining.

4. Catchment quality

The indicative reserve proposal actually crosses three catchment: Shoalhaven River; Clyde River/Jervis Bay River; and Deua River. The River Disturbance Index values for these three catchments are shown respectively on Figs 11-13. Monga State Forest can be seen to be a critical component of the Shoalhaven catchment – having relatively low disturbance values compared to the rest of the southern half of the catchment, and encompassing the headwaters of the Mongarlowe River. Buckenbowra occupies a similarly significant catchment position for the Clyde-River System.

5. Bioclim models

The bioclimatic profiles for *Eucryphia moorie* and *Telopea mongaensis* are given in Tables 4 and 5. The predicted climatic domains are mapped in Figures 14 and 15. Note the geographically restricted extent of the predicted optimal climatic conditions for these two important species, and that Monga State Forest encompasses both species core climatic domain.

6. Productivity

We analysed total biomass for data from a four hectare area of the wet sclerophyl vegetation at Monga State Forest (collected during undergraduate field trips), comparable sites (n=45) in East Gippsland (Gibbons, pers.com.), and also estimates from Kiola State Forest (Jones 1998). The Monga and East Gippsland sites are largely unlogged by modern forestry practices. The results were as follows: (a) Monga – 1836 t/ha^{-1}; (b) East Gippsland – 1639 t/ha^{-1}; and Kiola – 874 t/ha^{-1}. This is very strong empirical evidence that Monga State forest is an unusually high productivity landscape.

7. Critical Forest types/associations and species

When evaluating the conservation value of an area it is obviously important to compile the known taxonomic composition as this provides the information needed to apply the criteria of (a) Comprehensiveness, (b) rare/endangered/threatened species, and (c) genetic diversity. Appendix 1 lists from published sources and expert knowledge critical forest types/associations and plant and animal species found in the indicative reserve area.

VI. DISCUSSION

1. Hydrological Significance

The climatic analyses and the catchment evaluation both emphasis the regional hydrological significance of Monga State Forest. It is the head-waters of the Mongarlowe River, is forested, and has a relatively high rainfall with low seasonality (ie. has both summer and winter precipitation). This means that Monga tends to remain a relatively wet environment throughout the year and relative to other places in the region. We strongly suspect that Monga's year to year variation in precipitation is low on a regional basis. This has a number of ecological implications:

- The wet environment results in high growth rates (ie. both gross and net primary productivity); this has flow-on effects for arboreal animal productivity
- The stretch of the Mongarlowe River within Monga State Forest has a very low slope gradient. There are very few if any such landscapes in the region with a native forest cover.
- Monga represents a very significant habitat for herptefuana; frogs are particularly sensitive to water stress; hence Monga represents for this group of animals an important habitat refugia
- Down-stream agricultural land use benefits from base-flow, as this provides a regulated supply of water

There has only been limited scientific investigation into the impact of forestry operations on catchment hydrology (Australian State of Environment Report, 1996). However one of the few general principles that has emerged is that logging in high productivity forested landscapes increases surface run-off and flow at the expense of base-flow. This means that water leaves a catchment quickly following a rainfall event. While an unperturbed forested catchment will have a more regulated and continual flow of sub-surface water. A logged catchment will tend to be drier than an unlogged catchment, and have greater seasonal variation in wetness. The result is likely to be greater seasonal and year-to-year variation in landscape wetness, with resultant degradation in Monga's function as a regional refugia.

Monga State Forest lies atop the Eastern Escarpment. A large proportion of Monga is the upper catchment for the Mongarlowe River. The Mongarlowe River runs south to north for approximately forty kilometres along the top of the Eastern Escarpment without dropping down the escarpment face, instead turning inland to join the Shoalhaven River. Monga receives precipitation from winter westerly's and summer easterly's. Cloud interception and fog drip add to the total annual precipitation.

2. Climate Change

The combined Monga-Buckenbowra indicative area traverses a remarkable thermal gradient (see Fig 6). This is particularly significant in the light of projected global warming scenarios by the CSIRO Division of Atmospheric Research (Hennessy *et al*. 1998) which suggest that mean annual temperatures may raise between 0.5-2.7^{0}C over the next 50 years. Given this, the Monga-Buckenbowra area provides a continuous reserve system that will maxamise the opportunities for taxa to migrate and track optimal thermal conditions in the region.

3. Contribution of the indicative reserve boundary to regional reserve design

There are four large National Parks in the South Coast region - Budawang and Morton National Parks adjoin each other in the north and Deua and Wadbilliga are joined through the Badja Reserve Proposal in the south. These two pairs of large national parks are connected by Monga and Buckenbowra State Forests. A Monga-Buckenbowra National Park would function as an important landscape corridor to link these existing National Parks. This would contribute significantly to the Adequacy of the regional reserve network.

In the north east, the boundary borders the Kings Highway where Cabbage Tree Creek flows under it, providing an important connecting corridor, as this is the only wildlife underpass between there and west of Clyde Mountain. The western boundary of the indicative area follows the boundary of Monga State Forest which encompasses the headwaters of the Mongarlow River. The western section of the indicative area (outside the Mongarlowe River catchment) contains, around McCarthys Creek, one of the largest areas of wet, high productivity mature forest in the region (it also contains well developed Pinkwood rainforest). Near the western boundary of Monga is a Pleistocene sand dune (Stone 1985), which while outside the state forest is of considerable regional interest from both geomorphological and

prehistory perspectives. The middle section contains part of Buckenbowra State Forest and Quart Pot State Forest which are central to the reserve system corridor linking Deua National Park to Budawang National Park. The far south eastern section contains McGregors Creek catchment in Wandera State Forest – this area is nominated Wilderness and would improve the link to Deua National Park.

4. Monga as a drought and fire refugium

The combination of Monga State Forest's landscape setting, climate and vegetation cover result in high biological productivity with relatively low seasonal and year-to-year variation in wetness. Thus Monga functions in effect as a drought refugia for many animal species. While species may be common or abundant during normal years, such locations become critical during drought years or periods of extended climatic dryness. During these circumstances they function as refugia where populations can persist. When average conditions return, these refugia act as a source to repopulate the surrounding region.

The general wetness of the area also modifies the fire regime from that experienced in the surrounding region. Based on our experiences in analysing the fire regime in Central Victoria (Mackey *et al. in press*), Monga probably experiences an extended mean fire interval, thereby promoting fire sensitive vegetation types such as the stands of *Eucryphia moorei*.

Monga State forest therefore is important for ensuring that the regional reserve network meets its requirements under the criteria of Adequacy and Representativeness. Its productivity and refugia status add significantly to the ecological viability of the regional reserve network.

4. Species and associations of special interest and concerns

As documented in Appendix 1, the Monga-Buckenbowra indicative reserve area has a very high biodiversity. By way of summary we note the following:

- There is substantial areas of mature/old growth forest within the indicative reserve area. The mature/old growth *Eucalyptus fastigata* forest in Monga is particularly important as it represents a high productivity environment. This would stand it apart from other reserved samples of *E. fastigata* in the region.
- Monga contains large areas of *Eucryphia moorei* (Pinkwood) rainforest, a species largely endemic to southern NSW. The Pinkwoods in Monga reach enormous sizes and ages, some measuring four metres in width
- Buckenbowra contains some of the best developed and most significant stands of warm temperate rainforest in the region, such as the rainforest in Cabbage Tree Creek and Buckenbowra catchments
- The indicative area is the only place known where cool- temperate rainforest supports a co-dominance of *E. moorei* and *Atherosperma moschatum* (Black Sassafras)

- The indicative area is a major habitat of *Telopea mongaensis* (Monga Waratah) and *Telopea Oreades* (Gippsland Waratah). This is one of only two places in Australia where two species of waratahs grow so closely together.
- There are 7 known rainforest species growing at or near their southern limit of distribution
- There are two species of nationally threatened fauna plus one probable species. These are *Macquaria australasica* (Macquarie Perch), *Prototroctes maraena* (Australian Grayling)(Probable), and *Dasyurus maculatus* (Spotted-tailed Quoll)
- The Southern Brown Bandicoot (*Isoodon obesulus*) is found in the Monga-Buckenbowra Reserve Proposal Area and is listed as an endangered species (Schedule 1) on the NSW Threatened Species Conservation Act 1997.
- There are 16 species considered to be extant in the Monga-Buckenbowra indicative reserve area and which are listed as Vulnerable Species under the NSW Threatened Species Conservation Act 1997
- There are ninety-five species of birds known to live in the proposed area (Australian Heritage Commission,1992,4). Of these six (6) are listed as Vulnerable Species (Schedule 2 threatened species) on the NSW Threatened Species Conservation Act 1997
- The three threatened owls (Powerful, Masked and Sooty) have been recorded breeding in the Monga-Buckenbowra Reserve Proposal Area. The Boobook Owl *Ninox novaeseelandiae* and the Tawny Frog Mouth *Podargus ocellatus* are two more owls that also breed in the proposal area.
- The area contains fourteen known species of bats, indicating a high diverse bat fauna in the area. Of these bat species, five are threatened species listed as Vulnerable Species (Schedule 2 threatened species) on the NSW Threatened Species Act 1997
- The Monga-Buckenbowra area supports populations of *Petaurus australis* (Yellow-bellied Glider), *Dasyurus maculatus (*Tiger Quoll), and *Phascogale tapoatafa* (Brush-tailed Phascogale) all of which are classed as Vulnerable Species (schedule 2 threatened species) on the NSW Threatened Species Conservation Act 1997.
- The Giant Burrowing Frog (*Heliporus australiacus*) and the Stuttering Barred Frog (*Mixophyes balbus)* are threatened species, listed as Vulnerable Species (Schedule 2 threatened species) on the NSW Threatened Species conservation Act 1997. The latter is known from three records in Monga State Forest, while the latter is predicted to occur there; generally, Monga State forest is considered to be regionally a very important frog habitat but there has been little or no systematic survey work undertaken there.
- Microdonacia *pilosa sp.n.* is a species of leaf beetle confined to cool temperate rainforest on the eastern slopes of the coastal range between Clyde Mountain and the Monga area (Reid 1992,370). *Eucryphia moorei* is the sole known host plant (Reid 1992,370).
- There are 18 known species at or near their southern, northern, western , north-western and eastern limits of distribution for the Mongarlowe-Buckenbowra Rivers Area

5. Representativeness

The analyses presented above using the terrain and climatic classifications intersected with the land cover and geology data are sufficient to indicate:

- There is a significant degree of environmental variation found within what might otherwise be considered broadly distributed forest types.
- Only remnant patches of the combinations of climate/terrain/geology found within Monga State forest remain with relatively high biophysical naturalness
- Monga does occupy a regionally distinctive combination of climate, terrain and geology even when considered at relatively coarse scales.
- These factors together with its high primary productivity, present a strong case for its inclusion in a reserve in order for the regional system to meet the requirement of Representativeness.

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Appendix 1 Critical Forest types/associations and species found at Monga-Buckenbowra

The following sections detail the known taxonomic composition of the Monga-Buckenbowra indicative area. This review is critical to ensuring the area is adequately assessed against criteria relating to (a) Comprehensiveness, (b) rare/endangered/threatened species, and (c) genetic diversity.

A. Associations/forest types There would appear to be substantial areas of mature/old growth forest within Monga_Buckenbowra. The mature/old growth *E. fastigata* forest in Monga State Forest is particularly important as it represents a high productivity environment. This would stand it apart from other samples of *E.fastigata* reserved in the region.

Monga contains large areas of *E. moorei* (Pinkwood) rainforest, a species largely endemic to southern NSW. The Pinkwoods in Monga reach enormous sizes and ages, some measuring four metres in width and potentially thousands of years old. Pinkwoods are relic vegetation communities, having survived the climate fluxes of the Quaternary (last 1.6 million years), and thus are relics of Gondwanaland. Monga probably contains the most developed and viable stands of *E. moorei* in the region and stands at the core of the species' bioclimatic domain .

Buckenbowra contains some of the best developed and most significant stands of warm temperate rainforest in the region, such as the rainforest in Cabbage Tree Creek and Buckenbowra catchments. The warm-temperate rainforests in Buckenbowra State Forest go through a gradient from warm temperate to cool temperate rainforest as they rise up the escarpment into Monga. Some of these stands are as well developed as the warm-temperate rainforests nearer to the coast, containing old trees including 30 metre tall Giant Stinging Trees and woody vines up to 30 centemetres in diameter – both an indication of old age and low disturbance (see Fig 15). Plant species found here include: Scentless Rosewood; *Doryphora sassafras* Sassafras; Coachwood; Pencil Cedar; *Livistona australis* Cabbage Tree Palm; *Acmena Smithii* Lilly Pilly; Giant Stinging Tree; Water Gum; Featherwood; *Synoum glandulosum*; *Eupmatia laurina*; Gippsland waratah.
Other communities of flora in the indicative Monga-Buckenbowra reserve noted by the Australian Heritage Commission (1992) include: (a) Tall old growth forests of *Eucalyptus seiberi / Eucalyptus fastigata / Eucalyptus cypellocapa; Eucalyptus agglomerata / Eucalyptus muellerana / Eucalyptus cypellacapa; also Eucryphia moorei / Atherosperma moschatum, Eucalyptus sieberi / Eucalyptus cypellocapa / Eucalyptusobliqua, Eucalyptus fraxinoides / Eucalyptus fastigata, Eucalyptus obliqua / Angophora floibundar.*

B. Flora species lists

Within Suballiance 54 (Eucryphia – Doryphora / Atherosperma), Floyd (1990) listed the following set of co-occurring species (bold = definitely at Monga State Forest):

Scientific Name	**Common Name**
Trees	
Livistona australis	Cabbage Tree Palm
Atherosperma moschatum	
Doryphora sassafras	***Southern Sassafras***
Hedycarya angustifolia	Australian Mulberry
Acacia Melanoxylon	Blackwood
Pomaderris aspera	Hazel Pomaderris
Elaeocarpus holopetalus	**Black Olive Berry**
Eucryphia moorei	**Pinkwood**
Acmena Smithii	Lilly Pilly
Rapanea howittiana	Howitt's Muttonwood
Ehretia acuminata	Koda
Shrubs	
Cyatheaceae *Cyathea australis*	**Rough Treefern**
Cyathea leichhardtiana	Prickly Treefern
Dicksoniaceae *Dicksonia Antarctica*	**Soft Treefern**
Osmundaceae *Todea barbara*	King Fern
Pittosporaceae *Citriobatus pauciflorus*	Orange Thorn
Solanaceae *Solanum brownii*	Violet Nightshade
Rubiaceae *Sambucus australasica*	Yellow Elderberry
Herbs	
Lastreopsis acuminata	**Shiny Shield Fern**
Lastreopsis microsora	Creeping Shield Fern
Polystichum proliferum	**Mother Shield Fern**
Asplenium flabellifolium	Necklace Fern
Diplazium australe	Austral Lady Fern
Blechum nudum	**Fishbone Water Fern**
Bletchum patersonii	**Strap Water Fern**
Bletchum wattsii	**Hard Water Fern**
Dennstaedtia davallioides	Lacy Ground Fern
Histiopteris incisa	**Bats Wing Fern**
Lepidosperma elatius	Tall Sword Sedge
Australina muelleri	**Shade Nettle**
Elatostema reticulatum	Smooth Nettle
Urtica incisa	Shrub Nettle

Hydrocotyle acutfloba	Broad-leaf Pennywort
Hydrocotyle laxiflora	**Pennywort**

Vines

Microsorum diversifolium	**Kangaroo Fern**
Microsorum scandens	Fragrant Fern
Smilax australis	Austral Sarsaparilla
Clematis aristata	Travellers Joy
Clematis glyinoides	Erect Clematis
Rubus sp. aff. Moorei	Greenleaf Bramble
Rubus rosifolius	Roseleaf Bramble
Parsonsia brownii	**Mountain Silk Pod**
Parsonsia strminea	Ivy Silk Pod
Marsdenia rostrata	Stalked Doubah
Pandorea pandorana	**Wonga Vine**

Epiphytes

Asplenium bulbiferum	**Mother Spleemwort**
Asplenium flaccidum	Weeping Spleenwort
Grammitis billardieri	**Finger Fern**
Hymenophlllum cupressiforme	**Common Filmy Fern**
Hymenophlllum flabellatum	**Shiny Filmy Fern**
Polyphlebium venosum	**Veined Bristle Fern**
Pyrrosia rupestris	Rock Felt Fern
Tmesipteris billardieri	Long Fork Fern
Dendrobium pugioniforme	Dagger Orchid
Sarcochilus olivaceus	Lawyer Orchid
Fieldia australis	**Fieldia**

C. Fauna species list

Following is a list of species in the indicative Monga-Buckenbowra reserve area as listed in the NSW Wildlife Atlas – Fauna (1998). Also note that rainforest is significant in Buckenbowra because warm temperate rainforests are of importance to the maintenance of local populations of fruit eating birds (Australian Heritage Commission, 1992).

Scientific Name	**Common Name**
Frogs	
Crinia signifera	Common Eastern Froglet
Pseudophryne dendyi	Dendy's Toadlet
Litoria lesueuri	Lesueur's Frog
Litoria phyllochroa	Leaf Green Tree Frog
Litoria peronii	Peron's Tree Frog

Lizards / Skinks

Amphibolurus muricatus	Jacky Lizard
Physignathus lesueurii	Eastern Water Dragon
Varanus varius	Lace Monitor
Bassiana platynota	Red-throated Skink
Egernia sexatilis	Black Rock Skink
Eulamprus heatwolei	
Eulamprus quoyii	Eastern Water Skink
Lampropholis delicata	Grass Skink
Lampropholis guichenoti	Garden Skink
Nannosclncus maccoyi	McCoy's Skink
Saproscincus mustelinus	Weasel Skink
Ramphotyphlops nigrescens	

Snakes

Pseudechis porphyriacus	Red-bellied Black Snake
Rhinoplocephalus nigrescens	Eastern Small-eyed Snake

Birds

Accipiter cirrhocephalus	Collared Sparrowhawk
Aquila audax	Wedge-tailed Eagle
Leucosarcia melanoleuca	Wonga Pigeon
Lopholaimus antarcticus	Topknot Pigeon
Callocephalon fimbriatum	Gang-gang Cockatoo
Calyptorhynchus funereus	Yellow-tailed Black Cockatoo
Calyptorhynchus lathami	Glossy-black Cockatoo
Allsterus scapularis	Australian King-Parrot
Glossopsitta concinna	Musk Lorikeet
Platycercus elegans	Crimson Rosella
Scythrops novaehollandiae	Southern Boobook
Ninox strenua	Powerful Owl
Tyto tenebricosa	Sooty Owl
Eurostopodus mystacalis	White-throated Nightjar
Dacelo novaeguineae	Laughing Kookaburra
Eurystomus orientalis	Dollarbird
Menura novaehollandiae	Superb Lyrebird
Climacteris erythrops	Red-browed Treecreeper
Cormobates leucophaeus	White-throated Treecreeper
Malurus cyaneus	Superb Fairy-Wren
Malurus lamberti	Variegated Fairy-Wren
Acanthiza lineata	Striated Thornbill
Acanthiza nana	Yellow Thornbill
Acanthiza pusilla	Brown Thornbill

Gerygone mouki	Brown Gerrygone
Pardalotus punctatus	Spotted Pardalote
Pycnoptilus floccosus	Piolotbird
Sericornis frontalis	White-browed Scrubwren
Sericornis magnirostris	Large-billed Scrubwren
Acanthorhynchus tenuirostris	Eastern Spinebill
Lichenostomus chrysops	Yellow-faced Honeyeater
Lichenostomus leucotis	White-eared Honeyeater
Meliphaga lewinii	Lewin's Honeyeater
Melithreptus lunatus	White-naped Honeyeater
Myzomeia sanguinolenta	Scarlet Honeyeater
Philemon corniculatus	Noisy Friarbird
Phylidonyris novaehollandiae	New Holland Honeyeater
Eopsaltria australis	Eastern Yellow Robin
Petroica multicolor	Scarlet Robin
Petroica rosea	Rose Robin
Cinclosoma punctatum	Spotted Quail-thrush
Psophodes olivaceus	Eastern Whipbird
Colluricincia harmonica	Grey Shrike-thrush
Falcunculus frontatus	Crested Shrike-tit
Pachycephala pectoralis	Golden Whistler
Pachycephala rufiventris	Rufous Whistler
Rhipidura fuliginosa	Grey Fantail
Rhipidura rufifrons	Rufrous Fantail
Coracina novaehollandiae	Black-faced Cuckoo-shrike
Coracina tenuirostris	Cicadabird
Artamus cyanopterus	Dusky Woodswallow
Artamus supercilliosus	White-browed Woodswallow
Cracticus torquatus	Gry Butcherbird
Strepera gracullna	Pied Currawong
Strepera versicolor	Grey Currawong
Ailuroedus crassirostris	Green Catbird
Ptilonorhynchus violaceus	Satin Bowerbird
Neochmia temporalis	Red-browed Finch
Zosterops lateralie	Silvereye
Zoothera lunulata	Bassian Thrush
Falco cenchroides	Nankeen Kestrel
Falco subniger	Black Falcon
Cacomantis flabelliformis	Fan-tailed Cuckoo
Anthochaera carunculata	Red Wattlebird
Phylidonyris pyrrhoptera	Crescent Honeyeater
Petroica phoenicea	Flame Robin
Pachycephala olivacea	Olive Whistler

Pachycephala pectoralis	Golden Whistler
Gymnorhina tibicen	Australian Magpie
Corvus coronoides	Australian Raven
Corcorax melanorhamphos	White-winged Chough
Dicaeum hirundinaceum	Mistletoebird

Mammals / Marsupials

Vombatus ursinus	Common Wombat
Antechinus sp.	Unidentified species
Antechinus swainsonii	Dusky Antechinus
Dasyurus maculatus	Tiger Quoll
Phascogale tapoatafa	Brush-tailed Phascogale
Sminthopsis sp.	Dunnart
Perameles nasuta	Long-nosed Bandicoot
Trichosurus vulpecula	Common Brushtail Possum
Petauroides volans	Greater Glider
Petaurus breviceps	Sugar Glider
Pseudochairus paregrinus	Common Ringtail Possum
Macropus giganteus	Eastern Grey Kangaroo
Macropus rufogriseus	Red-necked Wallaby
Wallabia bicolor	Swamp Wallaby
Rattus fuscipes	Bush Rat
Rattus lutreolus	Swamp Rat
Rattus sp.	Rat

Bats

Nyctinomus australis	White-striped Mastiff Bat
Chalinolobus morio	Chocolate Wattle Bat
Chalinolobus gouldii	Gould's Wattled Bat
Nyctophilus geoffroyi	Lesser Long-eared Bat
Nyctophilus gouldi	Gould's Long-eared Bat
Vespadelus regulus	King River Eptesicus
Vespadelus vulturnus	Little Forest Eptesicus
Vespadelus darlington	
Scotorepens orion	Eastern Broad-nosed Bat

D. Unique associations of Flora

i. The indicative reserve area is the only place known where cool- temperate rainforest supports a co-dominance of *Eucryphia moorei* (Pinkwood) and *Atherosperma moschatum* (Black Sassafras) exists (Australian Heritage Commission,1992).

ii. The indicative reserve area is a major habitat of *Telopea mongaensis* (Monga Waratah) and *Telopea Oreades* (Gippsland Waratah). This is one of only two places in Australia where two

species of waratahs grow so closely together. The Gippsland Waratah population in Monga is severely disjunct (by 170 kilometres) and cohabitates with the uncommon and endemic Monga Waratah. A most interesting aspect of this asssociation is the fact that these two species have bred together. In Monga State Forest there is apparently a hybrid zone of some hundreds of metres.

E. Flora at the edge of their range

There are 7 known rainforest species growing at or near their southern limit of distribution, some being listed by Australian Heritage Commission (1992). These include: *Liparis reflexa; Citronella moorei; Ceratopetalum apetalum; Diospyros australis; Cryptocarya microneura; Livistona australis* (Orscheg and Parsons,1996). One species is known to be at its extreme northern limit of distribution, the Gippsland Waratah (*Telopea oreadies).*

F. Threatened fauna species

The Monga-Buckenbowra Reserve Proposal Area contains sixteen threatened vertebrate species. This is a high number of threatened species. It is important to note that there are many groups of fauna that have received little or no scientific investigation in this area.

There are three species of nationally threatened fauna in Monga-Buckenbowra Reserve Proposal plus one probable species. These are *Macquaria australasica* (Macquarie Perch), *Prototroctes maraena* (Australian Grayling)(Probable), and *Dasyurus maculatus* (Spotted-tailed Quoll). The Macquarie Perch lives in the Mongarlowe River, and the Buckenbowra River is a probable habitat of the Australian Grayling (Australian Heritage Commission, 1992). Both species of fish are listed as nationally threatened on the Endangered Species Protection Act 1992.

The Southern Brown Bandicoot (*Isoodon obesulus*) is found in the Monga-Buckenbowra Reserve Proposal Area and is listed as an endangered species (Schedule 1) on the NSW Threatened Species Conservation Act 1997. (An Endangered species is defined as an animal or plant species which is in danger of extinction and will probably not survive if it continues to be threatened.

Following is a list of species considered to be extant in the Monga-Buckenbowra indicative reserve area and listed as Vulnerable Species (Schedule 2 threatened species) on the NSW Threatened Species Conservation Act 1997. A vulnerable species is defined as an animal or plant species which will probably become endangered if it continues to be threatened:

Scientific Name	**Common Name**
Birds	
Calyptorhynchue lathami	Glossy Black-Cockatoo
Ninox strenue	Powerful Owl

Tyto Novaehollandiae	Masked Owl
Tyto tenebricosa	Sooty Owl
Pachycephala olivacea	Olive Whistler
Petroica rodinogaster	Pink Robin

Mammals - Bats

Miniopterus schreibersii	Common Bent-wing Bat
Scoteanax rueppellii	Greater Broad-nosed Bat
Mormopterus norfolkensis	Eastern Freetail Bat
Kerivoula papuensis	Golden-tipped Bat
Vespadelus troughtoni	Estern Cave Bat

Mammals - Gliders

Petaurus australis	Yellow-bellied Glider

Mammals - ground dwelling

Dasyurus maculatus	Tiger Quoll
Phascogale tapoatafa	Brush-tailed Phascogale

Frogs

Mixophyes balbus	Stuttering Barred Frog
Heliporus australiacus	Great burrowing Frog

Fish (nationally threatened)

Macquaria australasica	Macquarie Perch
Prototroctes maraena	Australian Grayling

G. Fauna groups of particular interest

Monga-Buckenbowra Reserve Proposal Area contains particularly high numbers of threatened bird (6) and bat (5) species.

i. Birds

Monga-Buckenbowra Reserve Proposal Area has an extremely rich bird fauna. There are ninty-five species of birds known to live in the proposed area (Australian Heritage Commission 1992). Of these six are listed as Vulnerable species (Schedule 2 threatened species) on the NSW Threatened Species Conservation Act 1997. These are:

Ninox strenua	Powerful Owl
Tyto tenebricosa	Sooty Owl
Tyto Novaehollandiae	Masked Owl
Pachycephala olivacea	Olive Whistler

Petroica rodinogaster	Pink Robin
Calyptorhynchus lathami	Glossy-Black Cockatoo

The three threatened owls (Powerful, Masked and Sooty) have been recorded breeding in the Monga-Buckenbowra Reserve Proposal Area. The Boobook Owl *Ninox novaeseelandiae* and the Tawny Frog Mouth *Podargus ocellatus* are two more owls that also breed in the proposal area. The area therefore contains a very diverse owl breeding habitat (Australian Heritage Commission 1992).

ii. Mammals - Arboreal marsupials

Bats - Microchiropteran

Monga-Buckenbowra Reserve Proposal Area contains fourteen known species of bats, indicating an extremely diverse bat fauna in the area. Of these bat species, five are threatened species listed as Vulnerable Species (Schedule 2 threatened species) on the NSW Threatened Species Act 1997. These are:

Miniopterus schreibersii	Common Bent-wing Bat
Scoteanax rueppellii	Greater Broad-nosed Bat
Mormopterus norfolkensis	Eastern Little Mastiff Bat
Kerivoula papuensis	Golden- tipped Bat
Vespadelus troughtoni	Eastern Cave Bat

Other species of bats in the Monga-Buckenbowra Reserve Proposal Area are:

Chalinolobus morio	Chocolate Wattle Bat
Chalinolobus gouldii	Gould's Wattled Bat
Nyctophilus geoffroyi	Lesser Long-eared Bat
Nyctophilus gouldi	Gould's Long-eared Bat
Vespadelus regulus	King River Eptesicus
Vespadelus vulturnus	Little Forest Eptesicus
Vespadelus darlingtoni	
Nyctinomus australis	White Striped Mastiff Bat
Scotorepens orion	Eastern Broad-nosed Bat

Note that all species of bat present in Monga-Buckenbowra Reserve Proposal Area are dependant upon hollows in old trees for habitat (Gibbons 1994).

Gliders

Yellow-bellied Glider

Petaurus australis is a vulnerable species in NSW, being the second biggest glider in Australia is prey to the two largest owls, the Powerful and Sooty owls. Trees containing suitable hollows for arboreal marsupial habitat are estimated to be between 144 and 194 years of age (Gibbons 1994). Old growth Eucalyptus forests of south-eastern Australia are optimum habitat for nesting by the Yellow-bellied Glider (Scotts 1991).

iii. Mammals -Ground dwelling

Spotted-tail Quoll

Dasyurus maculatus is a nationally threatened species listed as a vulnerable species on the Endangered Species Act 1992. Old growth Eucalyptus forests of south-eastern Australia are optimum habitat for nesting and foraging by the Spotted-tailed Quoll (Scotts 1991). The Tiger Quoll occurs at low population densities (Possingham 1991). The major causes to render the Spotted-tailed Quoll threatened are intensive forestry, fragmentation of habitat, siltation of streams and shooting, trapping and poisoning Wilson 1991).

Southern Brown Bandicoot

Isoodon obesulus is listed as an endangered species (Schedule 1, Endangered species, populations and ecological communities) on the NSW Threatened Species Act 1997. Bandicoots in NSW especially the Southern-Brown Bandicoot are an "extinction-prone group" (Ashby 1991). Diet includes ants, beetles, seeds, plant material and hypergeal fungal fruiting bodies. Habitat includes coastal heathland. (Claridge 1991).

iv. Herpetofauna - Amphibians and Reptiles

Frogs

Monga's moisture regime contributes to the high probability that this landscape is a regionally significant frog habitat and refugia. Frogs lose moisture directly through their skin hence a stable, wet environment is a crucial habitat requirement for many species. Dr. Osborne, a herpetology expert at the University of Canberra believes Monga to be extremely suitable habitat for frogs. Dr. Osborne predicts the presence of the Giant Burrowing Frog *Heliporus australiacus*, a threatened species, in Monga. Dr. Osborne has reviewed the distribution information relating to the Stuttering Barred Frog *Mixophyes balbus* and indicated three records from Monga State Forest. Dr. Osborne noted that there has been little or no frog work done in Monga.

Both frog species mentioned above are threatened species, listed as Vulnerable Species (Schedule 2 threatened species) on the NSW Threatened Species conservation Act 1997. Other species of frogs recorded in Monga-Buckenbowra Reserve Proposal Area (NSW Wildlife Atlas 1998) are:

Crinia signifera	Common Eastern Froglet
Pseudophryne dendyi	Dendy's Toadlet
Litoria lesueuri	Lesueur's Frog
Litoria phyllochroa	Leaf Green Tree Frog
Litoria peronii	Peron's Tree Frog

Old growth Eucalyptus forests of south-eastern Australia has been considered optimum habitat for foraging by *Mixophyes balbus* (Scotts 1991). The major reasons for the decline of *M. balbus* have been considered intensive forestry, fragmentation of habitat and changes in fire regimes (Wilson 1991). Habitat for *H. australiacus* is usually restricted to Hawkesbury

Sandstone. Distribution is confined to only part of the NSW and Victorian coastlines (Robinson 1993). One of the major causes for the decline of *H.austrsliacus* is the siltation of streams.

v. Invertebrate Fauna

There is an apparent lack of study of invertebrate species in the area. This very important group of fauna risks being largely ignored in RFA assessments. One consequence is that the risk of extinction for this group remains unknown.

The leaf beetle

Microdonacia Blackburn is a genus of leaf beetle. A recently identified species of this genus has been found at Monga state Forest, namely, *Micronacia pilosa sp.n.* This particular species of leaf beetle has a limited distribution being confined to cool temperate rainforest on the eastern slopes of the coastal range between Clyde Mountain and the Monga area, with *E. Moorei* being the sole known host plant (Reid 1992).

As noted above, *Eucyyphia moorei* is a Gondwanic relic, with Monga State Forest housing stands possibly many thousands of years old (J.Ash, pers.comm). This suggests that the leaf beetle and rainforest tree species have co-evolved together over a very long period of time. The leaf beetle is therefore possibly a primitive form, indicative of a larger set of primitive invertebrate forms. For example, stands of *Eucryphia moorei* occupy rich organic soils which have changed significantly for extended periods of time. It is therefore also possible that there could be very distinctive and perhaps primitive forms of soil fauna co-inhabiting with *E.moorei* (J.Ash, pers. comm).

H. Fauna species at the edge of their ranges

There are 18 known species at or near their southern, nothern, western, north-western and eastern limits of distribution listed in the Australian Heritage Commission's National Estate Report for the Mongarlowe-Buckenbowra Rivers Area(1992). These include:

i. Species at their southern limit of distribution

Adelotus brevis (Tusked Frog); *Mixophyes fasciolatus* (Great Barred Frog); *Pseudophryne dendyi*; *Litoria dentata* (Bleating Tree Frog); *Litoria fallax* (Eastern Dwarf Tree Frog); *Litoria freycineti* Lesueur's (Velvet Gecko); *Saiphos equalis*; *Sphenomorphus tenuis*; *Dendralaphis punctulatus* (Common Tree Snake); *Hemiaspis signata* (Black Bellied Swamp Snake).

ii. Species at their northern limit of distribution

*Isoodon obesulus (*Southern Brown Bandicoot); *Petroica rodinogaster* (Pink Robin)

iii. Species at their western limit of distribution

Ceyx Azurea (Azure Kingfisher); *Monarcha melanopsis* (Black Faced Monarch); *Perameles nasuta* (Long Nosed Bandicoot).

Species at their north-western limit of distribution include the undescribed *Hadronyche* species of funnelweb spider. Species at their eastern limit of distribution include an undescribed *Atrax* species of funnelweb spider.

Monga-Buckenbowra Reserve Proposal Area is also the transition zone over which three forms of the marsupial mouse *Antechinus stuartii* occur.

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Figure 1. The 99 group climate classification for the Southern RFA region

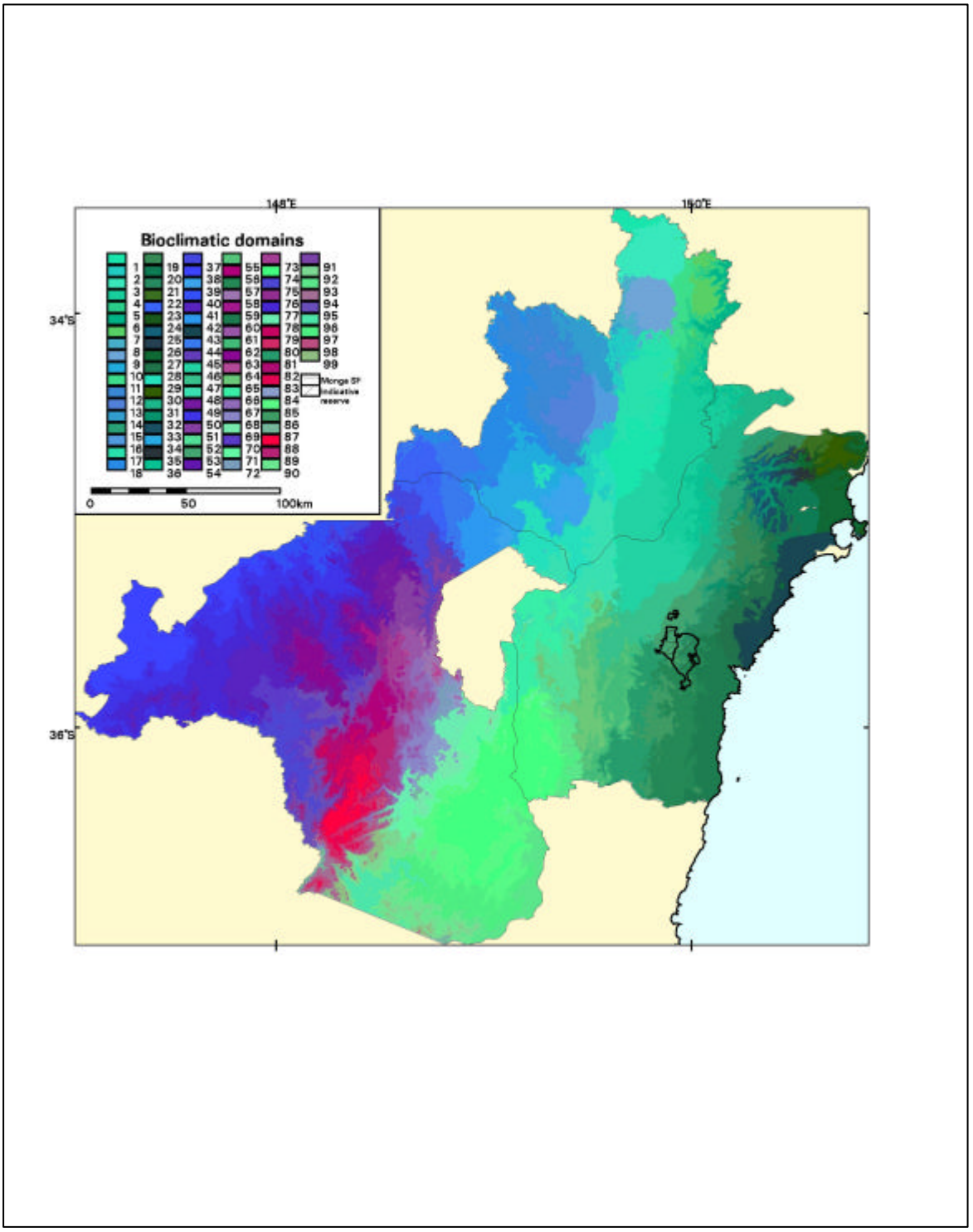


Figure 2. The 15 group climate classification for the Southern RFA region

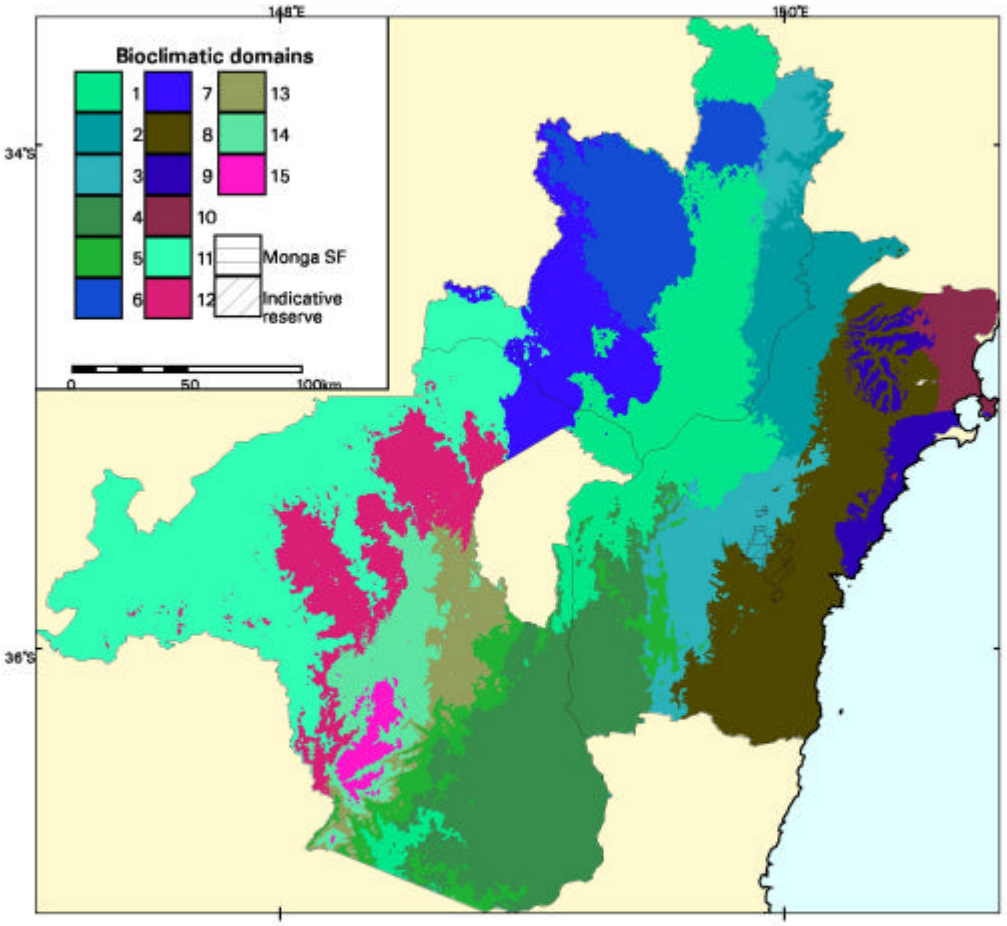


Figure 3a. Dendrogram showing inter-group similarity for the 15 group climate classification for the Southern RFA region

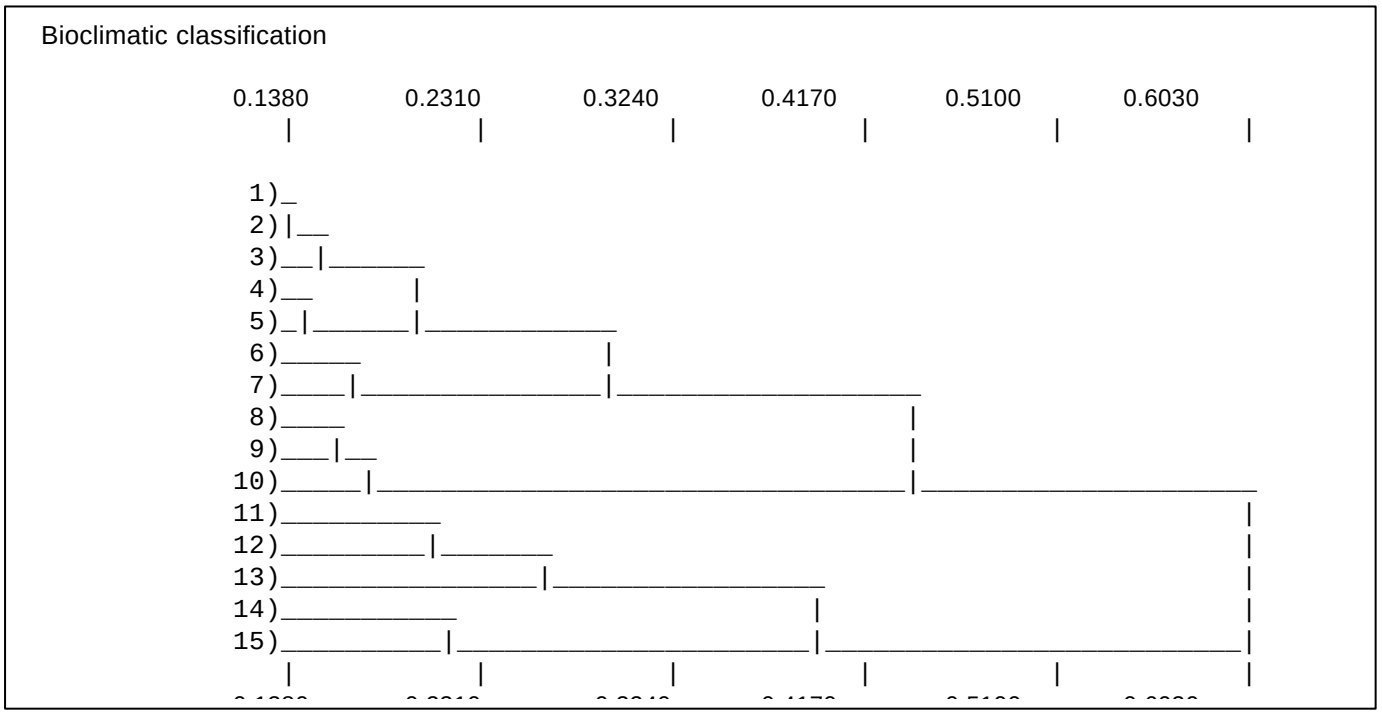


Figure 3b. Dendrogram showing inter-group similarity for the 14 group terrain classification for the Southern RFA region

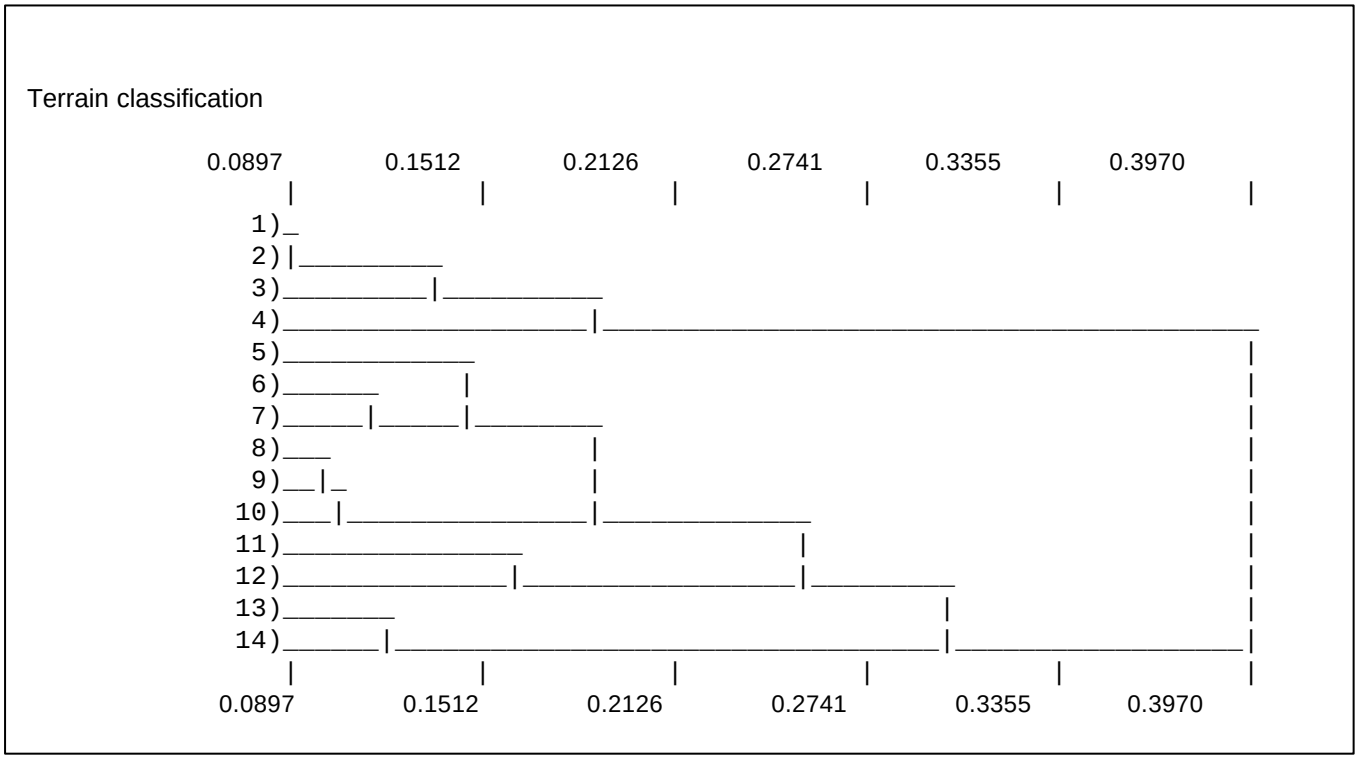


Figure 4. Rainfall seasonality for the Southern RFA region

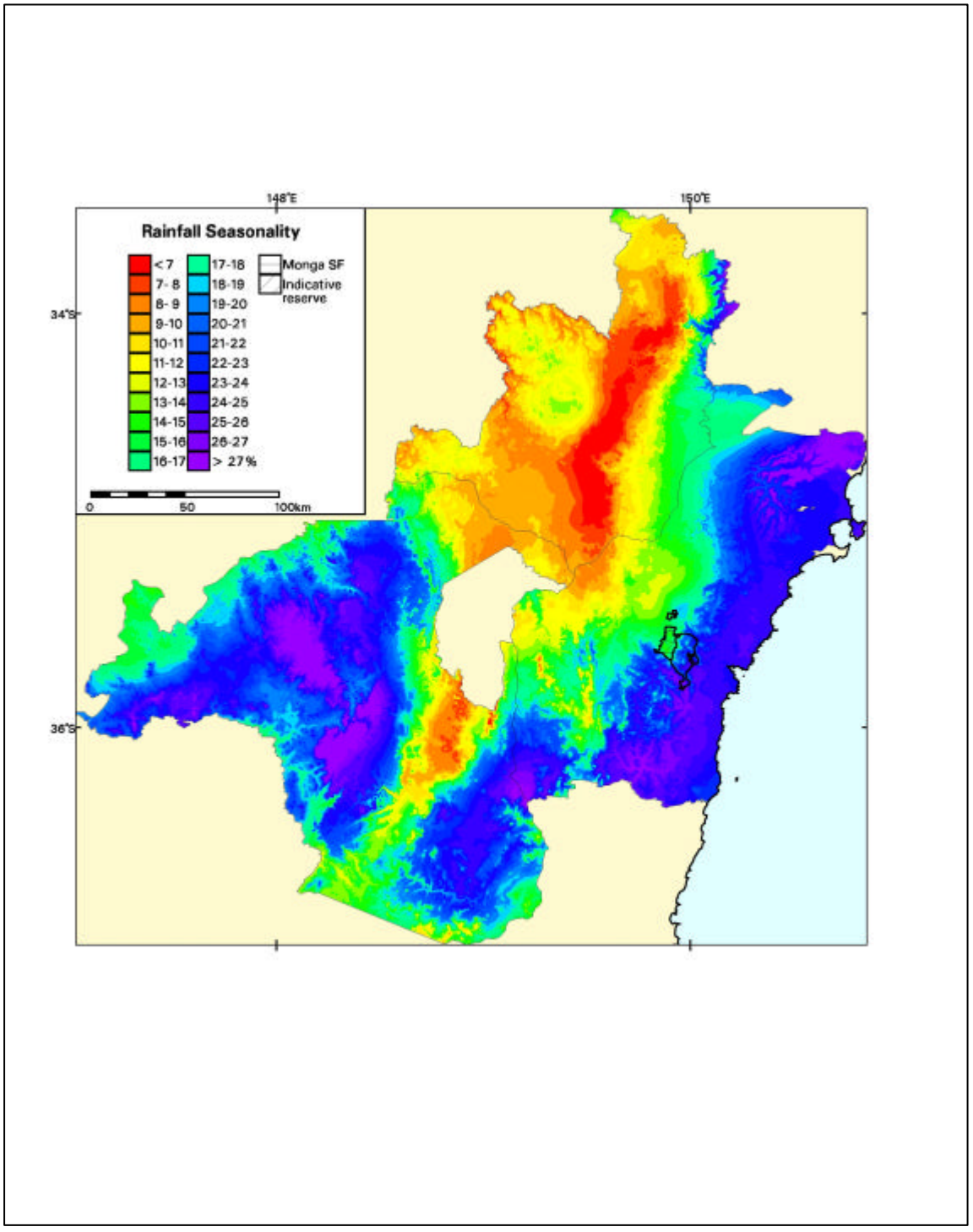


Figure 5. Annual total rainfall for the Southern RFA region

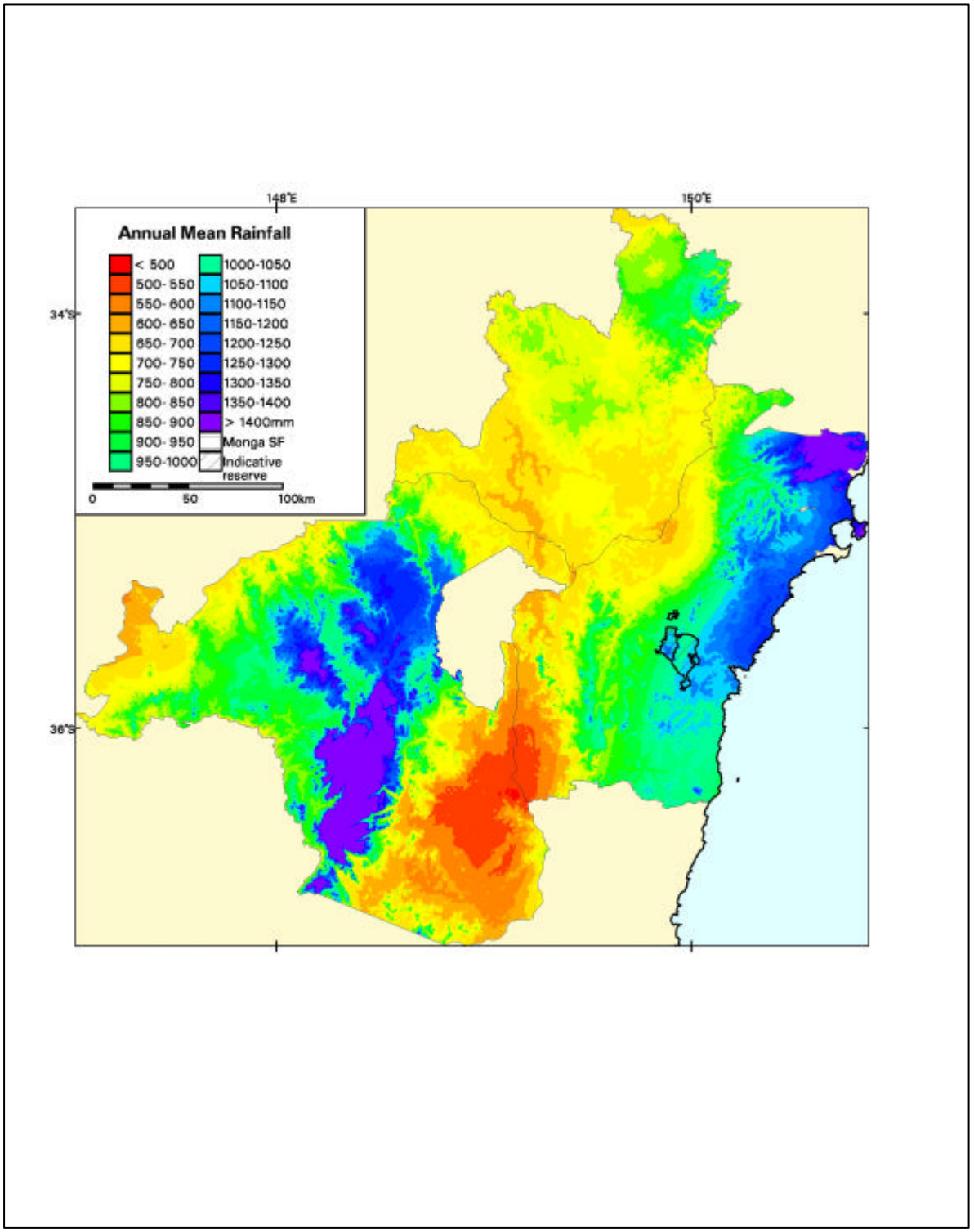


Figure 6. Annual mean temperature for the Southern RFA region

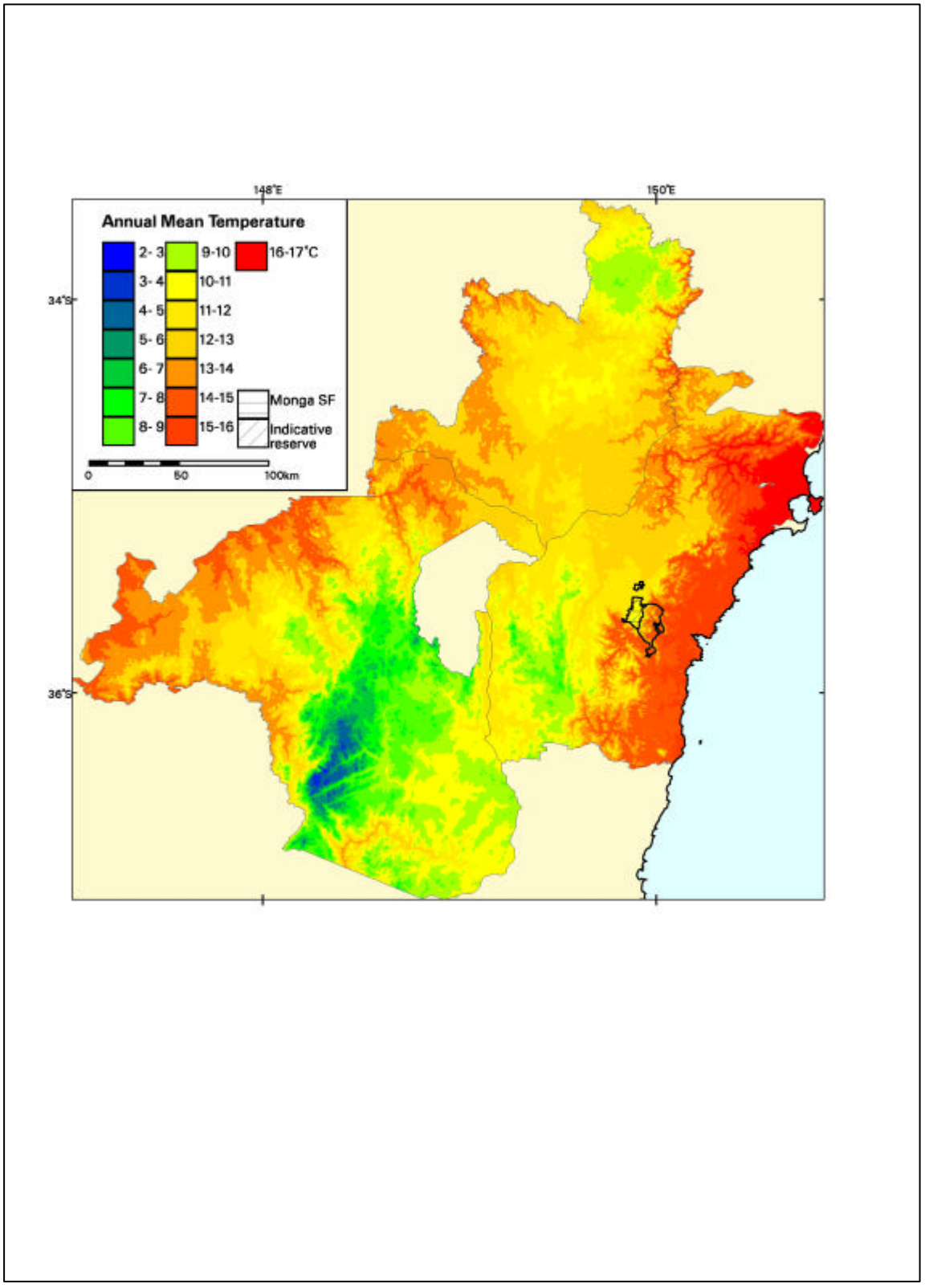


Figure 7. 40 group terrain classification for the Southern RFA region

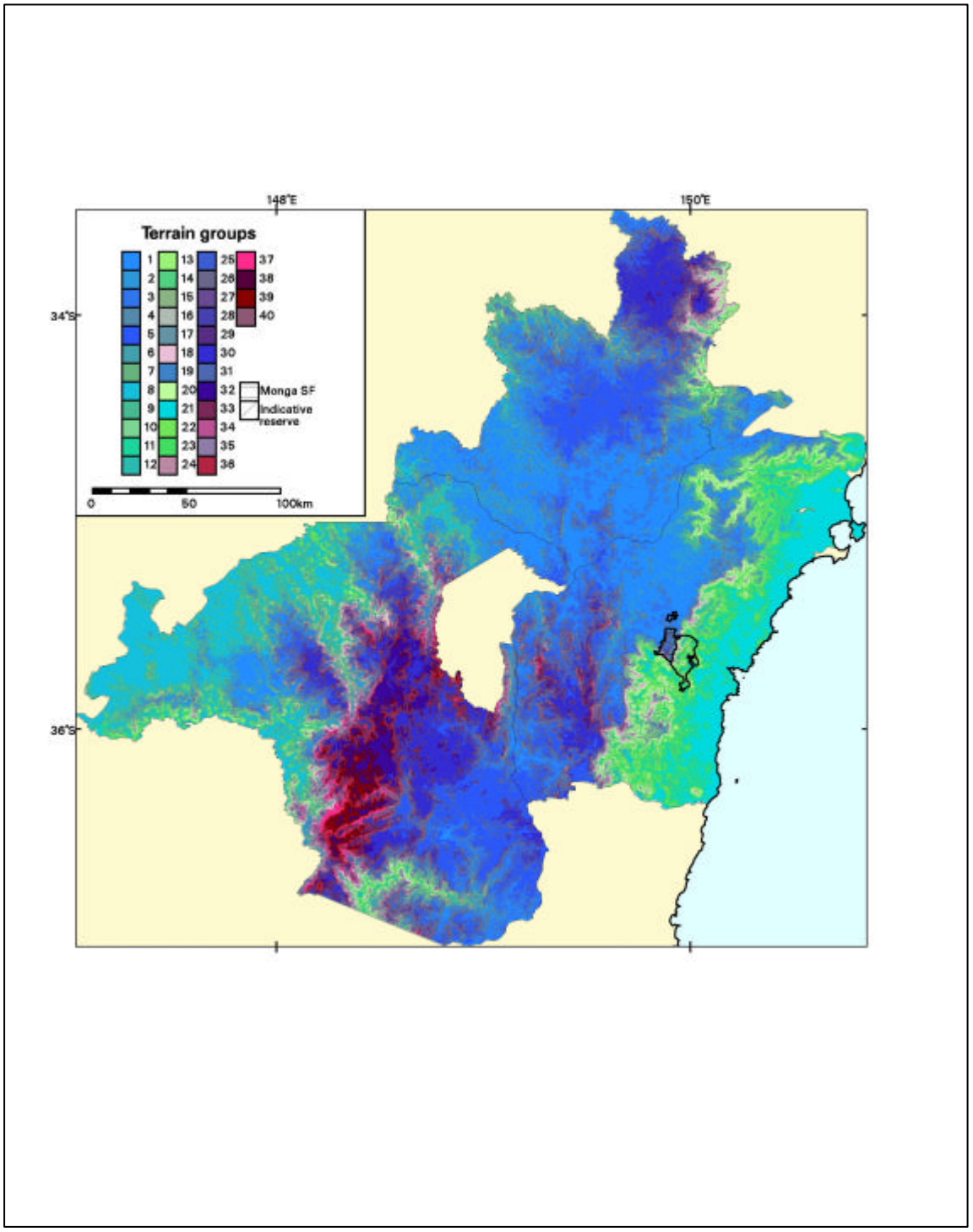


Figure 8. 14 group terrain classification for the Southern RFA region

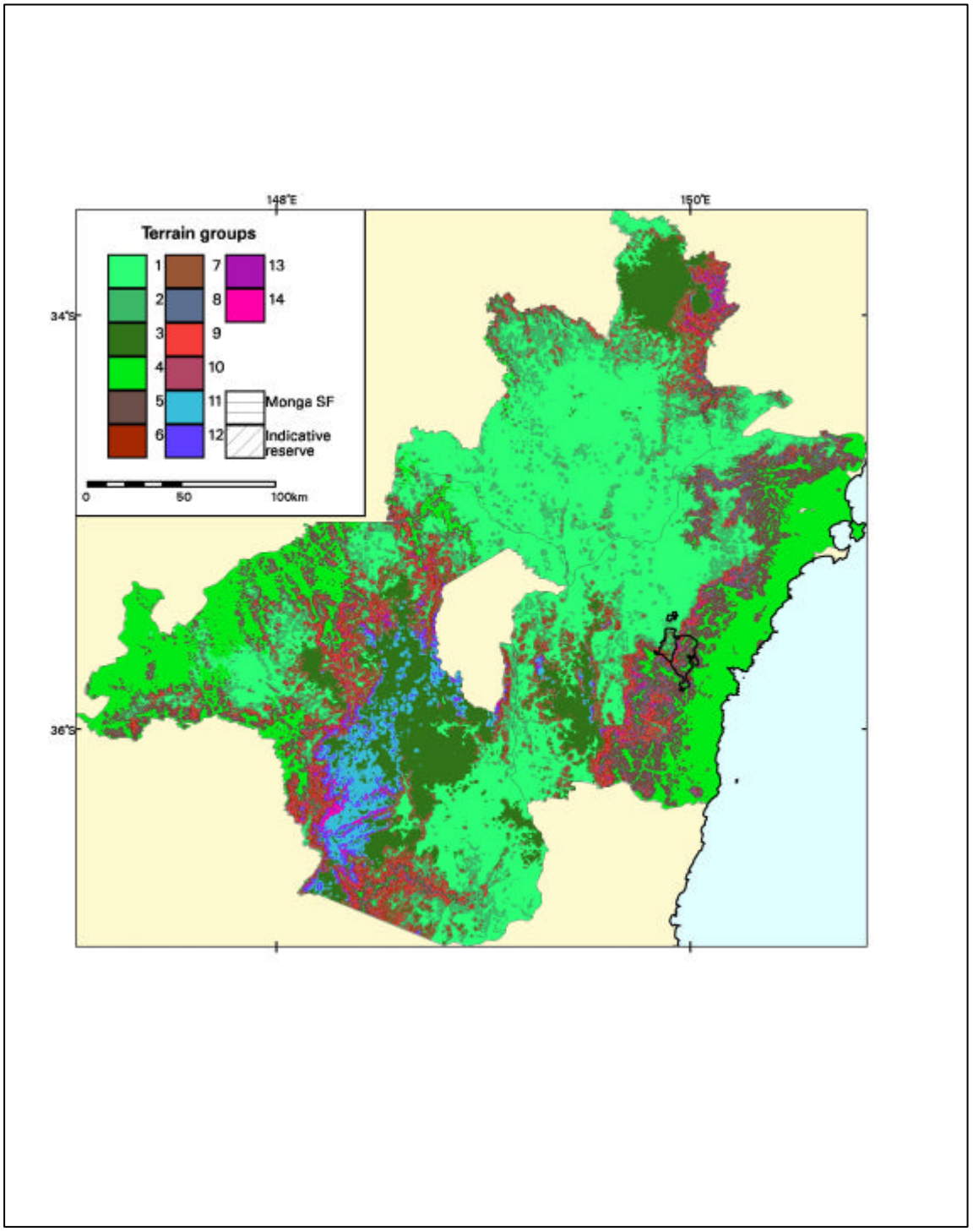
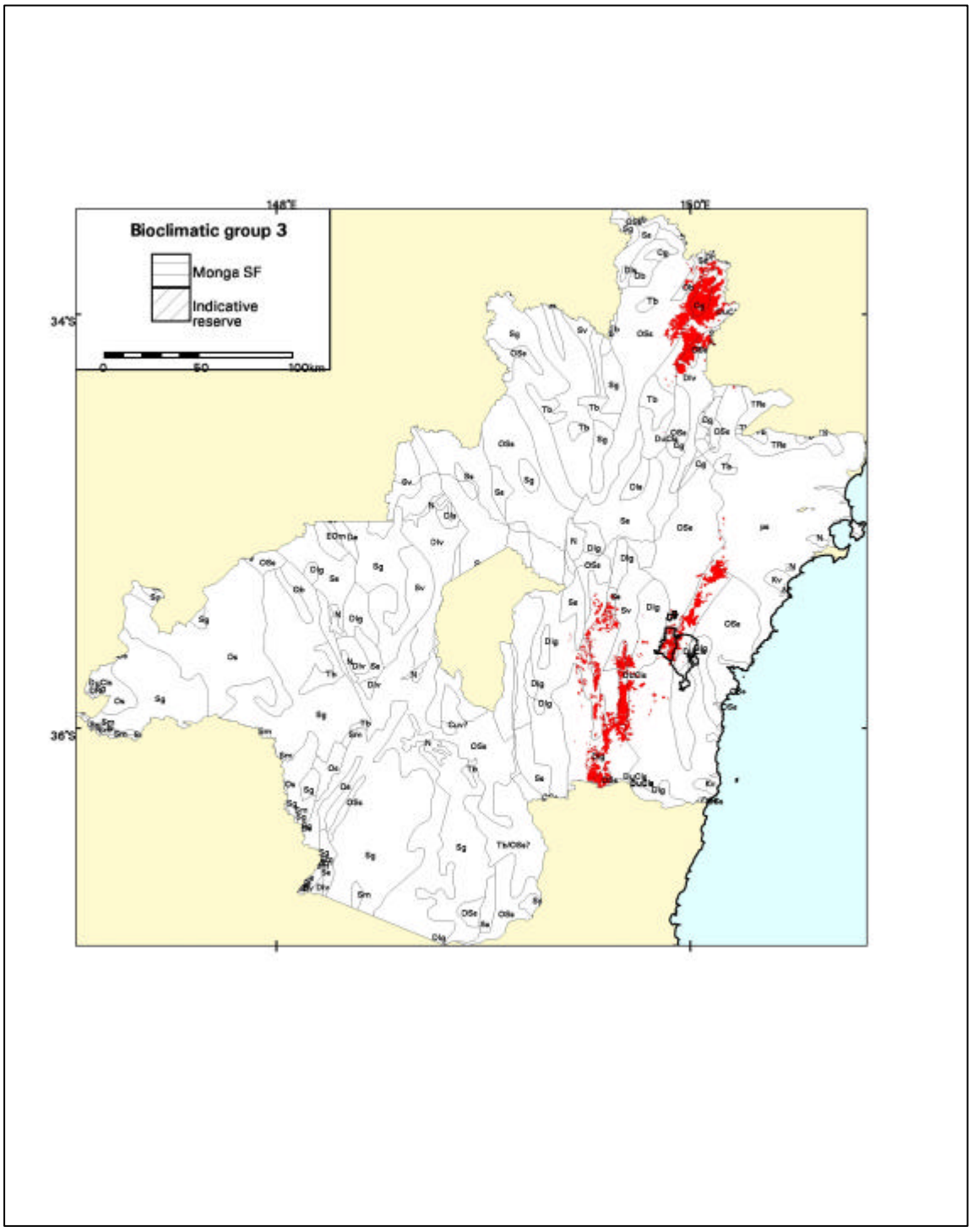
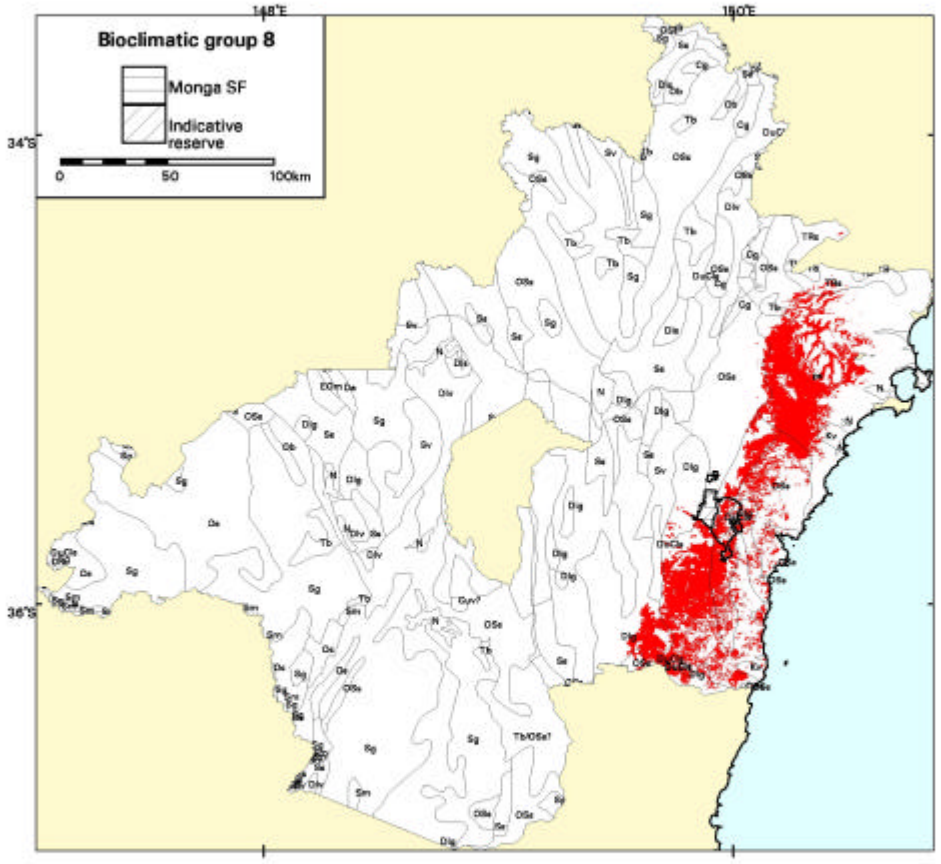
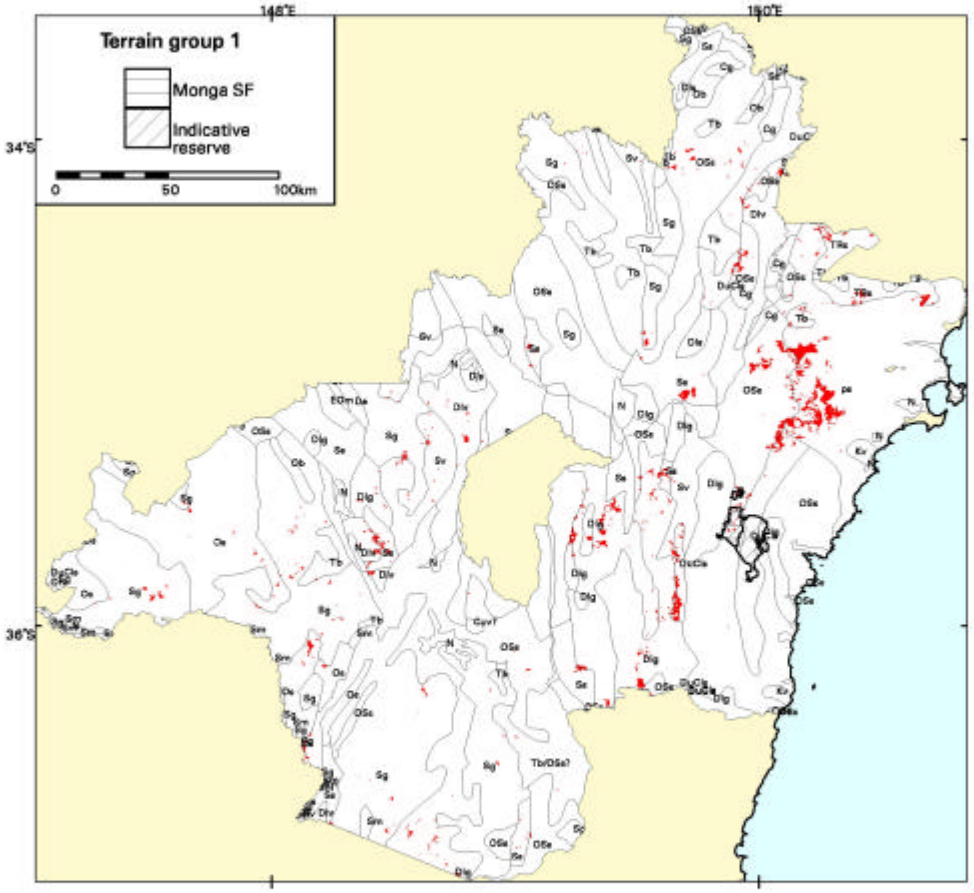
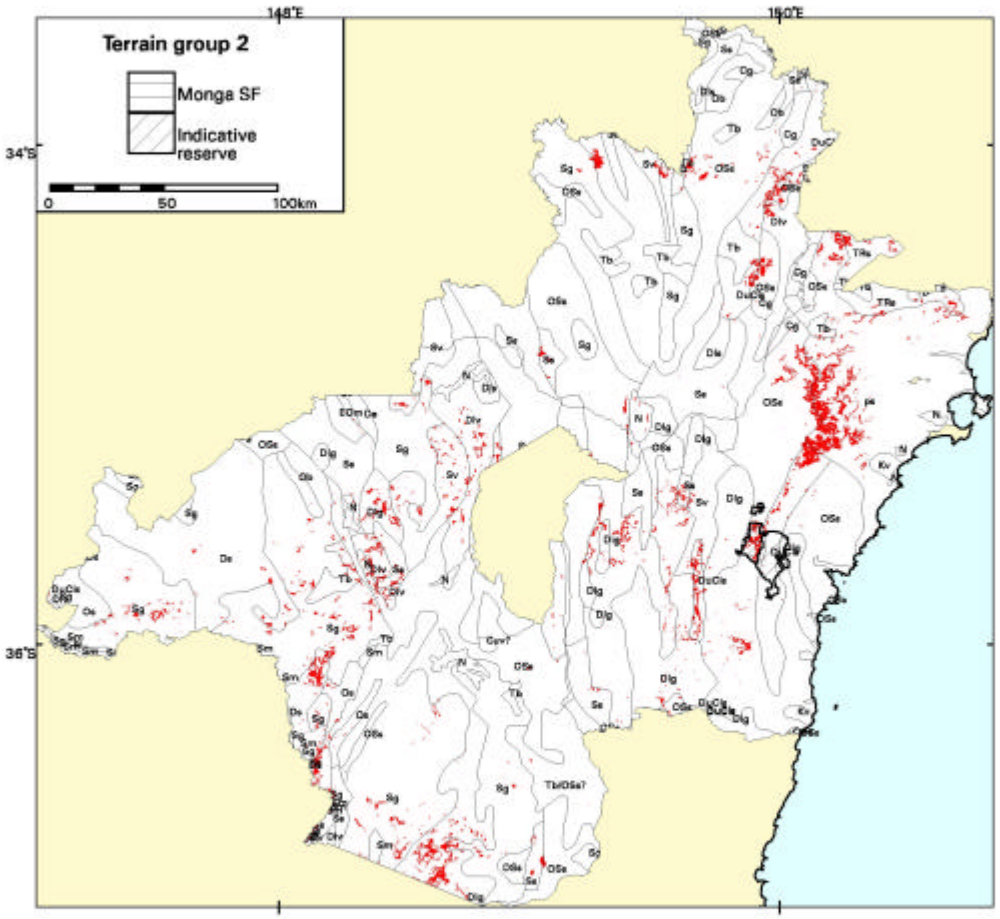


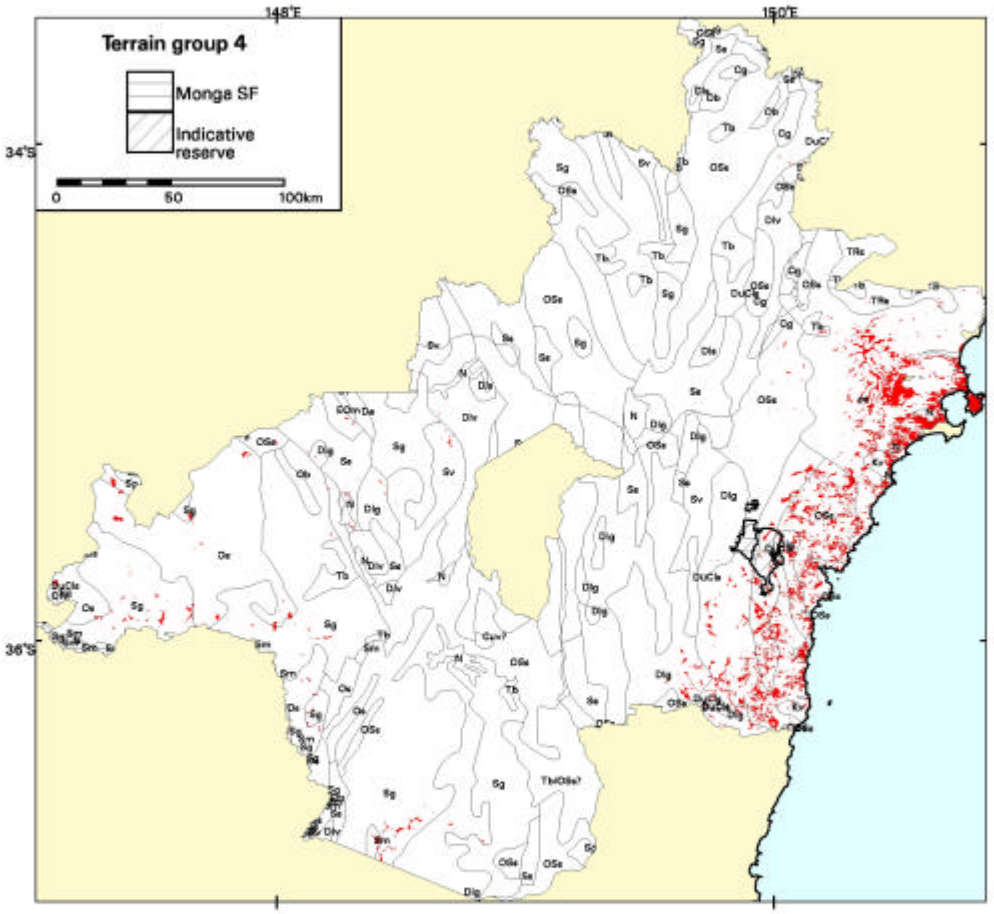
Figure 9.1-9.10 Highest quality natural vegetation cover of those climatic and terrain classification groups found within the indicative Monga-Buckenbowra area

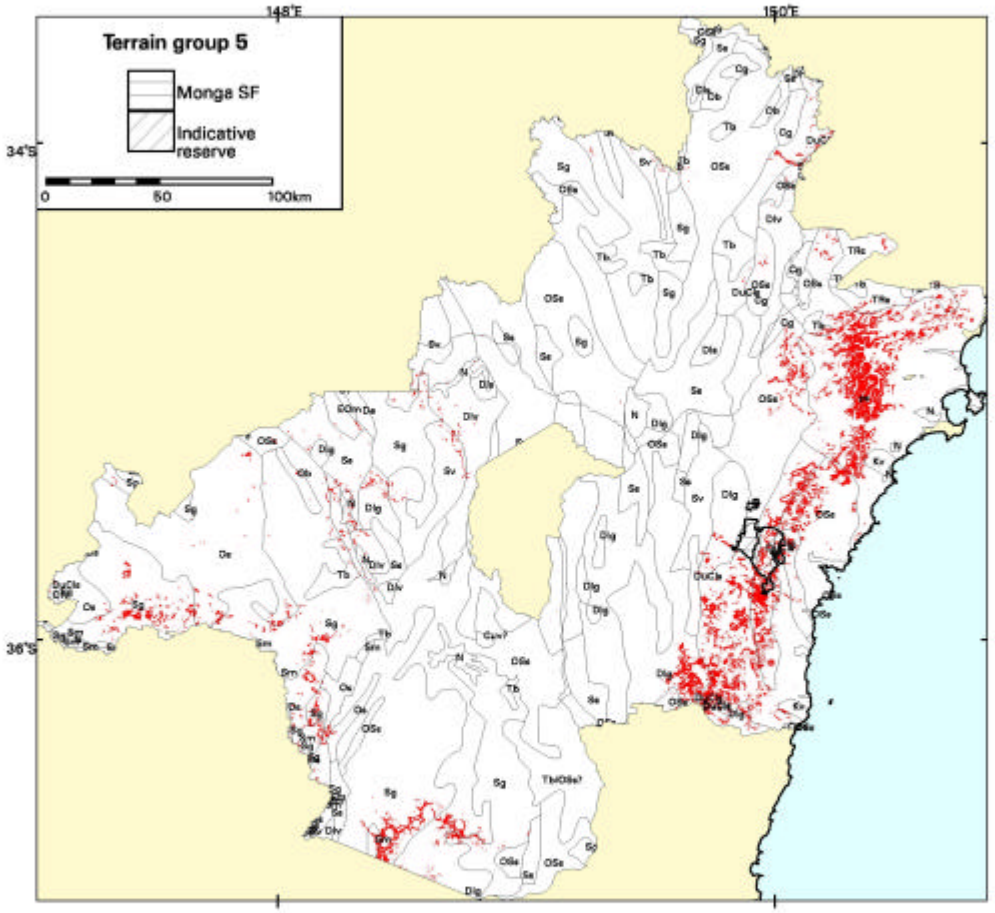


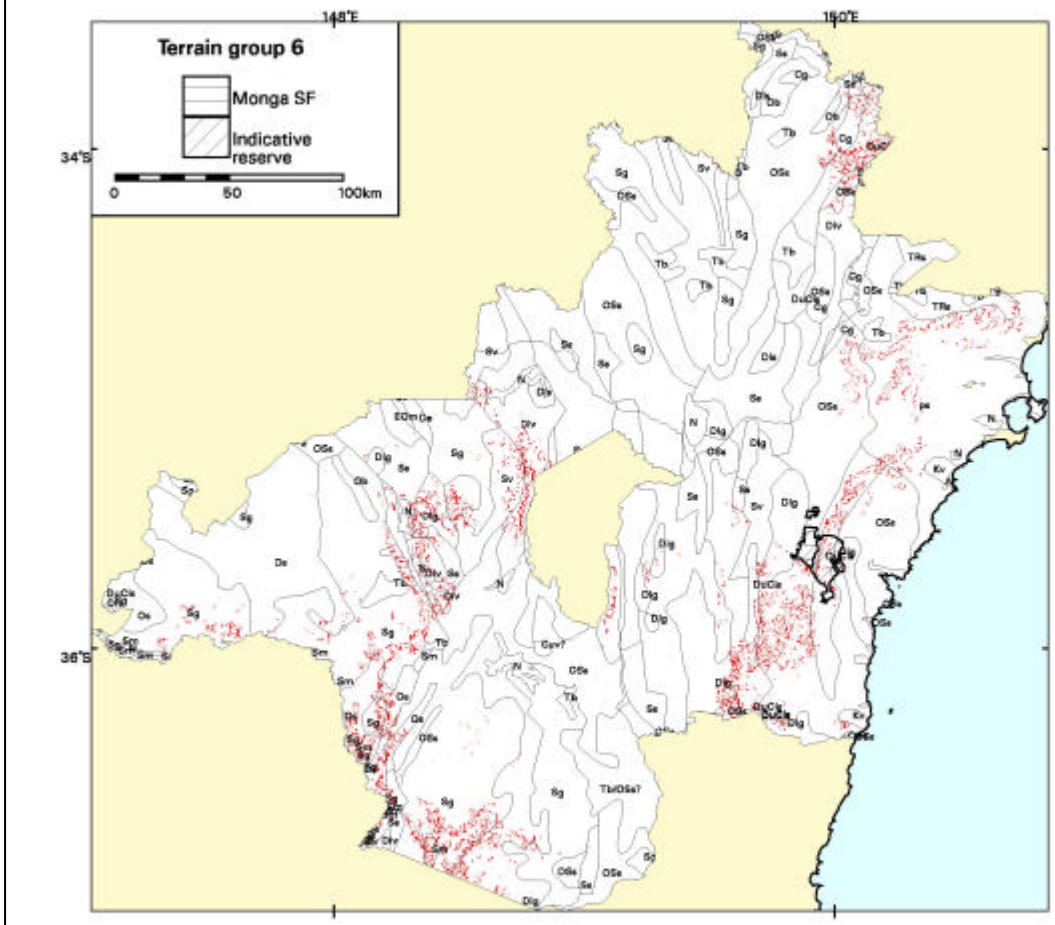

Bioclimatic group 8
Monga SF
Indicative reserve
0
50
100km
148°E
150°E
34°S
36°S

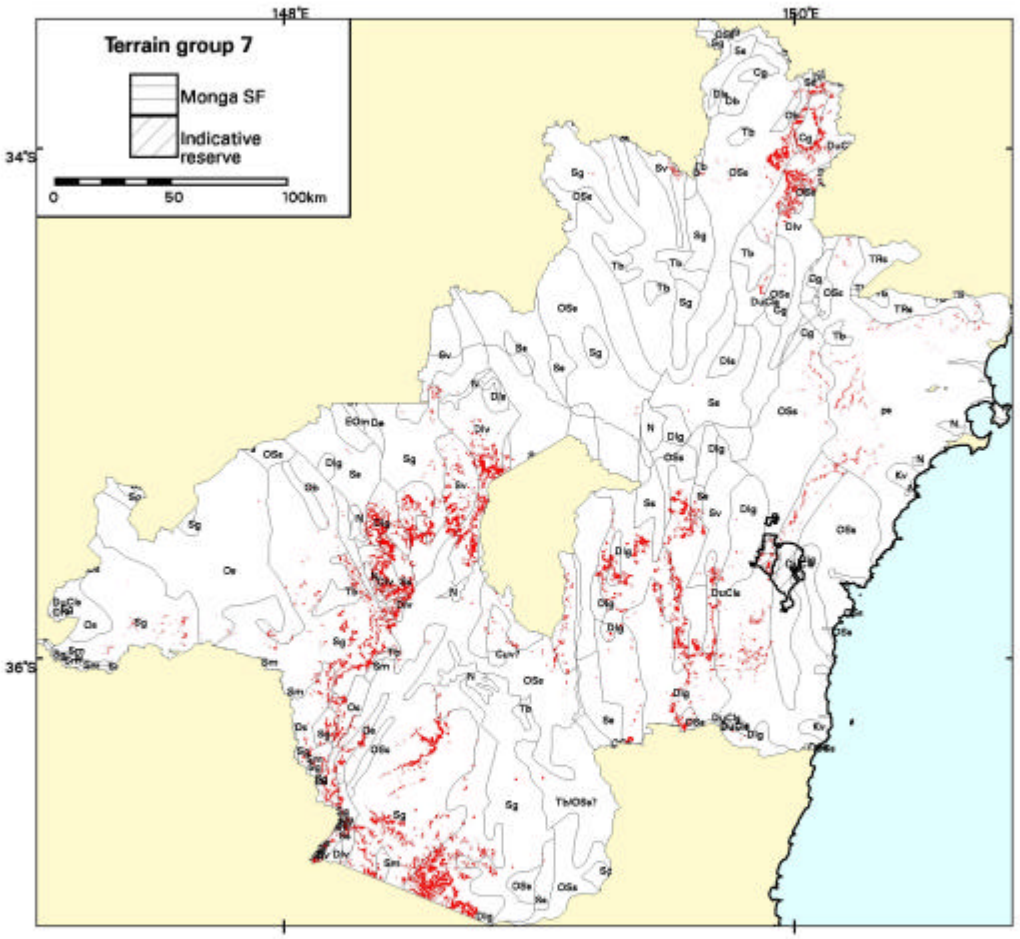

Terrain group 1
Monga SF
Indicative reserve
0
50
100km
34°S
36°S

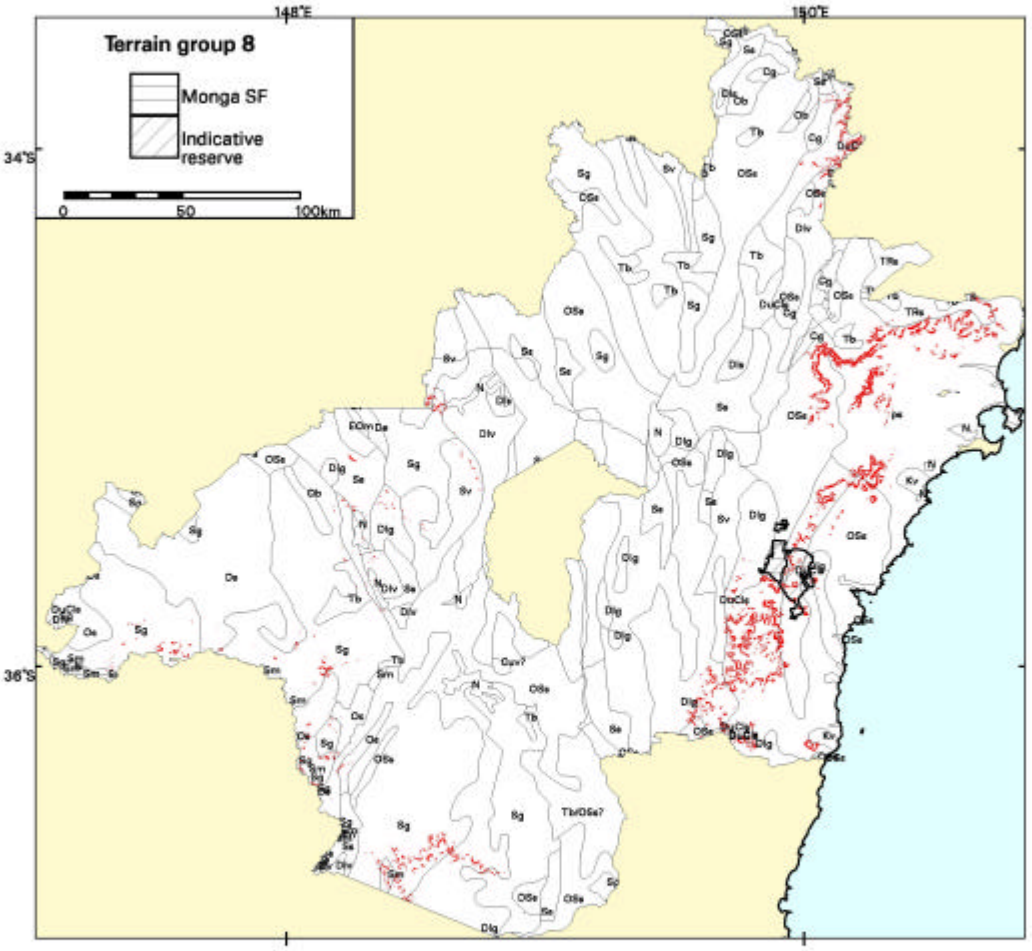

Terrain group 2
Monga SF
Indicative reserve
0
50
100km
148°E
150°E
34°S
36°S


Terrain group 4
Monga SF
Indicative reserve
0
50
100km
148°E
150°E
34°S
36°S


Terrain group 5
Monga SF
Indicative reserve
0
50
100km
148°E
150°E
34°S
36°S


Terrain group 6
Monga SF
Indicative reserve
0
50
100km
34°S
36°S


Terrain group 7
Monga SF
Indicative reserve
0
50
100km
148°E
150°E
34°S
36°S


Terrain group 8
Monga SF
Indicative reserve
0
50
100km
148°E
150°E
34°S
36°S

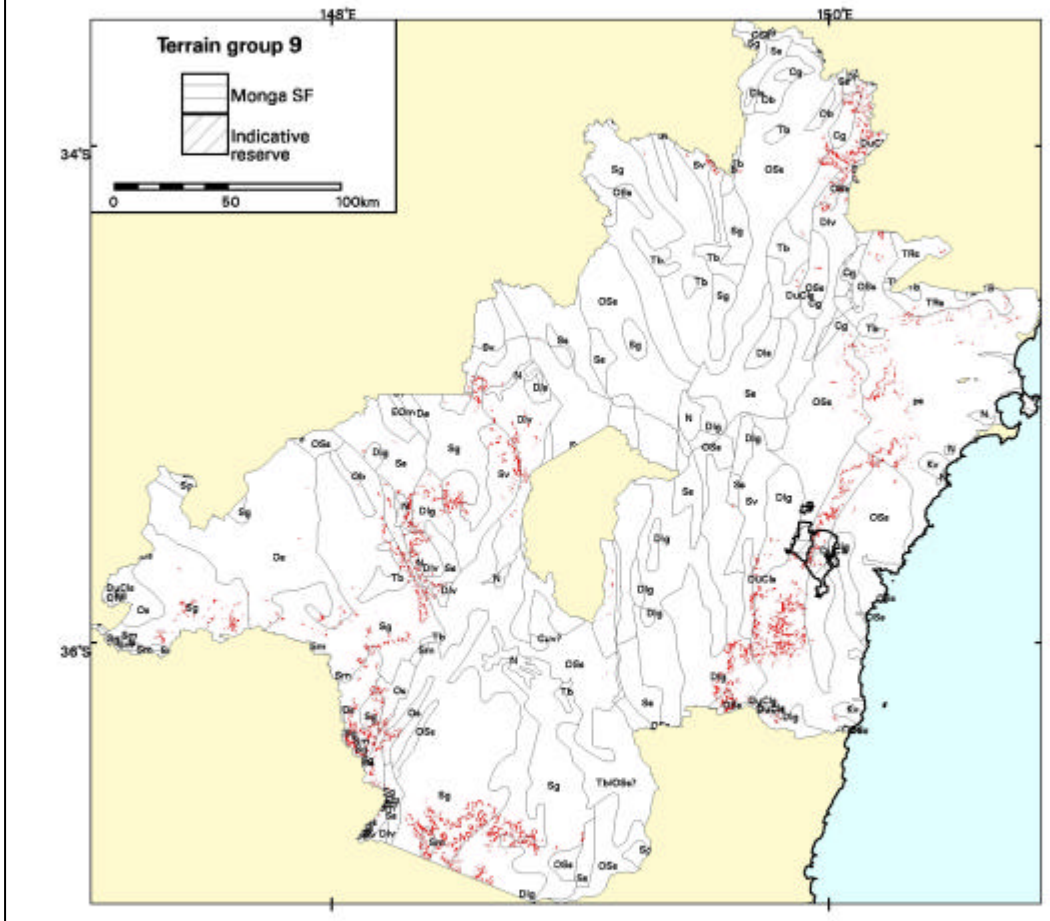
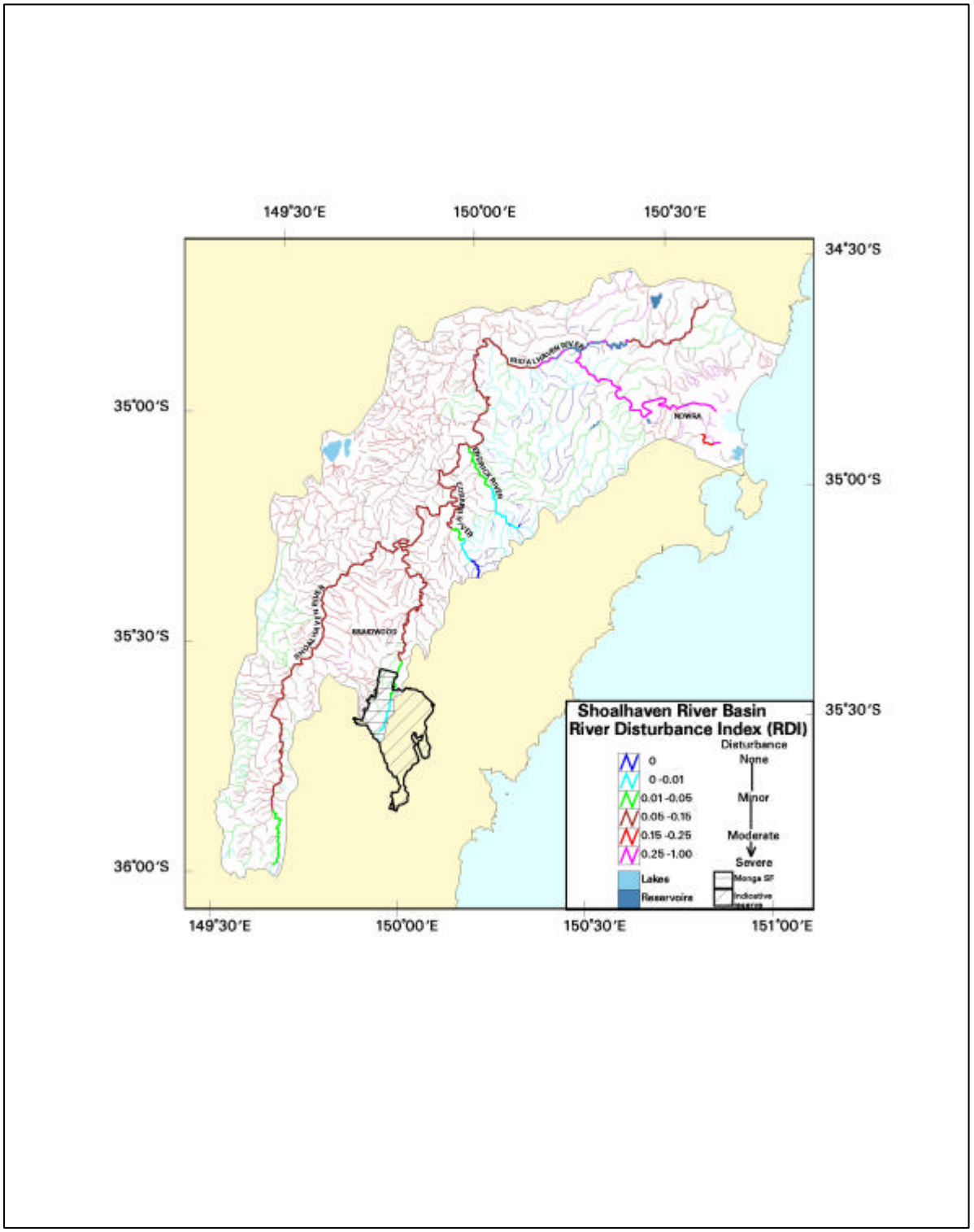
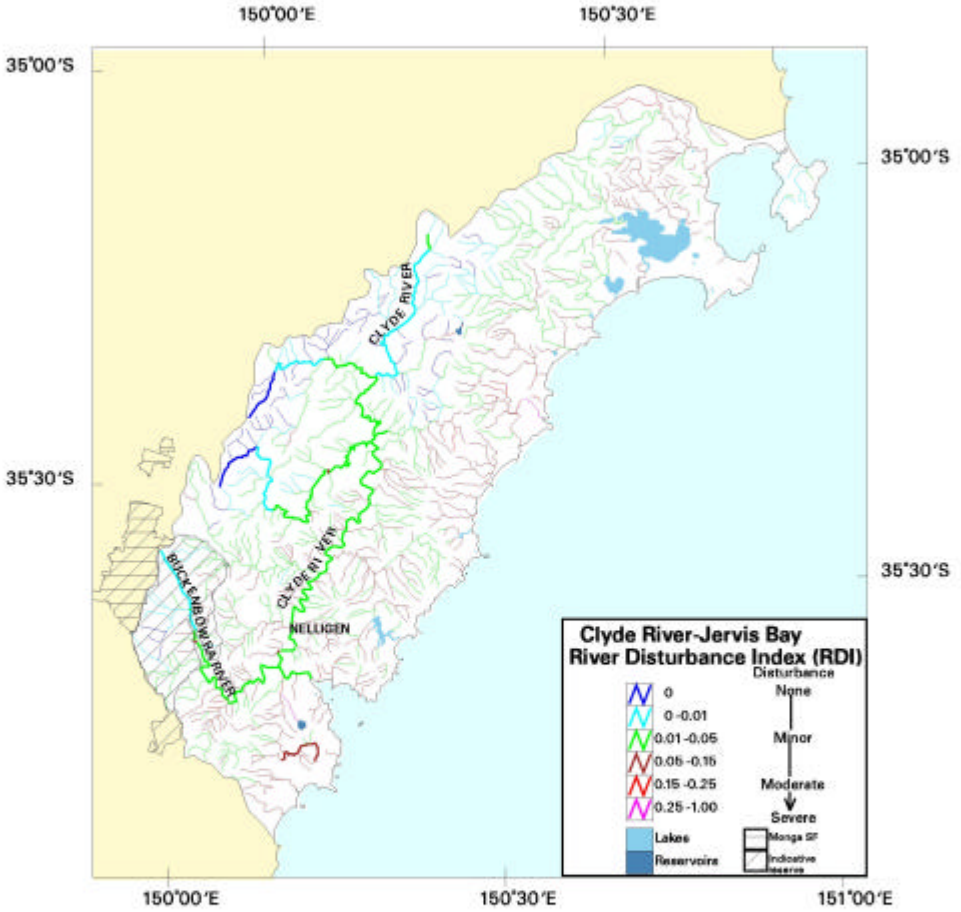

Terrain group 9
Monga SF
Indicative reserve
0
50
100km
148°E
150°E
34°S
36°S

Figure 10-12. River disturbance index of the three catchments crossed by the indicative Monga-Buckenbowra area: Shoalhaven River; Clyde River/Jervis Bay River; and Deua River




150°00'E
150°30'E
35°00'S
35°30'S
CLYDE RIVER
CLYDE RIVER
BUCKENBOWRA RIVER
NELLIGEN
Clyde River-Jervis Bay
River Disturbance Index (RDI)
0
0 -0.01
0.01 -0.05
0.05 -0.15
0.15 -0.25
0.25 -1.00
Lakes
Reservoirs
Disturbance
None
Minor
Moderate
Severe
151°00'E

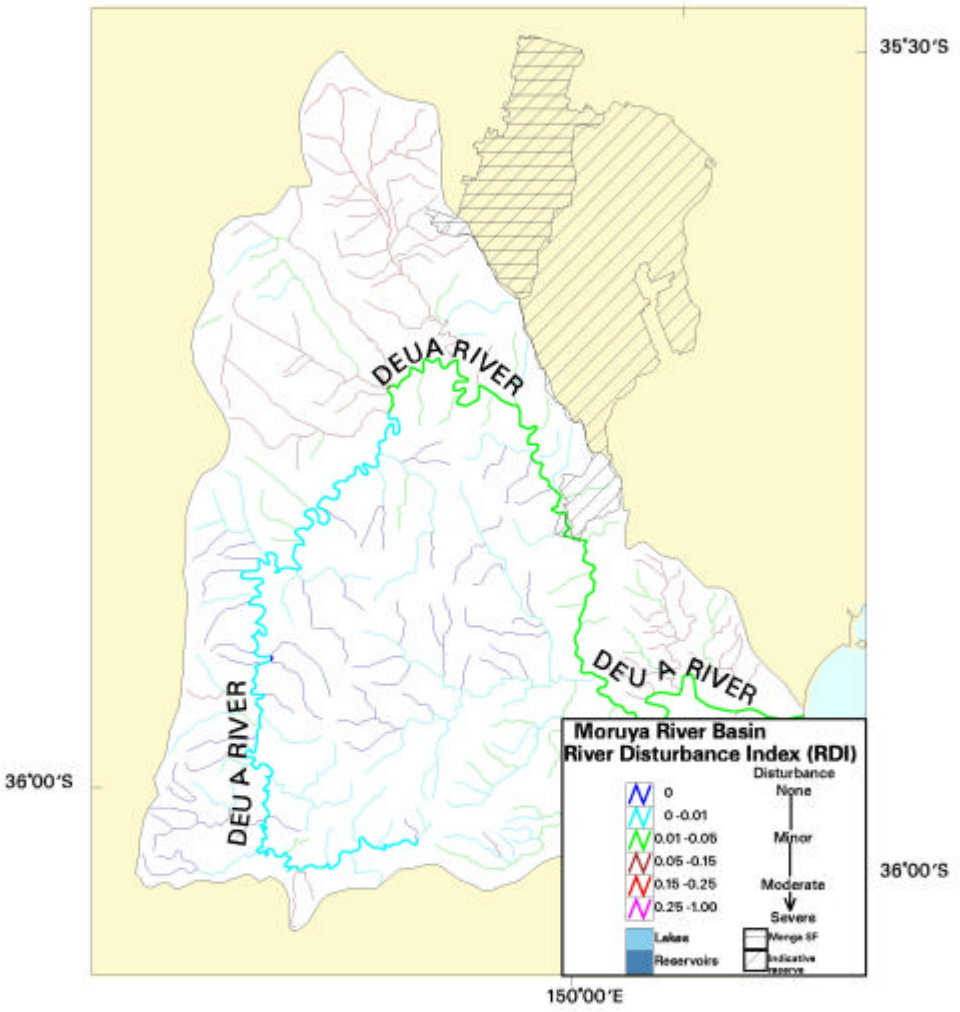

35°30'S
36°00'S
36°00'S
150°00'E
DEUA RIVER
DEU A RIVER
DEU A RIVER
Moruya River Basin
River Disturbance Index (RDI)
Disturbance
None
Minor
Moderate
Severe
0
0 -0.01
0.01 -0.05
0.05 -0.15
0.15 -0.25
0.25 -1.00
Lakes
Reservoirs

Figure 13. Spatial prediction of potential climatic domain for *Eucryphia moorei*

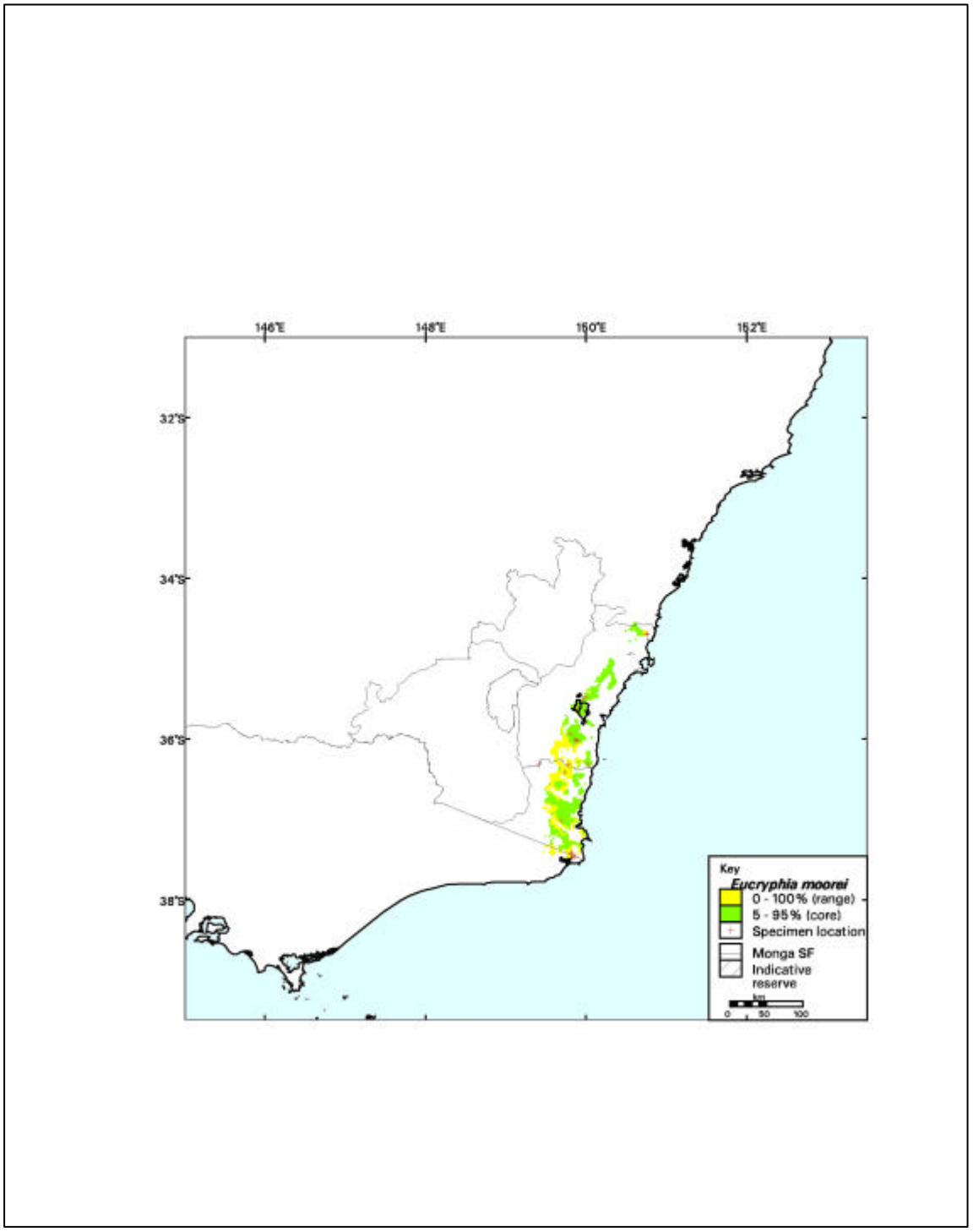


Figure 14. Spatial prediction of potential climatic domain for *Telopea mongaensis*

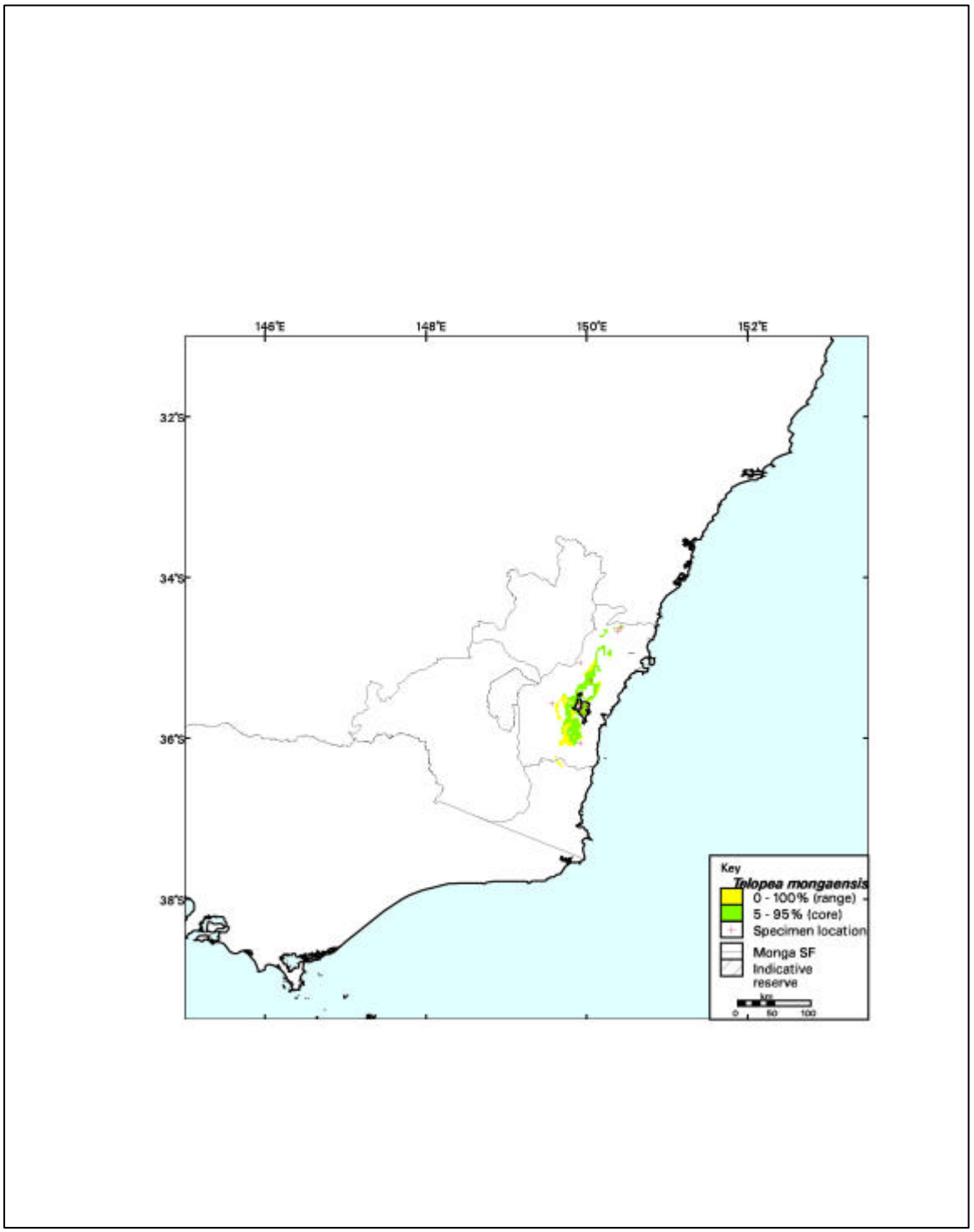


Figure 15. Woody vine (30cm diameter) in mature E. fastigata/sub-tropical rainforest association in Buckenbowra State Forest



Table 1. Median and mean attribute values for the 15 group climate classification for the Southern RFA region

Bioclimatic domains: Group medians.

Group No	# cells	ann temp	tempseas		maxt mnth		mint mnth		wetq temp		dryq temp		hotq temp		coldq temp		ann prec
	prec seas	prec wetq	prec dryq		ann rad	rad seas		rad wetq		rad dryq							
1	127651	11.9	1.73	26.3	-0.3	16.2	6.7	18.2	5.7	702	11	194	153	17	37	22.6	11.8
2	52971	13.1	1.65	26.8	1	18.6	8.1	19	7.1	752	17	226	142	17	36	21.1	12.9
3	56924	11.2	1.62	24.5	-0.6	16.3	6.4	17	5.3	905	16	267	183	16.3	37	20.3	12.2
4	119349	10.2	1.68	24.6	-2	15	4.8	16.2	4.2	597	21	182	112	16.6	39	24.1	11.2
5	32071	8.9	1.66	22.8	-2.6	10.5	3.8	14.8	3	776	13	229	171	16	40	20.5	9.9
6	55638	11.6	1.77	26.6	-0.3	6.9	14.9	18.1	5.3	788	11	221	169	17	37	12.4	17.7
7	52601	13	1.83	27.9	0.5	11.4	17.8	19.8	6.5	689	10	190	156	17.1	38	18.9	19.7
8	105763	14.3	1.37	25.2	2.8	18.1	10.1	19.2	9.2	1035	24	326	173	15.8	38	17.1	12.2
9	21726	15.5	1.23	25.4	5.1	14.2	11.9	20.1	10.9	1190	25	374	206	15.8	37	9.8	12.8
10	17190	16.4	1.18	25.3	6.7	19.4	12.7	20.6	12	1353	25	437	234	15.6	36	16.1	12.3
11	166224	13.3	1.87	29.2	0.9	7	20.1	20.3	6.7	832	20	257	159	16.5	42	8.9	22.9
12	61386	10.8	1.79	25.8	-0.6	5.1	17.2	17.4	4.4	1180	24	383	208	15.7	42	8.9	22.4
13	27851	8.3	1.7	22.5	-2.8	6.2	14.3	14.5	2.3	973	14	286	200	15.9	41	15.7	22.5
14	38306	7.2	1.68	20.7	-3.1	3.4	13.1	13.2	1.3	1418	24	450	244	15	43	11.9	21.3
15	8573	4.9	1.65	17.4	-4.6	1.2	10.7	10.8	-0.8	2002	24	645	342	14	43	11.3	19.7

Bioclimatic domains: Group means.

Group No	# cells	ann temp	tempseas		maxt mnth		mint mnth		wetq temp		dryq temp		hotq temp		coldq temp		ann prec		prec
seas	prec wetq	prec dryq	ann rad	rad seas	rad wetq	rad dryq													
1	127651	11.84	1.73	26.25	-0.33	15.87	7.68	18.13	5.64	709.21	11.15	197.14	154.7	16.94	37.1	22.55	11.9		
2	52971	13.24	1.64	26.77	1.02	18.61	8.23	19.15	7.24	764	17.96	231.81	144.18	16.91	35.97	20.95	12.86		
3	56924	11.02	1.62	24.35	-0.56	16.28	6.46	16.84	5.19	912.73	16.04	270.95	185.92	16.3	36.63	20.19	12.34		
4	119349	10.21	1.67	24.62	-2.04	14.67	4.8	16.24	4.22	610.79	20.33	185.73	115.53	16.55	38.59	23.66	10.89		
5	32071	8.9	1.65	22.95	-2.53	11.05	4.26	14.87	3	806.36	12.88	233.8	174.42	16.06	39.37	20.55	9.88		
6	55638	11.47	1.77	26.33	-0.37	6.39	14.25	17.97	5.22	797.27	10.77	221.75	173.28	17	37.1	12.37	17.09		
7	52601	12.98	1.83	27.98	0.52	11.09	17.92	19.73	6.45	691.81	9.59	190.82	157.34	17.1	38	18.01	20.3		
8	105763	14.21	1.38	25.19	2.88	17.97	9.98	19.14	9.1	1037.43		23.91	325.1	174.91	15.9	37.51	17.3	12.38	
9	21726	15.48	1.27	25.49	5.08	13.77	11.67	20.06	10.69	1177.54		25.35	369.09	204.5	15.84	37.41	9.79	12.8	
10	17190	15.77	1.22	25.22	6.02	18.9	11.99	20.12	11.18	1419.6	26.02	460.61	241.89	15.52	36.21	16.04	12.4		
11	166224	13.21	1.88	29.17	0.82	7.01	20	20.23	6.57	829.1	19.49	256.46	159.03	16.48	41.19	9.69	22.88		
12	61386	10.68	1.8	25.65	-0.56	5.23	17.22	17.34	4.37	1163.02		23.41	376.56	208.4	15.71	41.77	10.15	22.27	
13	27851	8.3	1.7	22.43	-2.8	6.07	14.18	14.46	2.31	967.55	13.45	283.14	204.06	15.88	40.64	15.69	21.96		
14	38306	7.27	1.68	20.78	-3.04	3.25	13.24	13.34	1.34	1434.84		23.34	456.24	249.2	14.99	42.65	11.61	21.24	
15	8573	4.86	1.65	17.31	-4.64	1.21	10.65	10.75	-0.91	2042.08		24.06	652.08	346.58	13.97	43.03	11.65	19.68	

Table 2. Median and mean attribute values for the 14 group terrain classification for the Southern RFA region

Terrain group means

Group No	# Cells	Elevation (m)	Relief (m)	Slope (o)
1	303980	723	73	2.0
2	130454	712	171	5.1
3	104187	1163	129	3.8
4	142192	203	89	2.3
5	88705	361	247	8.8
6	24415	642	394	9.8
7	60601	914	275	8.9
8	17148	415	444	19.3
9	20813	646	396	15.5
10	6973	906	424	20.0
11	25807	1491	269	8.4
12	12965	1317	438	15.1
13	3876	757	613	25.6
14	2108	1451	606	23.4

Table 3. Area of highest quality natural vegetation cover remaining in each climatic and terrain classfication group and geological unit found within the indicative Monga-Buckenbowra area

Area in conservation reserves for combinations of climate, terrain and lithology occurring within the Monga indicative reserve

Bioclimatic group	Terrain group	Lithology symbol	Reserved area (km2)	Out of reserves area (km2)	Total area (km2)	Highest LU class (%)	Area in reserves (%)
3	1	OSs	4.25	319.31	323.56	8	1
3	2	DuCls	71.07	91.88	162.95	68	44
3	2	OSs	6.45	128.83	135.28	52	5
3	3	OSs	13.49	191.65	205.13	29	7
3	5	OSs	0.32	0.95	1.27	55	25
3	6	DuCls	41.61	11.12	52.73	89	79
3	6	OSs	22.45	26.97	49.42	85	45
3	7	DuCls	59.48	74.47	133.95	77	44
3	7	OSs	34.86	186.02	220.88	63	16
3	8	Dlg	2.87	5.78	8.65	69	33
3	8	DuCls	6.44	1.39	7.83	98	82
3	8	OSs	3.56	3.17	6.73	76	53
3	9	Dlg	19.37	26.38	45.75	77	42
3	9	DuCls	48.42	12.66	61.09	90	79
3	9	OSs	26.52	17.06	43.58	87	61
3	10	DuCls	27.33	8.01	35.35	86	77
3	10	OSs	20.52	13.51	34.02	91	60
3	12	OSs	4.32	3.70	8.02	94	54
3	13	DuCls	48.26	1.93	50.20	96	96
3	13	OSs	10.09	12.60	22.69	87	44
5	3	OSs	26.15	273.49	299.65	29	9
5	7	OSs	106.77	71.96	178.73	71	60
8	2	DuCls	8.58	2.97	11.55	93	74
8	4	Dlg	13.84	347.79	361.82	23	4
8	4	DuCls	45.71	179.28	224.99	47	20
8	4	OSs	39.96	1425.05	1466.03	26	3
8	5	Dlg	79.59	225.95	305.54	60	26
8	5	DuCls	128.52	196.24	324.76	73	40

Table 4 Bioclimatic profile for Eucryphia moorei

Parameter:
mean S.D. 2.5% 5 % 10 % 25 % 50 % 75 % 90 % 95 % 97.5% maximum minimum
(the time period for this profile is months)

1. Annual Mean Temperature
12.20 1.41 10.00 10.30 10.70 11.20 12.10 13.90 14.20 4.30 14.30 14.30 9.80

2. Mean Diurnal Range(Mean(period max-min))
10.00 1.92 7.20 7.30 7.50 8.40 11.00 11.50 11.70 13.70 13.70 13.70 7.10

3. Isothermality 2/7
0.49 0.02 0.46 0.46 0.46 0.47 0.49 0.50 0.51 0.52 0.52 0.52 0.46

4. Temperature Seasonality (C of V)
1.38 0.20 1.06 1.07 1.09 1.17 1.47 1.55 1.59 1.65 1.65 1.65 1.05

5. Max Temperature of Warmest Period
22.80 1.18 21.40 21.50 21.60 21.90 22.80 23.80 24.30 26.20 26.20 26.20 21.40

6. Min Temperature of Coldest Period
2.30 2.58 -0.40 -0.30 -0.20 0.10 1.20 5.10 6.50 6.50 6.50 6.50 -0.40

7. Temperature Annual Range (5-6)
20.60 3.31 15.50 15.70 16.10 17.60 22.10 23.10 24.20 26.40 26.40 26.40 15.30

8. Mean Temperature of Wettest Quarter
15.00 2.47 9.20 9.70 11.60 13.20 16.10 17.00 18.30 18.30 18.30 18.30 8.70

9. Mean Temperature of Driest Quarter
9.10 4.10 5.40 5.80 6.40 6.90 7.70 10.30 17.60 18.00 18.00 18.00 5.10

10. Mean Temperature of Warmest Quarter
17.00 0.99 15.40 15.50 15.70 16.20 16.90 18.00 18.70 18.70 18.70 18.70 15.20

11. Mean Temperature of Coldest Quarter
7.30 1.99 4.40 4.60 4.90 5.90 6.80 9.60 10.60 10.60 10.60 10.60 4.30

12. Annual Precipitation
1166.00 302.21 795.00 858.00 984.00 1022.00 1085.00 1204.00 1927.00 1989.00 1989.00 1989.00 733.00

13. Precipitation of Wettest Period
125.00 42.57 87.00 96.00 98.00 105.00 116.00 127.00 245.00 245.00 245.00 245.00 79.00

14. Precipitation of Driest Period
69.00 14.70 38.00 41.00 55.00 58.00 73.00 80.00 93.00 96.00 96.00 96.00 35.00

15. Precipitation Seasonality(C of V)
18.00 6.40 11.00 11.00 11.00 12.00 21.00 23.00 29.00 29.00 29.00 29.00 10.00

16. Precipitation of Wettest Quarter
353.00 106.86 254.00 274.00 281.00 302.00 331.00 357.00 648.00 648.00 648.00 648.00 233.00

17. Precipitation of Driest Quarter
221.00 47.61 123.00 134.00 179.00 189.00 227.00 248.00 310.00 320.00 320.00 320.00 113.00

18. Precipitation of Warmest Quarter
310.00 88.29 221.00 224.00 230.00 249.00 303.00 338.00 539.00 539.00 539.00 539.00 217.00

19. Precipitation of Coldest Quarter
264.00 71.90 152.00 168.00 206.00 225.00 252.00 287.00 437.00 453.00 453.00 453.00 136.00

20. Annual Mean Radiation
16.10 0.23 15.80 15.80 15.80 15.80 16.20 16.30 16.40 16.40 16.40 16.40 15.80

21. Highest Period Radiation
23.90 0.30 23.20 23.20 23.30 23.70 23.90 24.00 24.30 24.50 24.50 24.50 23.20

22. Lowest Period Radiation
7.30 0.41 6.90 6.90 6.90 7.00 7.40 7.60 8.10 8.10 8.10 8.10 6.90

23. Radiation Seasonality (Cof V)
38.00 2.17 33.00 33.00 33.00 36.00 37.00 40.00 40.00 40.00 40.00 40.00 33.00

24. Radiation of Wettest Quarter
16.90 5.21 9.70 9.80 10.00 10.60 20.50 21.00 21.30 21.40 21.40 21.40 9.60

25. Radiation of Driest Quarter
13.30 3.30 11.30 11.40 11.40 11.60 12.00 12.80 20.30 20.60 20.60 20.60 11.30
26. Radiation of Warmest Quarter
22.20 1.05 20.60 20.70 20.70 20.90 22.90 23.10 23.20 23.50 23.50 23.50 20.60
27. Radiation of Coldest Quarter
9.10 0.50 8.50 8.60 8.60 8.70 9.00 9.50 10.00 10.10 10.10 10.10 8.50
28. Annual Mean Moisture Index
0.82 0.09 0.61 0.63 0.74 0.78 0.82 0.88 0.96 0.98 0.98 0.98 0.59
29. Highest Period Moisture Index
0.99 0.03 0.89 0.90 0.99 0.99 0.99 1.00 1.00 1.00 1.00 1.00 0.88
30. Lowest Period Moisture Index
0.51 0.14 0.36 0.37 0.40 0.44 0.49 0.56 0.83 0.88 0.88 0.88 0.34
31. Moisture Index Seasonality (C of V)
23.00 8.19 5.00 5.00 7.00 20.00 25.00 31.00 34.00 34.00 34.00 34.00 4.00
32. Mean Moisture Index of High Qtr. MI
0.99 0.03 0.85 0.86 0.99 0.99 0.99 1.00 1.00 1.00 1.00 1.00 0.85
33. Mean Moisture Index of Low Qtr. MI
0.56 0.14 0.39 0.40 0.43 0.48 0.54 0.65 0.90 0.92 0.92 0.92 0.37
34. Mean Moisture Index of Warm Qtr. MI
0.56 0.15 0.39 0.40 0.43 0.48 0.54 0.65 0.90 0.92 0.92 0.92 0.37
35. Mean Moisture Index of Cold Qtr. MI
0.99 0.03 0.85 0.86 0.99 0.99 0.99 1.00 1.00 1.00 1.00 1.00 0.85

Table 5 Bioclimatic profile for Telopea mongaensis

Parameter:
mean S.D. 2.5% 5 % 10 % 25 % 50 % 75 % 90 % 95 % 97.5% maximum minimum
(the time period for this profile is months)

1. Annual Mean Temperature
12.70 1.28 11.30 11.30 11.40 11.70 12.30 13.90 15.20 15.20 15.20 15.20 11.20

2. Mean Diurnal Range(Mean(period max-min))
11.60 0.49 11.00 11.00 11.10 11.30 11.50 11.80 12.90 13.00 13.00 13.00 10.90

3. Isothermality 2/7
0.49 0.01 0.48 0.49 0.49 0.49 0.49 0.50 0.51 0.51 0.51 0.51 0.48

4. Temperature Seasonality (C of V)
1.55 0.08 1.44 1.45 1.45 1.50 1.56 1.58 1.74 1.74 1.74 1.74 1.44

5. Max Temperature of Warmest Period
24.80 0.99 22.80 23.00 23.80 24.10 25.30 25.60 26.10 26.10 26.10 26.10 22.70

6. Min Temperature of Coldest Period
1.40 1.28 -0.50 -0.30 0.00 0.40 1.10 2.70 3.30 3.30 3.30 3.30 -0.60

7. Temperature Annual Range (5-6)
23.40 1.05 22.10 22.20 22.30 22.90 23.30 23.90 26.30 26.30 26.30 26.30 22.00

8. Mean Temperature of Wettest Quarter
16.00 2.55 11.20 11.30 11.50 16.10 16.90 17.80 18.40 18.60 18.60 18.60 11.00

9. Mean Temperature of Driest Quarter
8.00 1.39 6.50 6.60 6.70 6.90 7.60 9.40 10.70 10.70 10.70 10.70 6.50

10. Mean Temperature of Warmest Quarter
18.10 1.14 16.50 16.60 16.80 17.10 18.10 19.10 20.10 20.10 20.10 20.10 16.30

11. Mean Temperature of Coldest Quarter
7.20 1.42 5.60 5.70 5.70 6.00 6.70 8.50 9.90 9.90 9.90 9.90 5.60

12. Annual Precipitation
1038.00 140.40 726.00 736.00 757.00 1012.00 1065.00 1167.00 1204.00 1204.00 1204.00 1204.00 716.00

13. Precipitation of Wettest Period
111.00 19.70 73.00 75.00 78.00 107.00 111.00 131.00 137.00 139.00 139.00 139.00 72.00

14. Precipitation of Driest Period
59.00 7.53 46.00 47.00 50.00 54.00 60.00 67.00 72.00 72.00 72.00 72.00 45.00

15. Precipitation Seasonality(C of V)
19.00 3.67 15.00 15.00 15.00 15.00 21.00 22.00 24.00 24.00 24.00 24.00 15.00

16. Precipitation of Wettest Quarter
309.00 44.98 211.00 214.00 220.00 305.00 321.00 349.00 359.00 361.00 361.00 361.00 207.00

17. Precipitation of Driest Quarter
198.00 28.55 144.00 148.00 155.00 180.00 215.00 221.00 224.00 225.00 225.00 225.00 141.00

18. Precipitation of Warmest Quarter
280.00 37.51 198.00 204.00 215.00 277.00 291.00 305.00 319.00 324.00 324.00 324.00 193.00

19. Precipitation of Coldest Quarter
233.00 40.45 157.00 160.00 166.00 212.00 238.00 279.00 288.00 290.00 290.00 290.00 154.00

20. Annual Mean Radiation
16.30 0.05 16.20 16.20 16.30 16.30 16.30 16.30 16.50 16.50 16.50 16.50 16.20

21. Highest Period Radiation
23.70 0.23 23.40 23.40 23.40 23.70 23.80 23.80 24.30 24.30 24.30 24.30 23.40

22. Lowest Period Radiation
7.80 0.24 7.40 7.50 7.60 7.60 7.70 8.10 8.10 8.10 8.10 8.10 7.40

23. Radiation Seasonality (Cof V)
35.00 1.55 33.00 33.00 33.00 35.00 36.00 36.00 37.00 37.00 37.00 37.00 33.00

24. Radiation of Wettest Quarter
18.00 3.86 10.90 11.10 11.40 17.40 20.20 20.80 21.10 21.20 21.20 21.20 10.80

25. Radiation of Driest Quarter
12.30 0.33 11.90 11.90 12.00 12.10 12.20 12.80 12.80 12.80 12.80 12.80 11.90
26. Radiation of Warmest Quarter
22.60 0.37 22.10 22.10 22.10 22.60 22.70 22.80 23.20 23.30 23.30 23.30 22.10
27. Radiation of Coldest Quarter
9.60 0.32 9.20 9.20 9.20 9.30 9.40 10.10 10.10 10.10 10.10 10.10 9.10
28. Annual Mean Moisture Index
0.75 0.08 0.57 0.58 0.63 0.73 0.79 0.80 0.82 0.84 0.84 0.84 0.56
29. Highest Period Moisture Index
0.98 0.04 0.88 0.88 0.92 0.99 0.99 1.00 1.00 1.00 1.00 1.00 0.87
30. Lowest Period Moisture Index
0.41 0.07 0.28 0.29 0.31 0.38 0.43 0.46 0.53 0.53 0.53 0.53 0.27
31. Moisture Index Seasonality (C of V)
29.00 4.76 22.00 22.00 25.00 25.00 28.00 33.00 38.00 38.00 38.00 38.00 21.00
32. Mean Moisture Index of High Qtr. MI
0.97 0.05 0.85 0.85 0.90 0.98 1.00 1.00 1.00 1.00 1.00 1.00 0.84
33. Mean Moisture Index of Low Qtr. MI
0.46 0.07 0.32 0.33 0.36 0.43 0.50 0.52 0.58 0.58 0.58 0.58 0.31
34. Mean Moisture Index of Warm Qtr. MI
0.47 0.07 0.32 0.33 0.36 0.45 0.50 0.52 0.58 0.58 0.58 0.58 0.31
35. Mean Moisture Index of Cold Qtr. MI
0.97 0.04 0.85 0.85 0.90 0.97 0.99 1.00 1.00 1.00 1.00 1.00 0.84

Table 6. Bedrock geology of Australia (1:2 500 000)

Geology of Australia (1:2,500,000 scale): Bedrock Geology codes in RFA Southern region

Map code	Description	Age
Cg	Granitic rocks	Carboniferous
Cuv?	Acid volcanics	Carboniferous
De	Ultramafic intrusive rocks	Devonian
Dlg	Granitic rocks	Devonian
Dls	Siltstone, shale, sandstone	Devonian
Dlv	Acid and intermediate volcanics	Devonian
DuCls	Sandstone, siltstone, shale, chert, limestone, phyllite, schist	Devonian - Carboniferous
EOm	Schist, quartzite, phyllite, gneiss, metabasalt	Cambrian - Ordovician
Kv	Acid and intermediate volcanics and intrusives	Cretaceous
N	Not described	Undefined
OSs	Slate, siltstone, chert, phyllite, sandstone, conglomerate	Ordovician - Silurian
Ob	Intermediate and basic volcanics	Ordovician
Os	Sandstone, quartzite, slate, conglomerate, limestone	Ordovician
Sg	Granitic rocks	Silurian
Sm	Gneiss, schist, phyllite	Silurian
Ss	Siltstone, shale, sandstone, limestone	Silurian
Sv	Acid volcanics	Silurian
TRs	Sandstone, siltstone, mudstone	Triassic
Tb	Basalt, minor acid volcanics	Tertiary
Tb/OSs?	Basalt, minor acid volcanics OVERLYING Slate, siltstone, chert, phyllite, sandstone, conglomerate	Ordovician - Silurian; overlain by Tertiary
Undefined ps	Sandstone, siltstone, mudstone, tillite, limestone	Permian