POPULATION MANAGEMENT PLAN

BAGO PLATEAU
YELLOW-BELLIED GLIDER
(*Petaurus australis*)

Forestry Corporation of NSW

2013

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INTRODUCTION

In November 2008, the NSW Scientific Committee listed the Yellow-bellied Glider population on the Bago Plateau as an Endangered Population in Part 2 of Schedule 1 of the *Threatened Species Conservation Act 1995* (DECC 2008). A preliminary determination to delist the population was made in March 2012. A proposed final determination was made in April 2013 overturning the preliminary determination to delist the population. A proposed preliminary determination was concurrently drafted in April 2013 to list the population as endangered with different criteria to the original listing in 2008. The reasons given by the NSW Scientific Committee why the population is currently perceived to be facing a very high risk of extinction include:

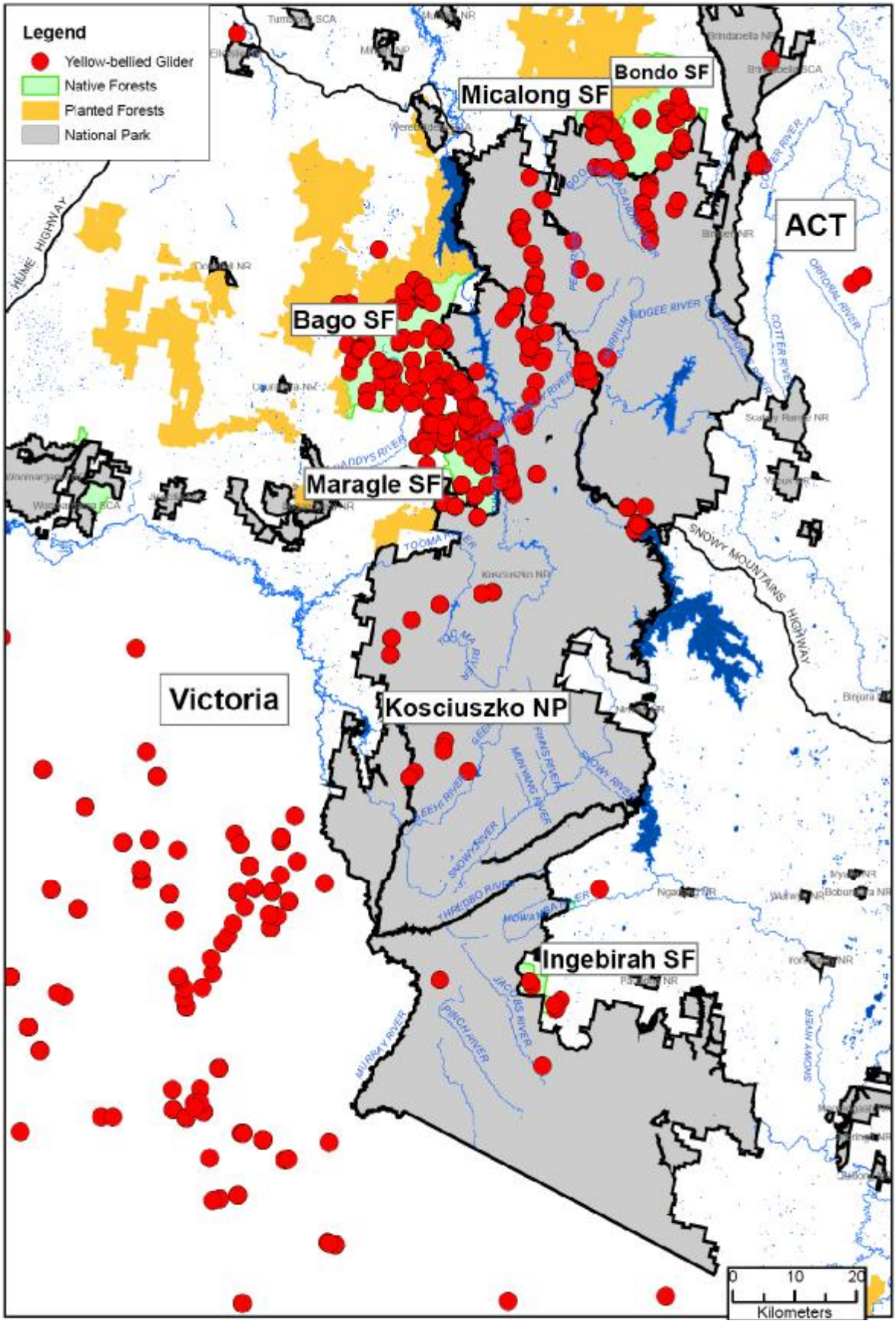
1. Powerline easements crossing the Bago Plateau may reduce glider movement sufficiently to represent a boundary to the population;
2. The population is of significant conservation value on the basis of unspecified effects of climate change; and
3. That despite data suggesting selective logging operations not having an impact on the population, it appears to be in decline.

The management of threatened species and their habitats within production native forests of the Tumbarumba area are regulated under the Threatened Species Licence (TSL) within the Integrated Forestry Operations Approval (IFOA) for the Tumut Region (2001). The IFOA is implemented by Forests NSW as an outcome of the Regional Forest Agreement endorsed by both state and federal governments. The change in status of the Yellow-bellied Glider on the Bago Plateau as an endangered population requires informed understanding of its ecology and threats posed by forestry activities, together with an assessment of the adequacy of historic and modified harvesting prescriptions to ensure its persistence.

The aim of this Population Management Plan is to address these issues and to provide a framework for the management of Yellow-bellied Glider within Bago and Maragle State Forests. An adaptive management approach is proposed involving monitoring and appropriately responding in order to mitigate potential threats to the population. These may include impacts from habitat alteration caused by timber harvesting operations, wildfire and inappropriate burning prescriptions and regimes. The plan will facilitate the development of modified management prescriptions and monitoring of Yellow-bellied Gliders within areas of varying habitat quality prior to and following prescribed disturbance events on the Bago Plateau. The plan also aims to guide future management and research on the population across its entire range.

The apparent absence of Yellow-bellied Glider throughout vast areas of suitable habitat within Kosciusko National Park was recently demonstrated to be an element of survey effort. Consequently, the status of Yellow-bellied Glider on the Bago Plateau is under review, with current knowledge suggesting they may be part of a larger population across the NSW southern highlands (Kambouris *et al* in press).

Figure 1. Yellow-bellied Glider on the Bago Plateau and surrounding southern highlands



PLANNING AREA

The Bago Plateau occurs in the south-western slopes region of the New South Wales Snowy Mountains. It is immediately north of the Victorian border and encompasses Bago State Forest (31,681ha), Maragle State Forest (12,332 ha) and part of Kosciuszko National Park (Figure 1). The area is surrounded by over 1.5 million hectares of contiguous reserved public land across three states that forms the Australian Alps National Parks and is also contiguous with Micalong, Bondo, Ingebyra and Mowamba State Forests. The Bago Plateau contains a high proportion of the known distribution of the Yellow-bellied Glider on the western slopes of NSW (Figure 1). These records primarily derive from targeted monitoring and pre-harvest surveys conducted by FCNSW (Kavanagh & Stanton 1998; FCNSW, unpublished data; NSW Wildlife Atlas 2010).

The region experiences relatively mild summers whilst winters are cool with frequent frosts and occasional snowfalls. Mean temperatures for Tumbarumba approximately 20 km west of the Bago Plateau range from a minimum of -0.2°C and maximum of 10.6°C in July, through to 11.9°C and 28.7°C in January. Annual rainfall is highly variable with the long term average being 974 mm per annum. February is the driest month averaging 52.6mm and August the wettest with 106.5mm (Bureau of Meteorology). Elevation ranges from approximately 450 m along the Tumut River valley which intersects the foothills of the north-eastern extent of Bago State Forest and forms part of the Murrumbidgee River catchment, to over 1300 m with most of the Bago Plateau in excess of 1000 m. The tributaries on the southern fall of the Bago Plateau including part of Maragle State Forest flow into the upper reaches of the Murray River.

The geology of the Bago Plateau is broadly dominated by granite and granodiorite overlain by tertiary volcanics and metamorphic sediments, with basaltic cappings along higher ridges (FCNSW 1986; Ryan *et al* 2000). Granite derived soils form deep clay loams at altitudes between 950 and 1300m and is more favourable for tree growth (Ryan *et* al 1997; FCNSW 1986) with adjacent Crown lands on more gentle slopes having been converted to pine plantations (FCNSW 1986; Kavanagh & Stanton 1998). Several montane forest communities occur throughout the Bago Plateau and are generally associated with moist gullies and the more fertile soils at higher elevations. Drier foothills also occur to the north-east and south west of the Bago Plateau.

Commercial timber mills were first established on the Bago Plateau from the 1870's, with smaller operations cutting timber for local gold mines a decade earlier (Hatich 1997). ***E. delegatensis*** occurs on sheltered sites at higher elevations and is of particular interest as a commercial timber resource which has been selectively harvested from the early 1900's (Lindsay 1939; FCNSW 1986). Areas of high elevation mixed species forests have also been harvested historically, but to a lesser extent. These are largely dominated by montane gum species including ***E. dalrympleana, E. viminalis, E. pauciflora*** and their association with ***E. robertsonii*** or ***E. delegatensis***. Data predating the signing of the Regional Forest Agreement (RFA) in 2001 suggests there has been no overall increase in area or intensity of harvesting on the Bago Plateau over the last decade (FCNSW unpublished data). No harvesting has occurred in recent years as a result of the change in status to Yellow-bellied Glider on the plateau. Wood supply agreements between the State of NSW and timber mills require timber to be sourced from Bago and Maragle State Forests for supply commitments to be met.

Significant fire events in 1917 and 1926 collectively burnt most of the Bago plateau. Older stands of trees are now uncommon across Bago and Maragle State Forests. Those remaining were mostly added to Kosciuszko National Park from 1944, and more recently including the

proclamation of Clarkes Hill Nature Reserve. Consequently, forest types containing *E. delegatensis* which take significantly longer to form tree hollows than most other eucalypt species contain few hollows available for shelter of arboreal mammals on the Bago Plateau (Lindsay 1939; Hatich 1997; Kavanagh & Stanton 1998; NSWRFA 2000; Kambouris *et al* in press).

DISTRIBUTION

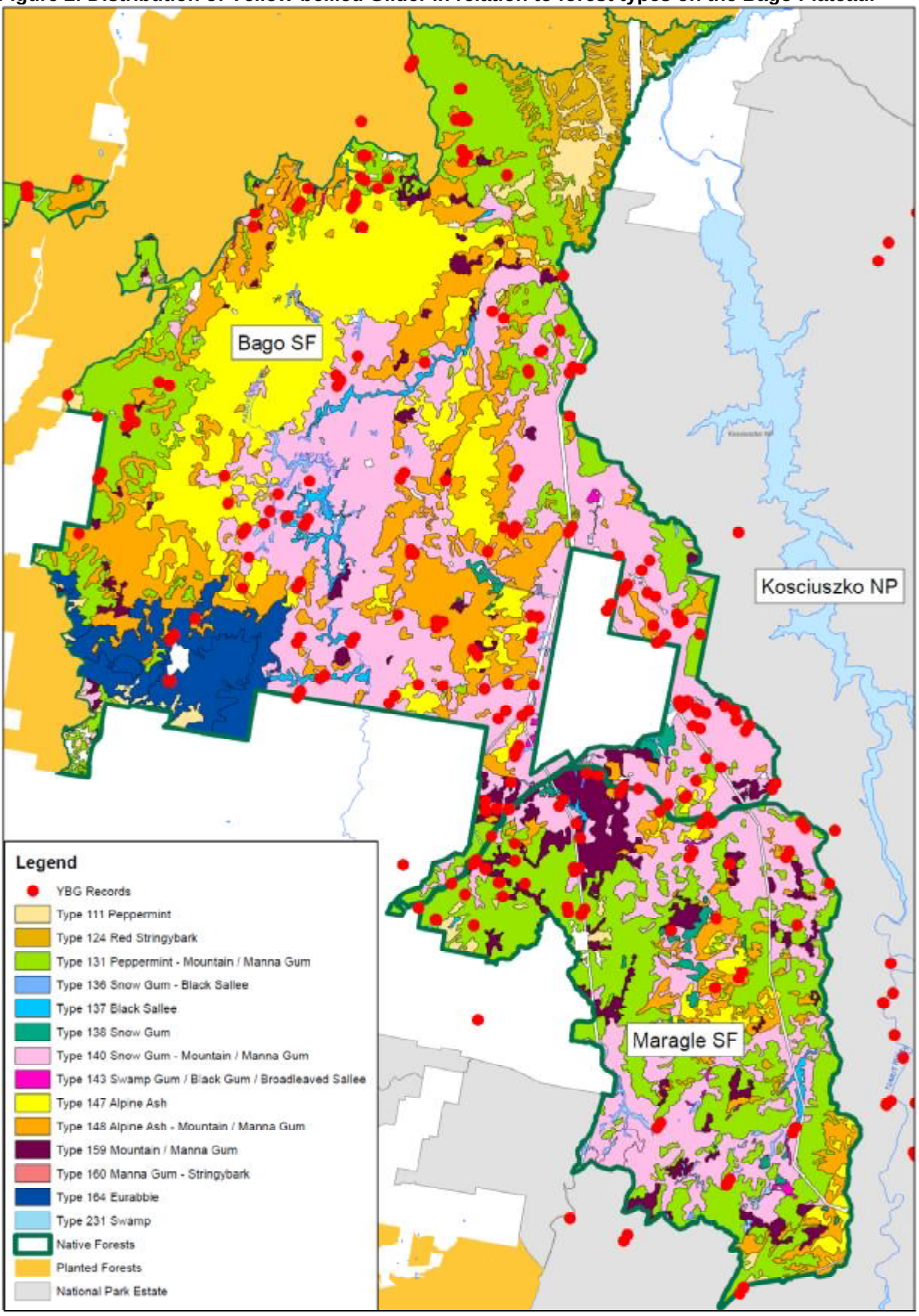
Like many petaurids, Yellow-bellied Gliders maintain strong preferences for particular forest types and have an extensive, yet selective distribution throughout eastern Australia (Henry & Craig 1984; Kavanagh 1984; Kavanagh 1987a; Braithwaite *et* al 1988; Bennett *et al* 1991; Goldingay & Kavanagh 1991; Kavanagh & Stanton 1998). Their range extends mostly along the Great Dividing Range and coastal forests from the Mt Windsor Tablelands north-west of Cairns to south-eastern South Australia, with disjunct populations occurring at either extent (Henry 1998; Quin *et al* 1996; Goldingay *et al* 2001).

Yellow-bellied Gliders occur on and surrounding the Bago Plateau within Bago and Maragle State Forests and Kosciuszko National Park. Their distribution includes Micalong and Bondo State Forests, and Namadgi and Brindabella National Parks to the north; Ingebirah State Forest, Snowy River and Errinundra National Park to the south-east; and the Alpine National Park to the south. The species occurs within areas of contiguous modelled habitat that ranges in elevation from 1300m on the Bago Plateau, to 560m along the Tumut River valley and up to 1420m ASL along the ranges within Kosciuszko NP (Kambouris *et al* in press). For the purposes of this plan, the distribution of the population is assumed to be restricted to areas on the Bago Plateau above 900m ASL (DECC 2008).

A baseline study by Kavanagh & Stanton (1998) on the Bago Plateau showed that Yellow-bellied Gliders typically prefer particular forest types containing a predominance of smooth barked eucalypts. Forest types (RN17) (FCNSW 1989) associated with all Yellow-bellied Glider records on the Bago Plateau are illustrated in Figure 2 and include FT140 *E. dalrympleana/E. viminalis/E. pauciflora ssp. pauciflora & ssp. niphophila,* FT148 *E. dalrympleana/E. viminalis/E. delegatensis,* FT159 *E. dalrympleana/E. viminalis,* FT 138 *E. pauciflora ssp. pauciflora & ssp. niphophila,* FT 131 *E. dalrympleana/E. viminalis/E. robertsonii,* FT 143 *E. camphora,* FT 137 *E. stellulata* and FT 164 *E. bicostata* with some association with FT 124 *E. macrorhyncha* and FT 111 *E. robertsonii / E. dives*. Other forest types also occur on the plateau including FT 147 *E. delegatensis,* however, Yellow-bellied Glider has not been detected within it despite considerable survey effort.

The absence of Yellow-bellied Glider in monospecific stands of *E. delegatensis* on the Bago Plateau has been observed in other high elevation forests in southern Australia (Bennett *et al* 1991; Lindenmayer 1992; Lindenmayer *et* al 1994). This may be due to an absence or inadequate abundance of key habitat requirements for the species including a diverse array of food resources to cater for all seasonal needs and a lack of suitable tree hollows observed in stands of *E. delegatensis* on the Bago Plateau (Lindsay 1939; Kavanagh & Stanton 1998; Kambouris *et al* in press).

Figure 2: Distribution of Yellow-bellied Glider in relation to forest types on the Bago Plateau.



SPECIES ECOLOGY

Reproduction

The reproductive biology of Yellow-bellied Glider is poorly understood, however births have been detected throughout the year with breeding thought to be stimulated by the availability of exudates (Henry 1998). Seasonal trends in births are apparent at different extents across its range with most records in Victoria occurring from August to December February to April at Kioloa on the central NSW South Coast; and June to August at Nitchaga Creek in north Queensland (Craig 1985; Goldingay *et al* 2001). Lactation and weaning has also been observed to coincide with periods of high arthropod availability (Goldingay & Kavanagh 1991).

Most gliders are polyoestrous, however Yellow-bellied Glider usually produce a single pouch young, with two rarely observed (Henry 1998; Goldingay *et al* 2001). Offspring stay in their mothers pouch for approximately 100 days, with an additional 50 days nestling to eventually disperse from their parents group at 18 to 24 months after being raised by both parents (Craig & Henry 1984; Craig 1985; Henry 1998).

Yellow-bellied Gliders have a life expectancy of at least 6 years (Henry & Craig 1984; Goldingay & Kavanagh 1991). The species demonstrates sexual dimorphism with the male adult heavier, tail length shorter and head wider than adult females, with variations also present between northern and southern populations (Quinn *et* al 1996; Goldingay *et al* 2001). Belly fur also appears to change colour transitionally with age from white or cream ventral fur in sub-adults to yellow in adults (Goldingay *et al* 2001).

Social Behaviour

Yellow-bellied Glider social behaviour is complex and inconsistent across its range; however typically occupy an exclusive home range as a family group which share resources within it (Goldingay & Kavanagh 1993). The species appears to forage on the same tree with other members of its family group, and is usually otherwise solitary whilst active (Henry & Craig 1984).

Family groups across the south of the species range usually consist of 3-4 individuals comprising a monogamous adult pair with sub-adult offspring and generally occur at low densities in preferred habitat (0.03 - 0.14 animals per ha) (Kavanagh 1984; Henry & Craig 1984; Craig 1985; Goldingay & Kavanagh 1993). This is in contrast to populations studied from Kioloa through to northern Queensland which occur at higher densities and family groups consist of up to 6 individuals, including a polygamous adult male with usually more than one breeding female and offspring (Mackowski 1986; Goldingay & Kavanagh 1993; Eyre & Smith 1997). These larger family group sizes have been observed to revert back to smaller monogamous groups in years of low food abundance, suggesting that food availability is a key determinant of habitat quality, utilisation and population density (Goldingay & Kavanagh 1993; Goldingay *et al* 2001).

Family groups undertake most of their activities in close association to each other including foraging and travelling whilst maintaining contact through a complex assortment of vocalisations (Goldingay & Kavanagh 1993; Henry 1995). Gliders are typically very vocal early in the evening as they leave their den and roam throughout their home range, quietening considerably once they settle to feed when they may remain silent for long periods (Craig 1995). Lindenmayer *et al* (1991b) suggest that the time of emergence from hollows after dusk is strongly correlated to the species body weight, field and standard metabolic rate. Yellow-bellied Glider has a higher proportional field metabolic rate and lower standard metabolic

rate than other large arboreal mammals. It consequently emerges from its den earlier in the evening and requires a higher energy diet of exudates and insects than other species with lower field metabolic rates.

Diet

Diet and foraging behaviour for Yellow-bellied Glider is best described as diverse and responsive to seasonal changes in tree phenology and habitat use (Kavanagh 1984). The species is regarded as a dietary opportunist and feeds on a variety of invertebrates, eucalypt sap, nectar, pollen, manna and insect exudates (Craig 1995; Kavanagh 1987b). The importance of each varies at different localities and is dependent on the seasonal availability of that and other food resources within a home range.The most abundant forest types within its home range may account for some of the seasonal dietary and habitat requirements, but not all (Kavanagh 1984). The species therefore requires an extensive home range to ensure its availability throughout the year (Henry & Craig 1984; Goldingay & Kavanagh 1993).

Foraging activities include licking flowers, incising bark and licking sap or manna, and searching under loose bark (Kavanagh 1987b). Shredding fibrous bark, biting and licking bark and foliage also occur but are less prevalent. Sap is obtained from insect and other eucalypt exudates such as nectar, manna, honeydew and saps. The species also incises through eucalypt bark to tap cambium and phloem tissue, leaving a distinctive “V” shaped or triangular incision as definitive evidence of its presence that last several years (Mackowski 1986; Kavanagh 1987a). Licking eucalypt exudates is not only important as a dietary component for Yellow-bellied Gliders, but also for social behaviour of family groups with members sharing the same few feed trees within a home range (Kavanagh 1987a).

Yellow-bellied Gliders are known to select foraging trees primarily based on species type and use trees of all sizes (Kavanagh1987a, b). This is evident on the Bago Plateau and Kosciuszko NP where 95.3% (82 of 86) incised feed trees detected were *E. dalrympleana* and *E. viminalis* and within montane gum forest types (Kambouris *et al* in press). Although other species including peppermints and ash are occasionally used in montane and coastal habitats, the importance of smooth barked eucalypts as a significant habitat attribute is clear. Feed trees varied significantly, with no clear preferences in girth, height and form concluded (Kambouris *et al* in press). Larger trees accounted for 20.7% of feed tree observations and did not appear to be consistently favoured as has been suggested in other high elevation forests of south-eastern Australia (see Lindenmayer *et al* 1991a; Milledge *et al* 1991; Lindenmayer *et al* 1994; Incoll *et al* 2001; Alexander *et al* 2002; DECC 2008). Height also varied markedly with species, forest type, aspect and topographic position in the landscape. This may reflect that Yellow-bellied Glider persistence and abundance is dependent on forest type and the composition of forest type mosaics rather than the age or size of trees within it (Kambouris *et al* in press).

Home Range

Yellow-bellied Glider is a communal species and typically occupies a home range as a family group. Its size is dependent on the availability of particular food types within a mosaic of forest types which provide a reliable variety of forage during all seasons (Henry & Craig 1984; Kavanagh 1984; Craig 1985; Kavanagh 1987a,b). A consequence of this is the species requirement for large home range of approximately 60 ha in south-eastern Australia and half of this to the north of its range (Henry & Craig 1984; Craig 1985; Goldingay & Kavanagh 1993; Goldingay *et al* 2001). These are effectively traversed with glides of up to 120m, with the species able to cover distances of over 2 kilometres in an evening (Fleay 1947; Henry & Craig 1984).

The proportion of floristic species present within a home range is often dependant on proximity to the coast, elevation and topographic position in the landscape with gums, peppermints and some rough barked species consistently represented (see Braithwaite 1983; Henry & Craig 1984; Kavanagh 1984; Goldingay & Kavanagh 1993; Henry 1998; Alexander *et al* 2002). Habitat induced differences in the social behaviour of Yellow-bellied gliders appear to be due to food resources present, therefore differences in home range sizes between southern and northern populations can be attributed to variations in habitat alone.

Home ranges are exclusive and rarely overlap between neighbouring family groups (Goldingay & Kavanagh 1993). Boundaries are established and maintained by scent marking and vocalisations, with olfaction playing an important role in group cohesion and recognition (Henry & Craig 1984; Craig 1985). Adult males possess scent producing glands on their head, sternum and base of the tail which are used to mark their territory and members of their family group within it (Henry & Craig 1984).

The species is one of the most vocal of all arboreal mammals, using a complex arrangement of vocalisations which make it conveniently conspicuous for monitoring (and probably to its predators). Vocalisations appear to allow regular contact within a family group, and less frequently with a member of an adjacent group (Craig 1985). 6 basic calls have been described as part of a regular repertoire and are often associated with various activities including gliding, climbing or feeding (Craig 1985).

Habitat Preferences

Yellow-bellied Glider is exclusively nocturnal and strictly arboreal, sheltering in tree hollows individually or with members of its family group during the day. The species demonstrates particular preferences for certain habitat attributes including feed tree species, regardless of what others may be abundant within its home range (Kavanagh 1984). Den trees with hollows typically higher from the ground than those used by other non-volant species also appear to be preferred (Lindenmayer *et al* 1991a,b).

Yellow-bellied Glider presence on the Bago Plateau is strongly correlated to forest type, with montane gum dominated and associated forest types accounting for all known records (Kavanagh & Stanton 1998; Kambouris *et al* in press). Yellow-bellied Gliders on the Bago Plateau prefer montane gum dominated forest types containing *E. dalrympleana, E. viminalis, E. pauciflora* and *E. stellulata* (FTs 140, 137 and 143); use mixed montane gum forest types with *E. robertsonii* or *E. delegatensis* proportionally to their availability in the landscape (FTs 131, 159, 164, 111 and 124); and avoid monospecific stands of *E. delegatensis* across the Bago Plateau and surrounding southern highlands (Kambouris *et al* in press).

The absence of Yellow-bellied Glider within pure stands of *E. delegatensis* was initially thought to be a consequence of the disturbance history on the Bago Plateau, particularly from the extensive wildfire and intensive logging history leading to an absence of mature hollow-bearing trees. However, Yellow-bellied Glider were consistently absent throughout mature patches of *E. delegatensis* within Maragle State Forest and more extensive stands within Kosciuszko NP (Kambouris *et* al in press). Similar observations of the species absence in monospecific stands occur elsewhere in high elevation forests throughout southern Australia (see Braithwaite *et al* 1988; Bennett *et al* 1991; Lindenmayer 1992; Lindenmayer *et* al 1994). This suggests monospecific stands of *E. delegatensis* may not adequately cater for the Yellow-bellied Gliders habitat requirements alone, and its association with other species, particularly montane gums across the NSW snowy mountains, may provide the key habitat attributes to adequately cater for its needs (Kambouris *et al* in press).

Tree species with extensive areas of smooth bark and subject to annual decoration from bark shedding are a critical habitat component for Yellow-bellied Glider and appear to account for most of the species foraging activity within an area, regardless of their availability (Kavanagh 1984; Craig 1985; Kavanagh 1987a). A mosaic of forest types with similar attributes of shedding bark at different times of the year would provide a significant proportion of the species food resource requirements within preferred habitats (Kavanagh 1987b; Braithwaite *et al* 1988). Kambouris *et al* (in press) suggest that this occurrence within montane gum dominated forest types on the Bago Plateau has led to their preference by Yellow-bellied Glider over other forest types which may be more widespread or abundant.

Montane gum forest types preferentially used by Yellow-bellied Gliders on the Bago Plateau are considered to provide high value habitat for the species (Table 1), whilst forest types occupied in proportion to their availability are considered to provide moderate value habitat (Kambouris *et al* in press). Forest types containing *E. viminalis* were also subjectively promoted to a higher habitat category as the species is recognised as an important food resource for Yellow-bellied Glider (Kavanagh 1987 a,b). Remaining forest types not occupied by the glider on the Bago Plateau are not considered to contribute to the persistence of the population. For the purposes of this Plan, modelled habitat for Yellow-bellied Glider on the Bago Plateau (Table 1) is stratified on the basis of observed occupancy (Kambouris *et al* (in press)) and based on RN17 Forest Type data provided to EPA as an accompaniment to the Plan in August 2013.

Table 1. Stratification of Yellow-bellied Glider habitat

Habitat Strata	**Forest Type (** RN17)	**Tree Associations**
High	140, 159, 143, 138, 137	*E. dalrympleana, E. viminalis, E. camphora, E. pauciflora ssp. pauciflora & ssp. niphophila, E. stellulata*
Moderate	131, 160, 148, 155, 164, 111, 124	*E. dalrympleana, E. viminalis, E. robertsonii, E. radiata, E. fastigata, E. bicostata, E. delegatensis, E. rubida, E. macrorhyncha*

Habitat Availability

An occupancy-based model of Yellow-bellied Glider habitat on the Bago Plateau indicates that there is 35,886 ha of suitable habitat available including 15,648 ha high quality and 20,238 ha moderate quality habitat (Figure 3) (Kambouris *et al* in press). This area is significantly less than that modelled previously for the Comprehensive Regional Assessment which included monospecific stands of *E. delegatensis* and areas of former State Forest that now form part of the adjacent formal reserve system. Extrapolation of the habitat model has estimated the availability of more than 440,000 ha of contiguous habitat within Bago and Maragle State Forests and the surrounding Snowy Mountains of NSW, including 387,548 ha within the adjacent Kosciuszko NP.

If home range is consistent throughout the southern extent of the species range, it may be as large as approximately 65 ha on the Bago Plateau. Consequently, the 35,886 ha of modelled habitat available on the Bago Plateau may provide for several hundred family groups and a few thousand individuals. As it is highly unlikely that all areas of available habitat are occupied, expected occupancy of approximately 40% within available habitat on the Bago Plateau may better reflect actual inhabitancy and may be higher in less disturbed or more diverse habitats than the Bago Plateau (Kambouris *et al* in press). It is likely that the continuous available habitat within the NSW southern highlands may contain approximately 3,000 family groups.

Habitat & Population Management

The availability of tree hollows is a critical habitat requirement for the Yellow-bellied Glider which is strictly arboreal. Members of family groups require multiple trees with large hollows across their home range within which to den (Henry & Craig 1984; Lindenmayer 1991b). Habitat preferences for montane gum dominated and associated forest types on the Bago Plateau also appears to be strongly correlated to the availability of large tree hollows. 94% of large hollows observed on the Bago Plateau were within montane gum forest types, with 79% of hollows occurring in montane gum species (Kambouris *et al* in press). 61% of large hollows were observed in *E. dalrympleana*. This again demonstrates the importance of the species as a key habitat attribute for Yellow-bellied Glider on the Bago Plateau. *E. pauciflora* (14%) was also regularly recorded, along with *E. robertsonii* (12%) in mixed forest types. Few hollows were observed in *E. delegatensis* stands, however, most of the trees were dead as a result of historic fire or insect damage and are typically not favoured by Yellow-bellied Gliders (Goldingay & Kavanagh 1991).

Tree hollow data collected from the Bago Plaetau suggests that a glider home range of approximately 60 ha on the Bago Plateau may contain 128–220 large tree hollows in areas of high quality habitat; and 20–35 hollows per home range equivalent area in the relatively depauperate stands of *E. delegatensis* which are not occupied by the species (Kambouris *et al* in press). Although the absence of tree hollows within living *E. delegatensis* on the Bago Plateau may be attributed to its extensive disturbance history, Kambouris *et al* (in press) suggest that the absence of Yellow-bellied Gliders in mature monospecific stands indicates that other more important habitat requirements are still not being met by of *E. delegatensis* or Forest Type 147 alone.

Provisions are in place to ensure timber harvesting and other forestry operations on the Bago Plateau are not detrimental to the conservation and persistence of threatened species under the TSL for the Tumut IFOA (2001). This has included the Yellow-bellied Glider until now. These measures are additional to existing dedicated reserves on the State Forest estate for the protection of flora and fauna values. Informal reserves, including landscape exclusions for species including large forest owls and their prey also occur; as do extensive wildlife corridors linking all riparian headwater and stream exclusions zones and other site-specific exclusions for protection of wetlands, threatened species and communities across State Forests.

The Tumut IFOA (2001) requires that of the net harvestable area of the tract, a minimum of 65% of the basal area must be retained during single tree selection silviculture and 77.5% during Australian group selection silviculture during any one logging operation. General habitat prescriptions also apply and include a minimum retention of 5 hollow-bearing habitat trees and an additional 5 hollow-recruitment trees per hectare, which commonly increases to 8 habitat trees per hectare where adequate densities of Greater Glider, which are considered sensitive to habitat disturbance (Kavanagh 2004; Kavanagh & Wheeler 2004), are detected. Additional to these general requirements are the species-specific prescriptions to cater for the Yellow-bellied Glider. They include a 50 metre radius exclusion zone around den trees, the retention of all sap feed trees, together with an additional 15 trees of recognised feed tree species (*E. viminalis, E. dalrympleana, E. fastigata* and *E. ovata*) within a 100 metre radius of each retained feed tree which must each have good crown development, minimal butt damage, not be suppressed and have a dbhob greater than 30 centimetres.

Evidence suggests that high intensity timber harvesting without mitigating impacts through adequate habitat retention has deleterious effects for sensitive arboreal fauna (see Lindenmayer *et al* 1991a; Milledge *et al* 1991; Lindenmayer *et al* 1994; Incoll *et al* 2001;

Alexander *et al* 2002). Sympathetic management through lower or variable intensity harvesting, or adequate retention of key habitat attributes, may have reduced or no effect on sensitive arboreal fauna. It has been demonstrated that Yellow-bellied Gliders are able to compensate and maintain occupancy of logged areas where effective management of these threats has occurred (Kavanagh 1987a; Lunney 1987; Kavanagh & Bamkin 1993; Eyer & Smith 1997; Kavanagh & Stanton 1998; Kavanagh & Webb 1998). Kambouris *et al* (in press) suggest this is also the case for Yellow-bellied Glider on the Bago Plateau, where conservative harvesting prescriptions under the Tumut IFOA (2001) have allowed for adequate retention of key habitat attributes for Yellow-bellied Glider occupancy to remain unchanged in recent decades.

Maintained occupancy of highly disturbed forests by Yellow-bellied Glider, both on the Bago Plateau and elsewhere, may be attributed to the species having dispersed habitat requirements within an extremely large home range (Kavanagh 1987b). The diverse foraging and habitat requirements of Yellow-bellied Glider are diluted within its extensive home range, making the effects of disturbance events, including timber harvesting under appropriate management prescriptions, tolerable for family groups (Kambouris *et al* in press). In comparison, the specialised habitat requirements of the Greater Glider are focused within a relatively small home range and may make it quite susceptible to disturbance (Kavanagh 2004; Kavanagh & Wheeler 2004).

Prior to the listing of the Yellow-bellied Glider population on the Bago Plateau as an Endangered Population, harvesting prescriptions under the Tumut IFOA (2001) appeared to be adequate for Yellow-bellied Glider to maintain occupancy as expected within suitable habitat. They also provided an opportunity to enhance current distribution into unoccupied areas through the retention of key habitat attributes following prescribed forestry operations. Consequently, the predicted effects of forestry operations under the Tumut IFOA (2001) on the population of Yellow-bellied Glider on the Bago Plateau were considered to be negligible.

However, given the listing of the Yellow-bellied Glider population on the Bago Plateau as an Endangered Population, additional habitat retention above existing IFOA requirements is warranted as a precautionary measure. This will offer an increased level of confidence that the population is adequately catered for. Additional prescriptions within high and moderate quality habitat above existing requirements for Yellow-bellied Glider will be implemented, as will monitoring to gauge the effectiveness of these measures.

Figure 3. Monitoring sites in relation to modelled Yellow-bellied Glider habitat within Bago & Maragle State Forests

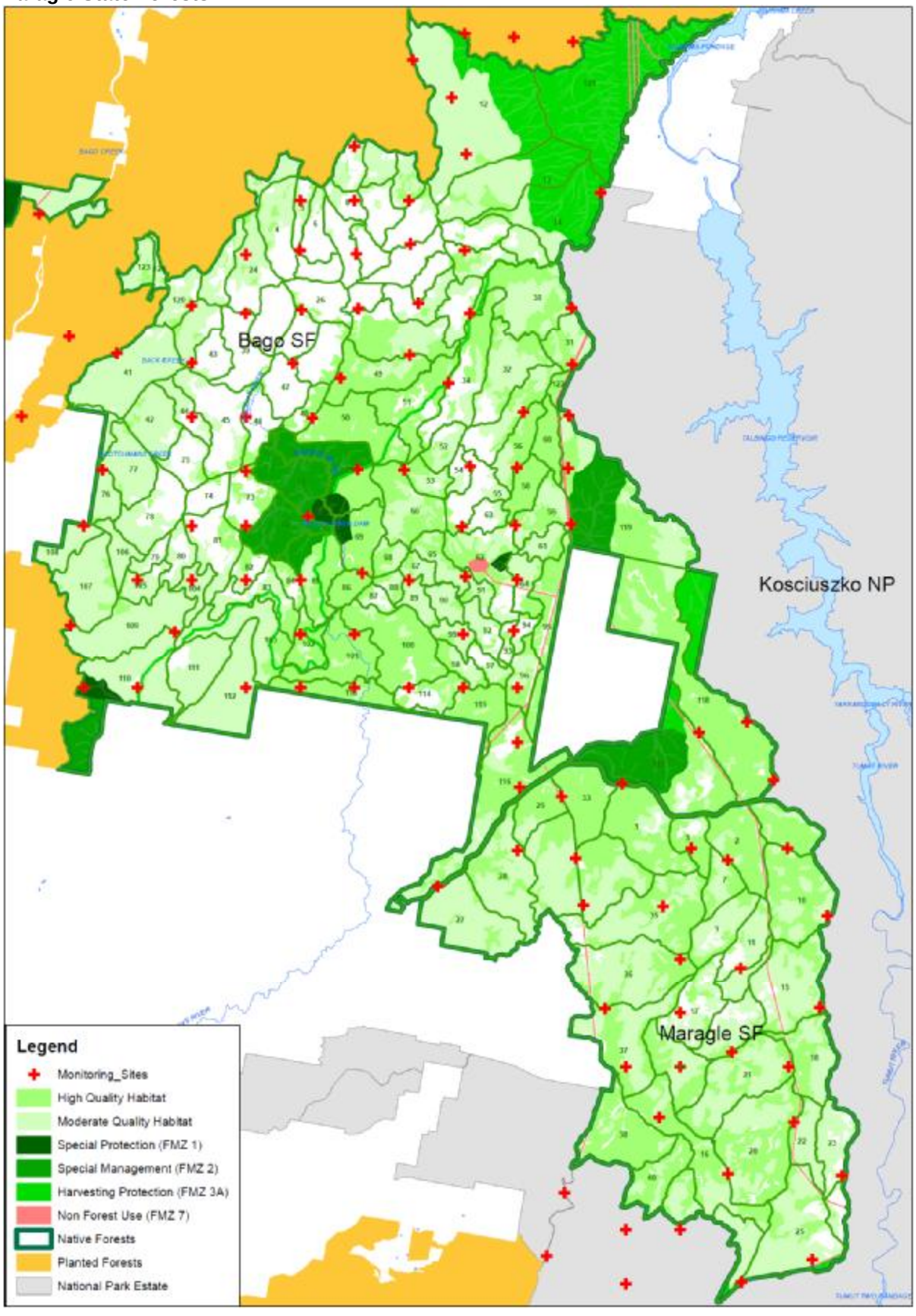
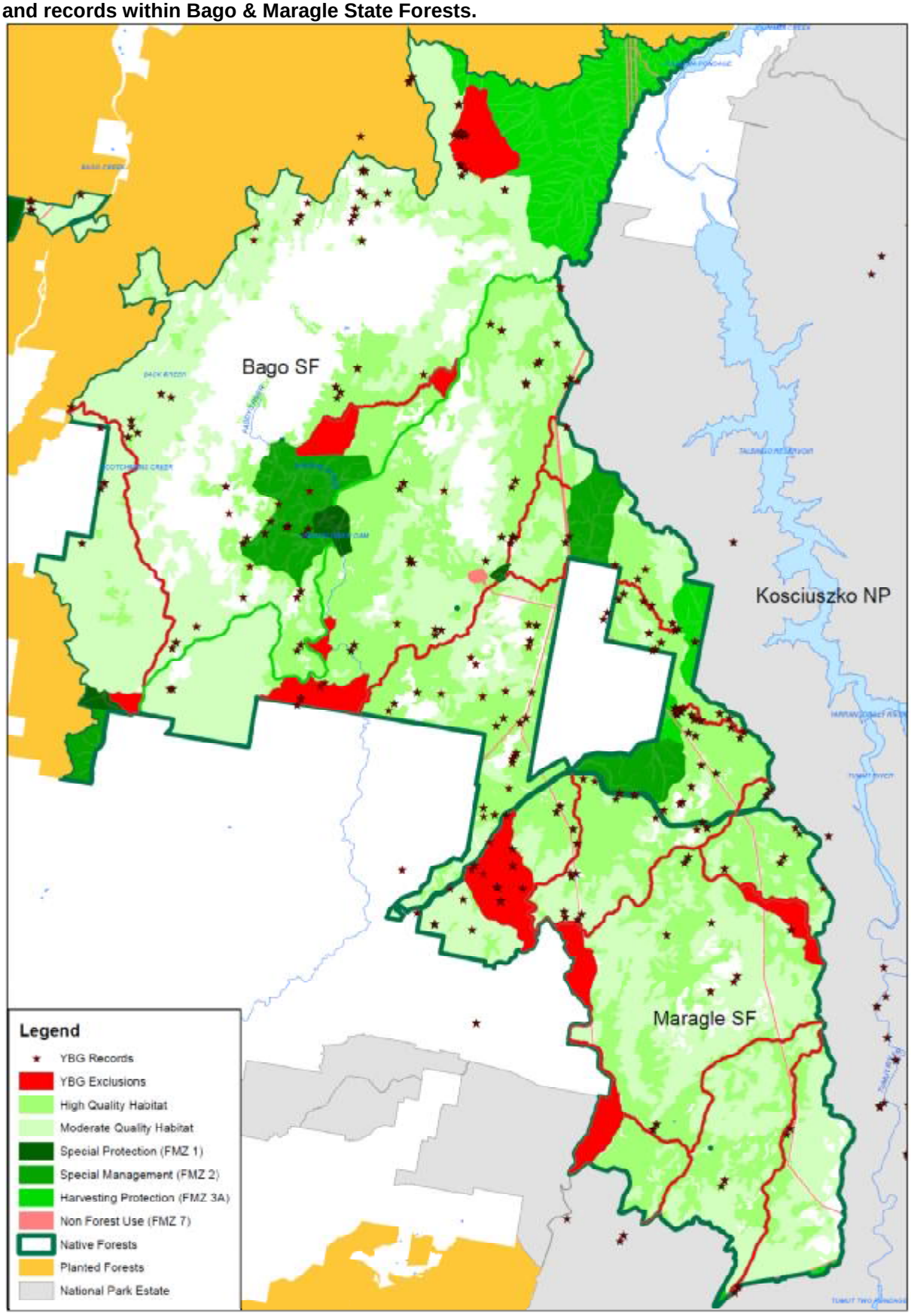


Figure 4. Proposed exclusions and corridors relative to modelled Yellow-bellied Glider habitat and records within Bago & Maragle State Forests.



ACTION PLAN

Introduction

The primary objective of the Population Management Plan is to allow for the protection of the Endangered Population of Yellow-bellied Glider and conservation of its habitat on the Bago Plateau. Habitat protection and population monitoring conditions will be modified for Bago and Maragle State Forests only, replacing those within the Tumut TSL for these forests. These measures include landscape harvesting exclusions, modified harvesting prescriptions and a long-term monitoring program assessing species occupancy and persistence in areas subject to native forest harvesting operations.

Management Prescriptions

Existing measures for the protection of Yellow-bellied Glider during harvesting operations within the Tumut IFOA area include:

- A 50 metre radius exclusion zone must be implemented around Yellow-bellied Glider dens.
- All Yellow-bellied Glider sap feed trees must be retained.
- Within a 100 metre radius of each retained Yellow-bellied Glider sap feed tree, 15 potential feed trees with DBH>30cm, good crown development, minimal butt damage and not suppressed must be retained . The feed trees retained should be of the same species as the identified sap feed tree, or be a tree species recognised as a sap feed tree in the area (*E. viminalis, E. fastigata, E. ovata, E. dalrympleana*).

General conditions also require the retention of a minimum of the 5 largest hollow-bearing trees, an additional 5 trees for hollow recruitment per hectare area; stream and drainage exclusions; and site specific and habitat exclusion and retention for other flora and fauna species.

The following conditions for the endangered population on the Bago Plateau are additional to existing Yellow-bellied Glider requirements within the Tumut TSL and shall apply from 1 September 2013 until 31 December 2020. These conditions include:

1. Additional landscape harvesting exclusions incorporating a proportion of High and Moderate quality habitat available across Bago and Maragle State Forests (as mapped in Figure 4).
2. A network of 100m wide wildlife corridor exclusions linking existing and new harvesting exclusions across Bago and Maragle State Forests (as mapped in Figure 4).
3. Retention of an additional 5 hollow bearing trees per hectare above existing requirements within the Tumut IFOA in areas designated as High quality habitat consisting of RN17 Forest Types 137, 138, 140, 143 and 159.
4. Retention of an additional 3 hollow bearing trees per hectare above existing requirements of the Tumut IFOA within areas designated as Moderate quality habitat consisting of RN17 Forest Types 111, 124, 131, 148, 155, 160 and 164.
5. No additional requirements within other forest types which are not considered to provide suitable Yellow-bellied Glider habitat.
6. Retained trees in High and Moderate quality habitat are to be distributed evenly within a compartments planned net harvest area with preference given to trees with larger hollows where present. The only exception to this may occur in regrowth stands of FT 148 where required hollow retention rates may be clustered in gum species due to the unlikely occurrence of hollows in regrowth *E. delegatensis*.

7. Where additional hollow bearing trees are not available to meet these requirements within the harvest area, retention of suitable montane gum species for recruitment of future hollows will occur.

FCNSW and EPA will maintain GIS layers relevant to the Management Prescriptions above (BagoYBG_Exclusions and BagoYBG_RN17) on their respective corporate databases.

Monitoring Program

In the period 1 September 2013 until 31 December 2020, an additional landscape monitoring program targeting Yellow-bellied Glider in Bago and Maragle State Forests is to occur. This is additional to existing survey conditions under the Tumut TSL which continue to apply.

The Yellow-bellied Glider monitoring program has three primary objectives:

- Assess the effectiveness of modified prescriptions in maintaining Yellow-bellied Glider occupancy at a compartment scale following a harvesting operation;
- Assess the effectiveness of modified prescriptions in maintaining Yellow-bellied Glider occupancy at landscape scale across Bago and Maragle State Forests; and
- Verify and refine stratified habitat modelling by ongoing assessment of the level of occupancy of Yellow-bellied Glider in each defined stratum.

Methods, Site Selection and Survey Effort

The ability to successfully determine whether the Population Management Plan is meeting the objectives will be dependent on the effectiveness of its monitoring strategy in testing each of the assumptions made. This will enable the refinement of habitat quality modelled for the Yellow-bellied Glider on the Bago Plateau, and assess the effectiveness of modified burning and timber harvesting prescriptions in allowing the species to persist.

A range of available techniques may be used for monitoring Yellow-bellied Glider, including both passive and active methods, such as listening, stag-watching, searching for feeding sign, scat identification, spotlighting, call-playback, trapping, radio-tracking and the use of hairtubes. Spotlighting has historically been used as the primary means of detecting arboreal mammals (see Braithwaite *et* al 1983; Lunney 1987; Braithwaite *et* al 1988; Davey 1990); however it is considered to underestimate Yellow-bellied Glider species densities when used in isolation (Kavanagh 1984). This may be due to the species agility and poor reflective eye shine in comparison to other arboreal mammals.

The characteristic loud vocalisations of Yellow-bellied Glider make the species readily detectable, if present. Its propensity to call in response to the broadcast of recorded calls for most nocturnal species also allows for its detection, if members of a family group forage silently or are otherwise not recorded by other passive means. This allows for the species to be detected whilst targeting more elusive species, such as Powerful and Masked Owls in the planning area.

A landscape scale monitoring program targeting arboreal mammals and owls across the planning area was established in 1995 and was intended to provide a baseline dataset for future studies (Kavanagh & Stanton 1998). A subset of these sites recently surveyed allowed for habitat preferences to be refined and land management practices to be assessed retrospectively, both spatially and temporally, by direct comparison with a larger data set (Kambouris *et al* in press).

Bago Plateau Monitoring Program

Landscape monitoring program

The selection of 126 sites at which nocturnal birds and arboreal mammals were surveyed across the Bago Plateau in 1995 was derived from randomly placed grid points at 1.7 km intervals across the landscape (Kavanagh & Stanton 1998) (Figure 3). A subset of these sites was resurveyed in 2010 which allowed understanding of habitat use to be refined and effects of timber harvesting on Yellow-bellied Glider to be assessed retrospectively.

111 of the 126 monitoring sites occur within or immediately adjacent to Bago and Maragle State Forests. One third (approximately 40) of the sites are to be surveyed annually by FCNSW on a three year rotation, allowing for all of the sites to be surveyed during a three year survey cycle. Sites selected for annual survey will consist of an even representation of the 4 broad forest types based on RN17 (FCNSW 1989) and be evenly distributed geographically. These broad forest types comprise of Peppermint/Gum, Montane Gums, Montane Gum/Alpine Ash and Alpine Ash.

Targeted surveys for harvesting events

Additional to the landscape monitoring program for Yellow-bellied Glider, preharvest surveys for nocturnal fauna will continue within Bago and Maragle State Forests as required under the Tumut Threatened Species Licence.

If Yellow-bellied Glider records or modelled habitat as identified in Table 1 occurs within a compartment scheduled for harvesting, the following additional survey is also required to complement landscape monitoring requirements:

1. Yellow-bellied Glider is to also be targeted during preharvest spotlight and nocturnal call playback surveys conducted under the Tumut Threatened Species Licence.
    a. Survey effort is to be consistent with the requirements of Conditions 8.7.3 (b), 8.8.5 and 8.8.6 Tumut TSL for the proposed Net Harvest Area.
2. Modified harvesting prescriptions are to be applied within the relevant compartment on the basis of modelled habitat quality as mapped, regardless of Yellow-bellied Glider presence.
3. Where Yellow-bellied glider is detected within the compartment during targeted spotlight or call playback surveys, the location is to be resurveyed annually for the following 2 years in order to assess the effectiveness of the modified prescriptions in adequately providing for the species persistence.
    a. The same spotlight transects and playback locations are to be surveyed during the subsequent years.

Survey Method

1. Scheduled landscape monitoring sites are to be visited once between spring and autumn during that annual monitoring season.
2. At each monitoring site, the following must occur:
    a. 15 minutes listening for un-elicited calls or other passive detections; followed by
    b. 15 minutes of call playback incorporating 5 minutes broadcast of Powerful Owl (*Ninox strenua*) and Masked Owl (*Tyto novaehollandiae*) recordings with a 5 minute listening period in between;
    c. 15 minutes spotlight searching a fixed radius area of 1 hectare, recording any arboreal mammal or owls in addition to a count of large tree hollows within the spotlight search area; followed by

d. Final passive listening period of 5 minutes at each site.
e. Where Yellow-bellied Glider is detected during the initial listening period, spotlight searching may occur simultaneously with call playback for owl species
f. Record date, time, weather details, forest height, estimated age or time since disturbance (eg fire or harvesting), tree species and forest type composition to confirm desktop assessments.

3. Review of data by FCNSW and EPA is to occur annually during winter in order to assess adequacy of modified prescriptions and whether broader management objectives are being met.

Critical action thresholds for the population, based on relative mean levels of site occupancy, shall be developed in consultation with EPA, to initiate management responses, if they are exceeded at any stage throughout the duration of the Population Management Plan.

Data Recording

A generic proforma shall be used across all study sites (Appendix 2). Data collected at each location shall include: date, time, GDA coordinates, general weather details, forest height estimates, estimated age or time since disturbance (eg fire or harvesting), tree species and forest type composition, tree hollows and host tree species, time and duration of survey activities as well as all target and opportunistic fauna observations.

Animal Care and Ethics

The survey and monitoring program will be conducted under the NPWS Scientific Licence No. SL100920 and Animal Care and Ethics Licence 04/13.

Scheduling of Operations

Annual scheduling of proposed harvesting operations and the associated monitoring program shall be forwarded by Forests NSW to EPA for advice during winter. The harvesting schedule shall include details about the relevant harvesting conditions, as outlined under *Management Prescriptions.*

OTHER MANAGEMENT CONSIDERATIONS

The primary objective of this Plan is to determine the ongoing presence of Yellow-bellied Glider within Bago and Maragle State forests; and determine distribution of the population and monitor changes in occupancy over time across all tenures.

Targeted survey for arboreal mammals and large forest owls during historical monitoring on the Bago Plateau, and more so since the commencement of pre-harvest surveys under the Tumut TSL in 2001, has resulted in a large dataset of sites where Yellow-bellied Glider was present within the Tumut RFA Region. The data has been compiled with preliminary analysis to determine any statistical trends in occupancy and habitat correlations. Development and implementation of the monitoring program proposed in this Plan will also consolidate the survey dataset.

Further analysis of the dataset will facilitate a more in-depth review of the ecology of the species and of the manageable impacts on its distribution and abundance. Linkages with higher education institutions may also be sought, and post graduate student projects developed. Supplementary research should aim to address any the following questions:

Management questions	Context
Home range and habitat use in high elevation forests	Assess home range and habitat use and conduct PVA on basis of populations disjunctness
Impacts of harvesting on home range and behaviour	Study effects of harvesting events on family groups, monitoring changes in home range and habitat use
Implications of power easements to glider movement	Assess impacts of 330kv power easements to glider movement, geographic and genetic distinctness.
Distribution and connectivity of across Snowy Mountains	Assess distribution of YBG across snowy mountains and determine if geographically or genetically disjunct.
Assess forest age class requirements	Assess importance of forest age and structural integrity as a key habitat attribute for YBG on the Bago Plateau
Impacts of silvicultural methods to habitat use	Assess effects of varying silviculture (AGS vs STS) on home range and habitat use of glider groups
YBG as an indicator species	YBG often referred to as an indicator of forest health. Fact or fiction given disturbance history of Bago Plateau
Impacts of low intensity fire (hazard reduction burning)	Assess the impacts of low intensity prescribed fire on habitat use of family groups on the Bago Plateau
High intensity wildfire	Assess the effectiveness of protection and suppression strategies in minimising the extent of high intensity wildfire and the consequent damage to YBG population and habitat

ADAPTIVE MANAGEMENT

After the completion of annual monitoring, FCNSW and EPA shall meet annually to review survey effort, results, problems encountered and any preliminary inferences from the collected data. This will be used to assess the need for monitoring design modification and provide feedback for the Population Management Plan review process. The periodic reporting process will be agreed and formalised between FCNSW and EPA to provide transparency.

The information obtained through the monitoring program will help to ascertain whether historic prescriptions were adequate and whether modified prescriptions implemented under the Population Management Plan are adequate for conserving the population. Results from any supplementary monitoring and additional research may provide information on Yellow-bellied Glider response to land management activities across all tenures.

Should the monitoring provide insufficient data to address the objectives of the Population Management Plan after the first 3 year cycle of intended survey, FCNSW and EPA will jointly review the plan and recommend amendments as necessary. Any review of the conditions applying to the management of Yellow-bellied Glider on State Forest on the basis of monitoring results, will require agreement between FCNSW and the EPA and will take into account potential effects on sustainable timber supply from the Tumut RFA sub-Region. Collected and analysed data from the monitoring program will also refine research questions and generate new directions in which additional information may be required.

REPORTING AND REVIEW

Annual reporting outlining results, conclusions and recommendations against monitoring program aims, review of management activities and the general direction of the Population Management Plan are required as specified above.

A formal review of the Population Management Plan between FCNSW and EPA will be undertaken in 2017. The review will form part of the adaptive management process with results being used to provide future direction for Yellow-bellied Glider management under the Population Management Plan. If issues arise in the period before the formal review, they will be addressed as part of the annual survey progress reporting process, or on an as needs basis.

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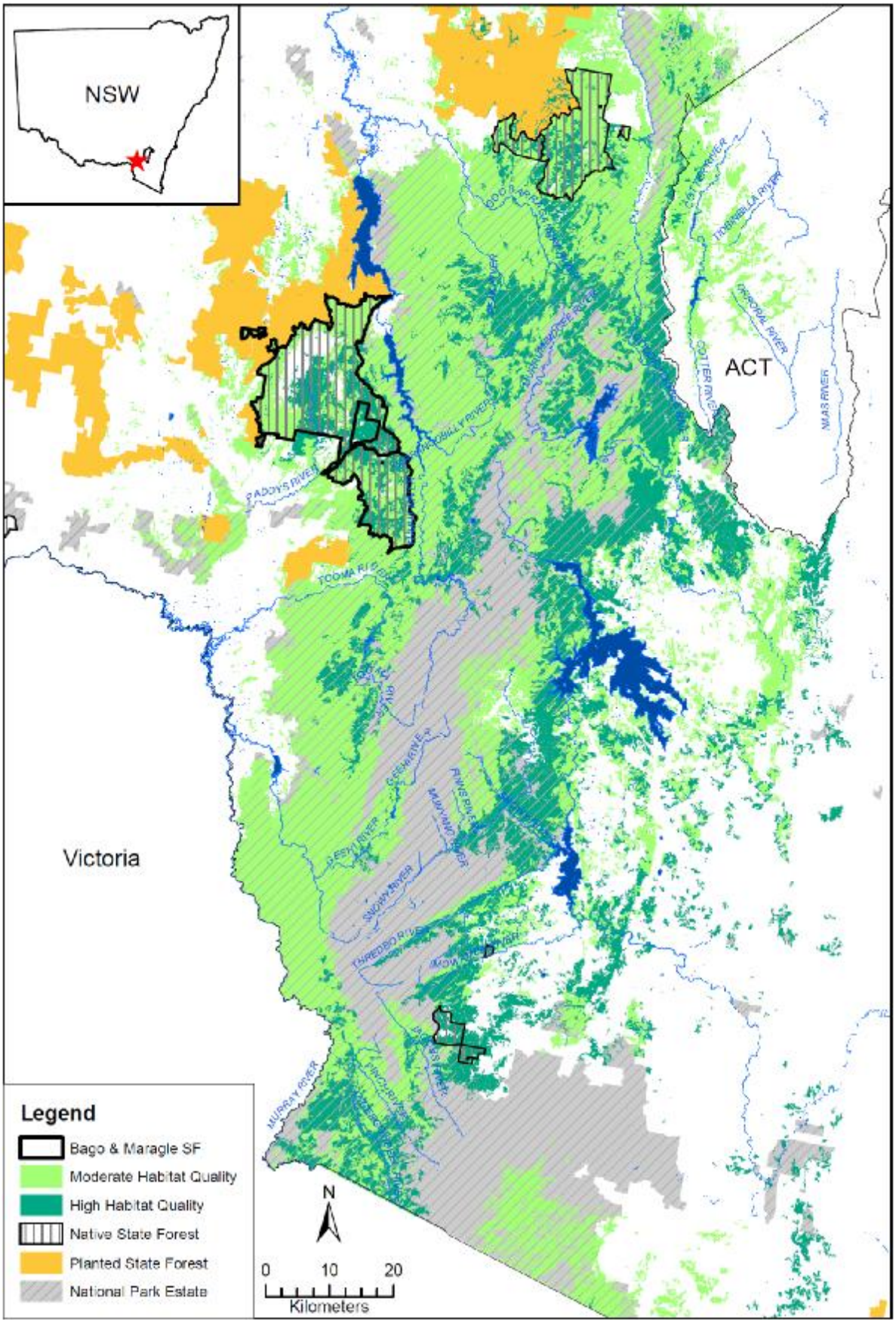
APPENDIX 1. YBG MODELLED HABITAT FOR NSW SNOWY MOUNTAINS



APPENDIX 2. BAGO PLATEAU YBG SURVEY DATA SHEET

BAGO / MARAGLE YBG CALL PLAYBACK – REGION NO.463

STATE FOREST		M.A - BAGO-MARAGLE		SITE ID:	
SURVEYOR(S)			DATE (Census1)	/ /	
SURVEY NAME	BAGO-MARAGLE YBG PRELIM SURVEY		DATE (Census2)	/ /	
Census 1 (24hr00:00)	Start Time: :	Finish Time: :	Total Time : HRS		
Census 2 (24hr00:00)	Start Time: :	Finish Time: :	Total Time : HRS		
SITE (AMG)	55 Zone	EASTING	NORTHING		
LOCATION DESCRIPTION					

WEATHER	Census 1	Census 2		Census 1	Census 2
Time Measurements Taken (24hr 00:00)			WIND [(1) calm (2) light (3) moderate (4) strong		
Temperature DRY ^{O}C WET ^{O}C			RAIN [(1) no evidence in last 24 hrs (2) evidence in last 24 hrs (3) during survey		
Relative Humidity %			NIGHT LIGHT (1) No Moon (2) Moon Obscured by Cloud (3) ¼ Moon (4) ½ Moon (5) ¾ Moon (6) Full Moon		

BROAD HABITAT TYPE	
Forest Type	Alpine Ash Mixed (Ash/Gum) Gum Gum/Peppermint Other……
Estimated Stand Age (Yrs):	<10 11-25 25 - 50 50-100 100+ Old Growth
Approx Stand Height: (m)	

HOLLOW BEARING TREES - 1ha (50m radius) of call playback site | Species A = Ash G= GUM P=P/mint O=Other:

Tree No.	Species	DBH	Tree No.	Species	DBH
1			6		
2			7		
3			8		
4			9		
5			10		

OBSERVATION DETAILS

CENSUS NO.	CALL PLAYED	SPECIES RESPONSE	OBS. TYPE	COUNT	RESPONSE (ESTIMATE)		AMGS / NOTES (appearance, sex, note if count or estimate)
					DISTANCE	BEARING	

X W = Heard Call O = Observed F = Tracks/Scratchings H = Hair/feathers/skin K = Dead R = Road Kill