Assessment of Tablelands Snow Gum, Black Sallee, Candlebark and Ribbon Gum Grassy Woodland TEC on NSW Crown Forest Estate

Survey, Classification and Mapping Completed for the NSW Environment Protection Authority

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Contents

1 Overview

Tablelands Snow Gum, Black Sallee, Candlebark and Ribbon Gum Grassy Woodland (Tablelands Snow Gum) is described in the final determination (the determination) as an open forest, woodland, open woodland or grassland, on various substrates at high elevation (above approximately 600 metres). Where it exists, the tree canopy is dominated by any combination of *Eucalyptus pauciflora* (Snow Gum), *Eucalyptus stellulata* (Black Sallee), *Eucalyptus rubida* (Candlebark) or *Eucalyptus viminalis* (Ribbon Gum). Locally, other eucalypts may also occur, such as *Eucalyptus aggregata* (Black Gum) and the endangered *Eucalyptus parvula* (Small-leaved Gum). An understorey of shrub species may be present, while the ground layer is dominated by the grasses *Themeda australis, Poa* spp., *Austrostipa* spp., and *Austrodanthonia* spp., and the forbs *Leptorhynchos squamatus, Chrysocephalum apiculatum* and *Asperula conferta*.

The determination cites two previously described vegetation communities, Frost Hollow Grassy Woodlands (Tozer et al. 2010) and Tablelands and Slopes Herb/Grassland/Woodland VG 153 (Gellie 2005), as being included in Tablelands Snow Gum. These are predominantly found on the NSW southern tablelands. It cites a further six communities mainly defined from the central tablelands – Map Units 44 and 45 (NSW National Parks and Wildlife Service 2003), Broad Vegetation Type (BVT) 25 (DEC 2006a; DEC 2006b), Map Units 11 and 15 (DEC 2006c) and community 5 (Hunter 2002) – as including Tablelands Snow Gum. No information is provided on the extent to which Tablelands Snow Gum is included in any of these communities, which components are regarded as Tablelands Snow Gum or how the parts which are not Tablelands Snow Gum may be distinguished. We defined a study area that encompassed the distribution of these communities and all bioregions and local government areas referenced in the determination. Our study area included over 468,000 hectares of state forest.

We analysed 8638 systematic flora survey plots, in relation to 365 previously defined communities in the region, including those of most relevance to Tablelands Snow Gum. Based on relationships to communities cited in the determination, we assessed 193 plots as belonging, or potentially belonging (in the case of communities not wholly included) to Tablelands Snow Gum. Of these, 79 plots are most closely related to Frost Hollow Grassy woodland or VG 153 and, we believe, can be confidently regarded as Tablelands Snow Gum. A further 76 plots are related to Map Units 11, 15, 44 or 45. At least some of these units belong to Tablelands Snow Gum, but it is not possible to determine which ones using the information provided in the final determination. As a precautionary approach, we regarded all of these units as belonging to Tablelands Snow Gum. An additional 38 plots belong to community 5 of Hunter (2002). This community occurs only at Mount Canobolas, is floristically distinct from any other assemblage cited in the determination, has little relationship with any community of relevance to our study and we have not considered it further.

We used presence-absence predictive distribution modelling to identify indicative (potential) distributions of each of the primary vegetation communities cited in the determination. We used this data to guide the assessment of likelihood that the assemblage occurs on any state forest in our region. The predicted distribution maps give a probability of occurrence across the study area, based on a modelled relationship with environmental and remotely sensed variables. The modelling also provided an opportunity to investigate the environmental relationships that separate vegetation classes assigned to the Tablelands Snow Gum TEC from other non-related vegetation types.

Approximately 1000 plots out of 8600 share the same dominant eucalypts as Tablelands Snow Gum but are distributed among 39 communities which are not cited in the final determination. We have assessed these as not Tablelands Snow Gum, but many of these may cause confusion in the field because of the similarity of tree dominants and a generally similar vegetation structure. Floristically, the Frost Hollow Grassy Woodland component (p22) of Tablelands Snow Gum is more closely related to other southern tablelands communities (especially p220 and p520 in Tozer et al. 2010) than to the central tablelands components of Tablelands Snow Gum (MU 11 and 15). There is no clear evidence of Tablelands Snow Gum occurring in southern tablelands state forests, but a few small areas in Tallaganda State Forest are related to both Frost Hollow Grassy Woodland and MU 11 and we have included them in Tablelands Snow Gum for the purpose of our assessment. On this basis, we used aerial photograph interpretation (API) to map approximately 72 hectares in Tallaganda State Forest, distributed among 19 patches, as possible Tablelands Snow Gum TEC. We also used API to extend existing detailed mapping of MU 11 in southern Ben Bullen State Forest to unmapped parts of the forest. Collectively these mapped approximately 769 hectares (in 150 patches) of the MU 11 component of Tablelands Snow Gum TEC in Ben Bullen and Newnes State Forests on the central tablelands.

2 Introduction

2.1 Project rationale

This project was initiated by the NSW Environment Protection Authority (EPA) and Forestry Corporation NSW (FCNSW) as a coordinated approach to resolve long standing issues surrounding the identification, extent and location of priority NSW Threatened Ecological Communities (TECs) that occur on the NSW state forest estate included within eastern Regional Forest Agreements.

2.2 Final determination

The conservation value and reservation status of *Tablelands Snow Gum, Black Sallee, Candlebark* and *Ribbon Gum Grassy Woodland* ('Tablelands Snow Gum' or Tableland Snow Gum TEC) was initially discussed by Crooks et al. (2008) prior to its listing as a Threatened Ecological Community (TEC). In that paper, it was stated that these naturally species-rich grassy woodlands were once widespread throughout the NSW Southern and Central Tablelands, but have become fragmented through extensive clearing for agriculture. Tablelands Snow Gum was subsequently determined as an Endangered Ecological Community in 2011 (NSW Scientific Committee 2011). Based on current understanding, the community forms an open forest, woodland, open woodland, or grassland with low tree cover, on various substrates at high elevation. Where it exists, the tree canopy is dominated by any combination of *Eucalyptus pauciflora* (Snow Gum), *Eucalyptus stellulata* (Black Sallee), *Eucalyptus rubida* (Candlebark) or *Eucalyptus viminalis* (Ribbon Gum). Locally, other eucalypts may also occur, such as *Eucalyptus aggregate* (Black Gum) and the endangered *Eucalyptus parvula* (Small-leaved Gum). An understorey of shrub species may be present, including such species as *Hymenanthera dentata* and *Melichrus urceolatus*, while the ground layer is dominated by the grasses *Themeda australis, Poa* spp., *Austrostipa* spp., and *Austrodanthonia* spp., and the forbs *Leptorhynchos squamatus, Chrysocephalum apiculatum* and *Asperula conferta* (NSW Scientific Committee 2011).

Some specific exclusions are also detailed in Paragraph 6 of NSW Scientific Committee (2011), including the various high elevation woodland communities dominated by *Eucalyptus pauciflora* subsp. *niphophila* and subsp. *debeuzevillei*, and *Eucalyptus lacrimans* of the Australian Alps, South Eastern Highlands and Sydney Basin bioregions, and the endangered *Ribbon Gum, Mountain Gum, Snow Gum Grassy Forest/Woodland of the New England Tableland Bioregion*. These do not form part of the Tableland Snow Gum TEC.

Related vegetation communities are also detailed in Paragraph 6, which may intergrade with Tableland Snow Gum. These include *White Box Yellow Box Blakely's Red Gum Woodland* (NSW TSC Act 1995 TEC) (Costin 1954; Fallding 2002; Keith 2004); *Montane Peatlands and Swamps of the New England Tableland, NSW North Coast*, *Sydney Basin, South East Corner, South Eastern Highlands and Australian Alps Bioregions* (NSW TSC Act 1995 TEC); and *Natural Temperate Grassland of the Southern Tablelands of NSW and the Australian Capital Territory* (Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999 Threatened Ecological Community) (Costin 1954; Fallding 2002; Keith 2004).

2.3 Initial TEC Reference Panel interpretation

Under the *Threatened Species Conservation Act 1995* (TSC Act), TECs are defined by two characteristics: an assemblage of species and a particular location. The TEC Reference Panel (the Panel) agreed that the occurrence of Tableland Snow Gum is constrained to the IBRA Bioregions stated in the final determination, but that contiguous areas within adjacent bioregions should be included in analysis and mapping. The panel agreed that Tableland Snow is a TEC which has been defined from previous quantitative floristic analyses. Accordingly, the assemblage of species is interpreted by reference to vegetation communities which have been previously described from quantitative floristic analysis and which have been explicitly listed in the determination. The Tableland Snow Gum final determination describes a number of environmental descriptors but the panel noted that these should be used as a guide and not as diagnostic features.

Based on the final determination for Tableland Snow Gum, Table 1 summarises the key determining features of this community. The four bioregions mentioned (Key Determiner *a*) cover a collective area of nearly 180,000 square kilometres in New South Wales, although within that landmass elevation, geology and landscape features (Key Determiners *f* and *g*) restrict the potential area considerably. Structurally, Tableland Snow Gum occurs across a wide range of classes, from open forest to grassland (Key Determiner *c*), however only landscapes dominated or formerly dominated by four characteristic eucalypts (Key Determiner *d*) are included.

Table 1: Key determinants of Tablelands Snow Gum TEC, from NSW Scientific Committee (2011)

Key determiners		Paragraph in NSWSC (2011)
a	NSW occurrences fall within the South Eastern Highlands, Sydney Basin, South East Corner & NSW South Western Slopes bioregions, with known sites in 20 local government areas. May occur elsewhere in these bioregions.	1,7
b	Characterised by the listed 58 plant species, including nine eucalypts, two wattles and 18 grasses.	2
c	Forms an open forest, woodland, open woodland or grassland, and includes secondary grassland where dominant trees have been removed.	4
d	Where trees are present, dominated in the canopy by *Eucalyptus pauciflora*, *Eucalyptus stellulata*, *Eucalyptus rubida* and/or *Eucalyptus viminalis, Eucalyptus aggregata* or *Eucalyptus parvula* may also occur locally.	4
e	Understorey characterised by *Hymenanthera dentata* and *Melichrus urceolatus* in the shrub layer, with a ground layer dominated by grasses and other herbaceous species including *Themeda australis*, *Poa* spp., *Austrostipa* spp., *Austrodanthonia* spp., *Leptorhynchos squamatus*, *Chrysocephalum apiculatum*, and *Asperula conferta*.	4
f	Mainly occurs on valley floors, margins of frost hollows, footslopes and undulating hills, between 600 to 1400 metre altitudes.	5
g	Occurs on a variety of substrates including granite, basalt, metasediments and Quaternary alluvium.	5
h	Includes communities described as Frost Hollow Grassy Woodlands by Tozer et al. (2010) and Tablelands and Slopes Herb/ Grassland/ Woodland by Gellie (2005) and is included in MUs 44 and 45 of NSW NPWS (2003), BVT25 of DEC (2006a, 2006b), MUs 11 and 15 of NSW DEC (2006c), and Community 5 of Hunter (2002).	6

2.4 Assessment area

2.4.1 State forests subject to assessment

The study area includes Crown Forest estate situated within Southern and Eden Integrated Forestry Operations Approval (IFOA) regions. A total of 73 state forests were included in this assessment (Table 2). State forests excluded from the assessment include those areas defined as Forest Management Zones 5 (Hardwood Plantations) and Zone 6 (Softwood Plantations). Small areas of native forest wholly enclosed or adjoining Forest Management Zone 6 (Softwoods) are also excluded from assessment as they are considered to be outside of the authority of the IFOA. An additional set of Forests situated within the “Bathurst Softwoods Region” on the Central Tablelands were also identified by the NSW EPA as requiring assessment. These forests are also identified in Table 2. The study area encompasses some state forests that are useful to the assessment of Tablelands Snow Gum TEC but are not subject to assessment in this report.

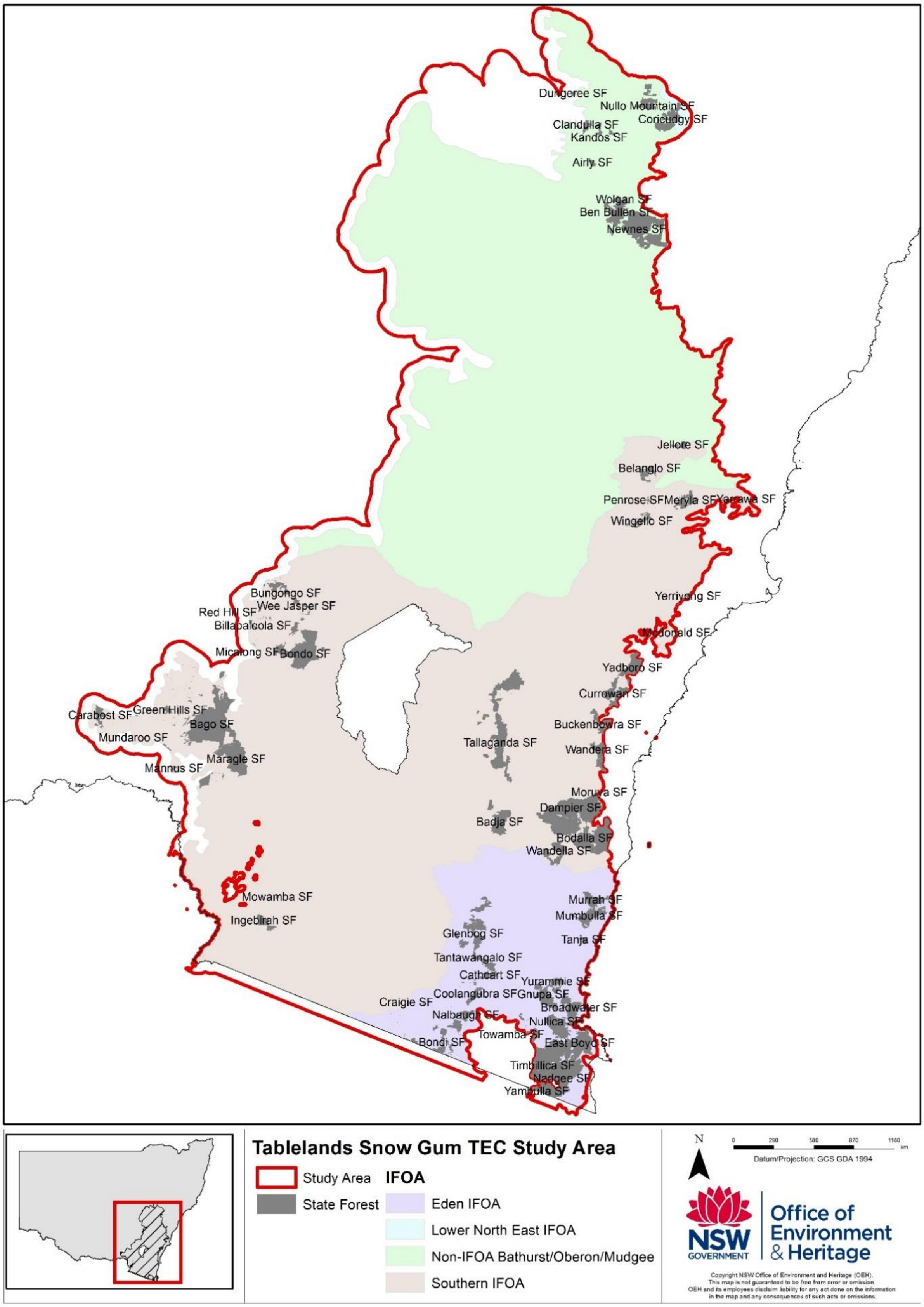
Table 2: State forests included within the study area.

IFOA Region	State Forest (SF)	Area (Ha)	IFOA	State Forest (SF)	Area (Ha)
Non-IFOA	Airly SF	632	Southern IFOA	Penrose SF	472
Non-IFOA	Ben Bullen SF	8252	Southern IFOA	Red Hill SF	141
Non-IFOA	Clandulla SF	1561	Southern IFOA	Shallow Crossing SF	3854
Non-IFOA	Coricudgy SF	7582	Southern IFOA	Tallaganda SF	23909
Non-IFOA	Dungeree SF	370	Southern IFOA	Wandella SF	5497
Non-IFOA	Kandos SF	1396	Southern IFOA	Wandera SF	5199
Non-IFOA	Newnes SF	22575	Southern IFOA	Wee Jasper SF	1464
Non-IFOA	Nullo Mountain SF	5370	Southern IFOA	Wingello SF	2466
Non-IFOA	Wolgan SF	1205	Southern IFOA	Yadboro SF	10745
Southern IFOA	Badja SF	7695	Southern IFOA	Yarrawa SF	179
Southern IFOA	Bago SF	36106	Southern IFOA	Yerriyong SF	6598
Southern IFOA	Belanglo SF	2838	Eden IFOA	Bombala SF	339
Southern IFOA	Billapaloola SF	727	Eden IFOA	Bondi SF	6780
Southern IFOA	Bodalla SF	24060	Eden IFOA	Broadwater SF	168
Southern IFOA	Bolaro SF	1779	Eden IFOA	Bruces Creek SF	793
Southern IFOA	Bondo SF	16586	Eden IFOA	Cathcart SF	1725
Southern IFOA	Buckenbowra SF	5192	Eden IFOA	Coolangubra SF	2274
Southern IFOA	Bungongo SF	2857	Eden IFOA	Craigie SF	100
Southern IFOA	Carabost SF	2849	Eden IFOA	East Boyd SF	21070
Southern IFOA	Currowan SF	11974	Eden IFOA	Glen Allen SF	1454
Southern IFOA	Dampier SF	33766	Eden IFOA	Glenbog SF	8852
Southern IFOA	Green Hills SF	1166	Eden IFOA	Gnupa SF	1321
Southern IFOA	Ingebirah SF	2653	Eden IFOA	Mumbulla SF	6147
Southern IFOA	Jellore SF	1409	Eden IFOA	Murrah SF	4221
Southern IFOA	Mannus SF	636	Eden IFOA	Nadgee SF	20603
Southern IFOA	Maragle SF	14216	Eden IFOA	Nalbaugh SF	2281
Southern IFOA	Mcdonald SF	3681	Eden IFOA	Nullica SF	18344
Southern IFOA	Meryla SF	4350	Eden IFOA	Tanja SF	868
Southern IFOA	Micalong SF	3177	Eden IFOA	Tantawangalo SF	3404
Southern IFOA	Mogo SF	15499	Eden IFOA	Timbillica SF	9173
Southern IFOA	Moruya SF	4060	Eden IFOA	Towamba SF	1638
Southern IFOA	Mowamba SF	162	Eden IFOA	Yambulla SF	46882
Southern IFOA	Mundaroo SF	1	Eden IFOA	Yurammie SF	4059
				Total	468,136

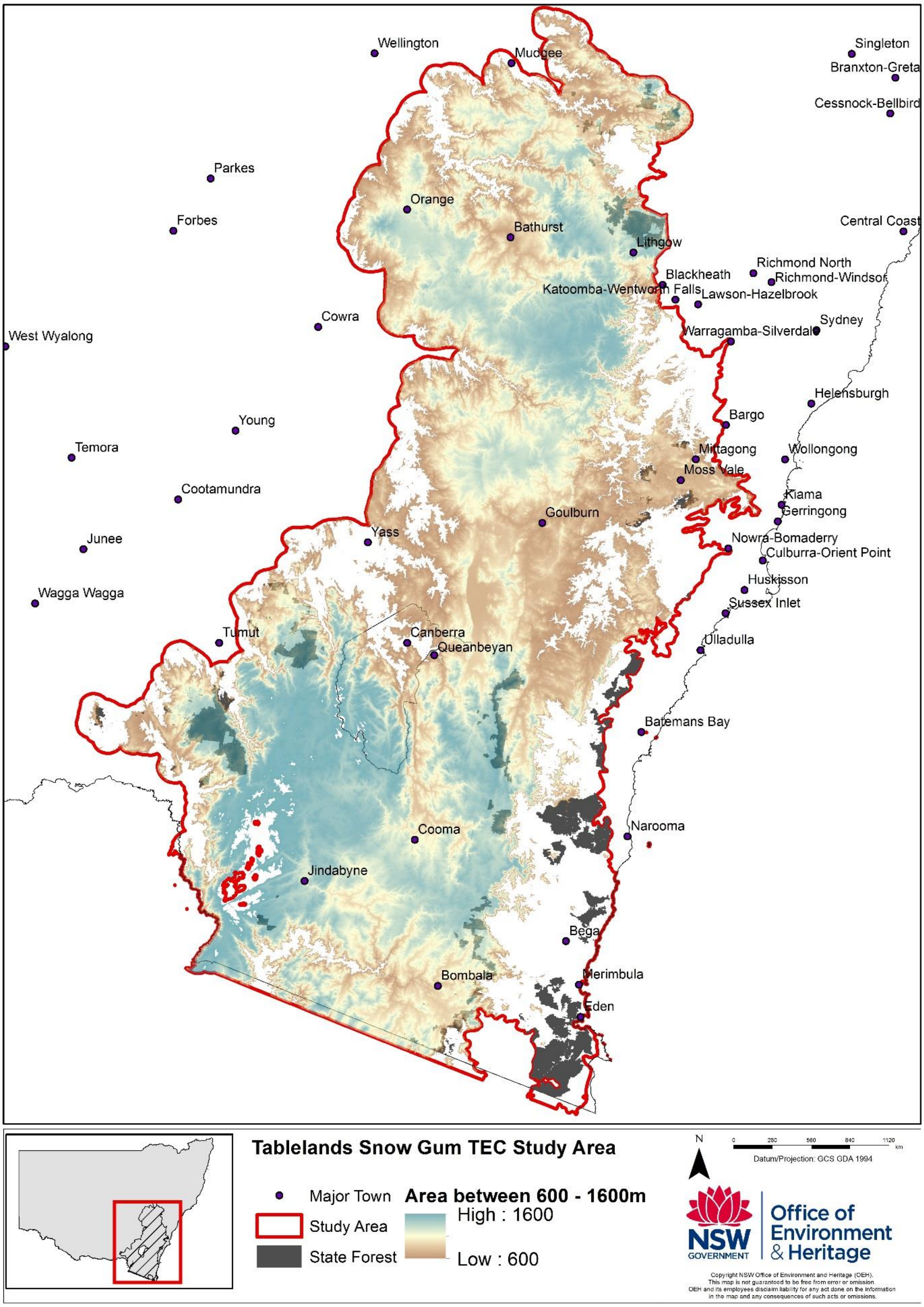
2.4.2 Location and study area boundaries

The study area was defined by the IBRA subregions that cover the 600-1400 metre elevation range within the South Eastern Highlands, Sydney Basin, South East Corner and Australian Alps bioregions (Maps 1 and 2) as described in the final determination. The study area was expanded in the far north to include the full extent of MU11 as mapped in Western Blue Mountains vegetation mapping study (DEC 2006c). Similarly, a five kilometre buffer was applied to the western margin to capture floristic survey sites of interest that marginally fall within the NSW South Western Slopes bioregion. To avoid introducing a much greater range of vegetation types not relevant to the TEC final determination, all land in the Australia Alps bioregion above 1600 metres was excluded from the study area.

Map 1: Tablelands Snow Gum TEC study area



<u>Map 2:</u> **Elevations between 600 and 1600m across the study area**



2.5 Project team

This project was completed by the by the Ecology and Classification Team in the OEH Native Vegetation Information Science Branch. It was initiated and funded by the NSW Environment Protection Authority under the oversight of the Director, Forestry Branch.

The project was managed by Daniel Connolly. Doug Binns undertook the floristic analysis of survey sites, and has interpreted the relationships and relatedness between relevant vegetation communities. Allen McIlwee performed the indicative distribution modelling. Owen Maguire and Bob Wilson undertook API mapping using 3D stereo imagery across the study area. Flora survey sites were completed by Jackie Miles, Stephen Bell and Paul McPherson (with additional samples completed by Ken Turner). Field assistance was provided by Paula Pollock (EPA), Ken Turner and Daniel Connolly. Dan Bowles provided GIS, mapping and technical support. A preliminary technical report on the distribution of Tablelands Snow Gum was prepared by Stephen Bell.

3 Methodology

3.1 Approach

Analysis and mapping was guided by the general principles and particular interpretation of Tablelands Snow Gum TEC adopted by the Panel, described in Section 1.2. For the purpose of this project, Tableland Snow Gum is interpreted to be defined by floristic plot data allocated to vegetation communities which have been previously described from quantitative floristic analysis, and which have been explicitly listed in the final determination. Two such communities (SCIVI p22 Frost Hollow Grassy Woodland and Gellie (2005) VG153 Tablelands and Slopes Herb/Grassland/Woodland) are described as being 'included in' Tableland Snow Gum, from which it may be inferred that all plots allocated to these communities belong to Tableland Snow Gum. A further five communities (Warragamba MU44 and MU45, Western Blue Mountains MU11 and MU15 and Mt Canobolas unit 5) are described as 'including' Tableland Snow Gum, from which it may be inferred that at least some plots allocated to these communities belong to Tableland Snow Gum. There are additional communities regarded as including Tableland Snow Gum but they are not based on quantitative field data and are too broadly defined to be useful in numerical analysis.

Plots in which standard floristic data have been collected (comprising data already held in the VIS database over all tenures and data collected specifically for this project in state forests) were compared with plots previously allocated to the communities listed in the Tableland Snow Gum final determination. A number of methods were used for comparison, comprising both dissimilarity-based methods and methods based on multivariate regression. The results were then used to assess the likelihood that plots in state forests belonged to one or more of the communities listed in the final determination. There is no single preferred method of making these comparisons and no objective threshold to determine whether or not a plot belongs to a community (and thus Tableland Snow Gum). Options for different methods and thresholds represent narrower or broader interpretations of Tableland Snow Gum, but this approach using plot-based floristic comparison provides a means of consistently allocating plots to being either Tableland Snow Gum or not for a range of interpretation options.

Ecological modelling was undertaken to predict the distribution of the p22/g153, MU11, MU45 and Unit5 communities mentioned above. The purpose of the habitat modelling was to predict the likelihood of occurrence for each community across all candidate state forests in the study area. As such, the models attempt to identify unsurveyed areas of habitat that are environmentally similar to where a vegetation community is known to occur. Not all potentially suitable habitats are expected to be occupied, so the models are unable to map the actual distribution of a community or TEC, however, they are an important tool for identifying which state forests could potentially support a community of interest, and therefore require more detailed follow up survey and API mapping work. They also indicate which state forests can be excluded from this process, as they have little to no chance of supporting the vegetation community in question. The modelling also provided an opportunity to investigate the environmental relationships that separate vegetation classes assigned to the Tableland Snow Gum TEC from other non-related vegetation types.

3.2 Existing vegetation data

3.2.1 Existing vegetation classification

A number of previous regional or local analyses included a significant number of plots from large parts of the Tableland Snow Gum study area. These are listed below, with the abbreviated name or code used in this report given in brackets, where appropriate, after the report citation. There is substantial overlap in the sets of plots used for various studies. Most studies have used plots from earlier studies as well as new data.

- Hunter (2002) Mt Canobolas SRA, comprising 50 plots and including the only plots which have been allocated to vegetation community Unit 5 cited in the final determination.
- NSW NPWS (2003) Warragamba Special Area (WAR), in the north east part of the study area, comprising 302 plots in our study area, including 21 previously allocated to MU11 and MU15, cited in the Tableland Snow Gum final determination.
- Gellie (2005) covered most of the southern part of the study area, comprising 2161 plots used in analysis. Cited by the final determination and directly relevant to the interpretation of Tableland Snow Gum. We have applied a 'g' prefix to numbers used by Gellie (2005) to identify vegetation groups.
- DEC (2006c) Western Blue Mountains (WBM), in the northern part of the study area, comprising 286 plots, seven of which had been allocated to MU44 and MU45, relevant to the interpretation of Tableland Snow Gum.
- Tozer et al. (2010) (SCIVI) Covered the eastern part of the study area, comprising 5118 plots used for analysis. Cited by the final determination and directly relevant to the interpretation of Tableland Snow Gum.
- Armstrong et al. (2012) Upper Murrumbidgee Catchment (UMC) within the study area, comprising 3154 plots. Post-dates the final determination, but the authors made an assessment of relationships between communities which they recognised and Tableland Snow Gum.

3.2.2 Existing vegetation data

Data for a total of 16,578 plots were available within the study area. A recent review of OEH systematic flora survey data holdings in eastern NSW (OEH in prep) was available for the project. The review identified a subset of data suitable for use in quantitative vegetation classification on the basis that it met a set of predefined criteria, namely that sites:

- provided location co-ordinates with a stated precision of less than 100 metres in accuracy
- covered a fixed survey search area of approximately 0.04 hectares
- supported an inventory of all vascular plants
- provided a documented method that assigns a quantitative and/or semi quantitative measure of the cover and abundance of each species recorded

We assessed 8638 plots as comprising full floristic data suitable for analysis. We obtained information on allocations of these plots to previously defined vegetation communities made by the studies described above in Section 2.2.1. Of the 8638 plots, 6691 had been previously allocated by at least one of these studies. Of the 6691 previously allocated plots, a total of three plots in state forests in our study area (Table 2) have been allocated to a community cited in the Tableland Snow Gum final determination (as described in Section 2.1). These were all in Ben Bullen State Forest and all previously assigned to MU11 by NSW NPWS (2003).

3.2.3 Data preparation and taxonomic review

All species in the pooled dataset was standardised for analysis using a review completed for all flora survey data compiled for the Eastern NSW Classification (OEH in prep). Nomenclature was standardised to follow Harden (1990-93; 2000-2002) and updated to reflect currently accepted revisions using the PlantNETWebsite (Royal Botanic Gardens, 2002). The data was amended to:

- exclude exotic species
- exclude species identified to genus level only

- improve consistency in assignment of subspecies or varieties to species.

Cover and abundance score data extracted from the pooled data set was standardised to a six class modified braun-blanquet score. The transformation algorithm available within the OEH VIS Flora Survey data analysis module was applied to the analysis dataset.

3.3 New survey effort

3.3.1 Survey stratification and design

A targeted survey effort was employed to sample candidate environmental attributes and canopy species combinations considered by the TEC Reference Panel to be useful determinants of the possible location of the TEC. Tallaganda and Badja State Forests were chosen by the TEC Panel as the areas of initial investigation. Potential areas of cold-air drainage, swamp margins and drainage depressions were initially identified from environmental variables and digital aerial imagery. Points were located within the GIS and examined in relation to the distribution of existing mapping classifications relevant to the TEC final determination (see Map Units 22, 220 and 520 from Tozer et al. 2010; Map Unit 153 from Gellie 2005; and Forest Types 136,137 and 143 from Baur 1979). Existing systematic survey sites were then overlaid on the coverage of candidate areas and map unit classes to assess sampling adequacy. A set of 30 site locations was then selected from across Tallaganda and Badja State Forests. In total, 22 new sample plots were surveyed within Tallaganda and Badja State Forests during April 2014.

A second phase of targeted survey effort was completed across additional forests on the Southern Tablelands where candidate habitat was present. A set of site locations were preferentially located by an experienced aerial photograph interpreter to identify swamp margins, drainage depressions and alluvial forests that supported key canopy and ground layer characteristics. A subset of sites was also randomly chosen to sample preliminary outputs of potential TEC distribution based on predictive models. In total a further 23 samples were collected from Glenbog, Tantawangalow, Nalbaugh, Ingebirah, Bungongo and Craigie State Forests.

3.3.2 Survey method

Systematic field sampling was completed using the principles and methods set out by Sivertsen (2009) as part of the OEH Vegetation Type Survey Interim Standard. Sites were located in the field using a global positioning system (GPS). Sites were completed by experienced botanists using a 0.04 hectare search area measured by field tapes to approximate a 20 by 20 metre search area. Within each site all vascular plant species were recorded and assigned a separate score for the cover and abundance for each species. Species that could not be identified in the field were recorded to the nearest possible family or genus and collected for later identification. At each site estimates were made of the height range, projected foliage cover and dominant species of each vegetation stratum recognisable at the site. Measurements were taken of slope and aspect. Notes on topographic position, geology, soil type and depth were also compiled. Estimations were made of the percentage of rock outcropping, surface rock, litter and bare soil. Evidence of recent fire, erosion, clearing, grazing and weed invasion or soil disturbance was recorded. The location of the site was determined using a GPS or a topographic map where a reliable GPS reading could not be taken. Elevation values were recorded from a GPS and topographic map readings. Digital photographs were also taken at each site.

Table 3: Braun-Blanquet-to-cover abundance conversion table.

Modified Braun-Blanquet 6 point scale	Raw Cover Score	Raw Abundance Score
1 (<5% and few)	<5%	≤3

2(<5% and many)	<5%	≥3
3 (5-25%)	≥5 and <25%	any
4 (25%-50%)	≥25% and <50%	any
5 (50%-75%)	≥50% and <75%	any
6 (75%-100%)	≥75%	any

3.4 Classification analyses

3.4.1 Clustering

There is a range of methods available for quantitative classification of vegetation communities. Results may vary depending on which method is used and which parameters are chosen for a particular method. There is no single best method, but the most widely used method is clustering of sites based on pairwise dissimilarities. As results vary with varying dissimilarity measures, comparisons with previous classification require use of the same measures. Relationships among plots vary depending on the data pool used, so that introducing additional data may change the composition of previously defined groups. Most clustering methods result in a plot being allocated to a single vegetation community. A plot may also be related to other communities, but these interrelationships are not evident from allocations.

As an alternative, fuzzy clustering methods assign a membership value to each plot for each community, which provides a measure of the likelihood that a plot belongs to any particular community. For this project, noise clustering (De Cáceres, Font & Olivia 2010) was selected as the most appropriate fuzzy clustering method for three reasons: it allows specification of fixed clusters defined from previously described groups and provides direct allocations to those groups; it is relatively robust to outliers (which have a large difference from all previously defined groups or communities) and allows clustering into new groups; and it is robust to the prevalence of transitional plots with relationships to two or more previously defined communities. The latter are both characteristic of data for the study area. Noise Clustering requires specification of a fuzziness coefficient (where a coefficient of 1.0 is equivalent to hard clustering which allocates each plot to only one community) and a threshold distance for outliers.

Following a number of trial runs with different subsets of data, different fixed groups and different parameters, we chose a fuzziness coefficient of 1.1 and an outlier threshold of 0.85. These parameters resulted in results which were relatively robust to different data and which had a high degree of consistency with previous classifications. Analyses were done using functions in the ‘vegclust’ package in R 3.1.1. (De Cáceres, Font & Oliva 2010).

A number of analyses were conducted using different subsets of data and different sets of previously defined communities, as follows:

1. The full set of plots was filtered by excluding those with mean dissimilarity to any Tableland Snow Gum community >0.86, to provide a subset of 3293 plots most likely to include plots related to Tableland Snow Gum. For this subset, fixed clusters were derived from plot allocations to communities defined by those studies cited in the final determination (Gellie 2005, Tozer et al. 2010, DEC 2006c, NPWS 2003 and Hunter 2002). This provided an assessment of the membership of all plots to communities directly relevant to the determination. For plots which were used in two or more of these studies, inclusion in a fixed group used the allocation for the most recent of the several studies.
2. The full set of 8618 suitable plots surveyed up to the end of 2014 was used for analysis and the post-determination study of Armstrong et al. (2012) was included for definition of fixed groups, but fixed groups were defined only for communities considered likely to be floristically related to Tableland Snow Gum or occurring in broadly similar habitats. In the case of floristically related communities, we chose all

communities grouped into the class of Southern Tablelands Grassy Woodlands and Dry Sclerophyll Forests by Tozer et al. (2010) plus all communities regarded by Armstrong et al. (2012) as including or possibly containing parts of Tableland Snow Gum (as listed in their Table 7). In the case of communities which occupied similar habitat, we chose all communities which were represented by >50% of their plots in an environmental envelope defined by roughness index and soil bulk density thresholds, based on a preliminary analysis of relationships between environmental factors and plots allocated to Tableland Snow Gum using the methods described under Section 2.4.4. Results were compared to results of Analysis 1 to provide an indication of robustness of relationships and allocations to communities.

3. An analysis similar to the above, using the same fixed groups, using a subset of only plots allocated to those groups but including the additional 20 plots surveyed in state forests in early 2015. This analysis was designed to test relationships of the additional 20 plots to relevant communities with potential similarity to Tableland Snow Gum.

From the above analyses, we generally allocated plots to communities using the rules below. For each step, we applied the rule only to plots which remained unallocated from preceding steps.

1. Use Analysis 2 if membership of a previously defined group from this analysis >=0.5.
2. Use Analysis 1 if membership of a previously defined group from Analysis 1 >=0.5.
3. Use allocation from either Analysis 1 or Analysis 2, whichever has greatest membership, provided either has membership of a previously defined group >=0.25.
4. Use allocation from either Analysis 1 or Analysis 2, whichever has greatest membership, provided either has membership of a previously undefined group >=0.5.
5. Use Analysis 3 if membership of a previously defined group >=0.25.
6. We left plots unallocated, indicating ambiguous relationships or relationships to communities not considered relevant to Tableland Snow Gum, if they were not allocated with any of the above rules.

3.4.2 Multivariate regression

We used multivariate regression to make pair-wise comparisons of selected pairs of communities to test their degree of floristic similarity to other pairs, using the ‘mvabund’ package in R3.1.1 (Warton, Wright & Wang 2012) with data converted to presence/absence and a binomial link function. An alternative which could be used appropriately for the ordinal-scale scores available in our study is ordinal regression using a cumulative logit link, but initial trials showed that this did not provide any advantage over the simpler presence/absence with binomial link. Multivariate regression does not rely on calculation of dissimilarities so provides an independent comparison with distance-based methods.

For each pair of communities, the difference in summed AIC is calculated, summed across all species in both communities combined, between a null model and a model using community as the factor.

The ratio of summed AIC to the number of species provides a measure of the extent to which recognising two separate communities provides a better model of species occurrence than does a single combined group. A higher ratio indicates communities which are more clearly distinct. We also used the AIC from multiple regression to rank species by their contribution to differences between communities and to define diagnostic species for a community. In the latter case, we compared a community to all other plots as a group. Using this method provides an advantage over alternatives which rank species by their contribution to dissimilarity values, because the latter may inappropriately rank species as highly discriminatory simply because they have high variance.

3.4.3 Other methods

We made a comparison between the assemblage as listed in the final determination and the various communities either cited in the determination or regarded as Tableland Snow Gum by Armstrong et al. (2012). For this comparison we used floristic data from plots allocated to these communities in the original studies in which they were defined. We based the comparison simply on the proportion of the species listed as the Tableland Snow Gum assemblage which were present in the group of plots comprising the community to be compared. The proportion depends on both the degree of concordance and the number of plots from which the pool of species is drawn. To allow a valid comparison among communities, we calculated the expected proportion as the mean of the proportions from 100 repeated random samples of size N from a set of reference plots, where N is the number of plots in the community being compared. The reference set comprised all plots allocated to the community with the highest N. We then calculated a relative concordance value for each community as observed proportion/expected proportion.

3.4.4 Allocation of standard floristic plots to Tableland Snow Gum and other communities

We assessed plots as being Tableland Snow Gum if their membership of any floristic community cited in the final determination (as listed in Section 3.1 and Table 1; we refer to these as 'Tableland Snow Gum communities' and all other communities as 'non-Tableland Snow Gum communities'), using any of the rules described in Section 3.4.1, was 0.5 or above, or if they had been originally allocated to a Tableland Snow Gum community in a study cited in the determination. We considered that plots which belonged to a Tableland Snow Gum community with membership <0.5 were potentially Tableland Snow Gum. We assessed these further, individually, based on their membership of various communities in the different analyses described in Section 3.4.1. If a potential Tableland Snow Gum plot had a strong membership (we used membership value >0.75 as a guide) in a non-Tableland Snow Gum community in at least one analysis, we assessed it as belong to that community and not Tableland Snow Gum. Alternatively, if a potential Tableland Snow Gum plot consistently had its primary (highest) membership in a Tableland Snow Gum community, across two or more analyses, or if it had low membership in all non-Tableland Snow Gum communities, we assessed it as Tableland Snow Gum on a precautionary basis, even if the membership value in a Tableland Snow Gum community was low.

3.5 Indicative TEC distribution map

A niche modelling approach (also known as species or habitat distribution modelling) was used to create an indicative (potential) distribution map of Tableland Snow Gum vegetation classes (see Section 2.4.4). This approach attempts to extrapolate the fundamental niche of the vegetation communities in question outside the locations where they are known to be present (realised niche), by relating known occurrence and absence to environmental predictors.

In order to model the distribution of Tableland Snow Gum, we need to characterise the environmental conditions that are suitable for the TEC to exist. The inclusion of the absence data from the site allocation allows us to constrain the potential distribution model to a set of favourable environmental conditions that are not occupied by other existing vegetation communities. Nonetheless, without API and associated on-ground validation, it is difficult to determine the extent to which potentially suitable habitat is occupied by the TEC.

3.5.1 The modelling process

Ecological niche modelling involves the use of environmental data describing factors that are known to have either a direct (proximal) or indirect (distal) impact on a species or ecological community. Proximal variables directly affect the distribution of the biotic entity, while distal variables are correlated to varying degrees with the causal ones (Austin 2002).

Two types of modelling were undertaken for the project. First, we ran a model to predict the distribution of 35 vegetation communities simultaneously using a technique called Boosted Regression Trees (BRT), with each of the communities/classes modelled according to a multinomial distribution. These communities are listed in Table 4 and were chosen either because they were likely to be floristically similar to Tableland Snow Gum or they occupied a similar habitat. The communities were those chosen as fixed groups for Analysis 2 in Section 2.4.1 and the criteria for their selection is explained more fully in that section. We considered that modelling all such similar communities in a multi-class model had the potential to reveal subtle differences in distribution which otherwise might not be apparent from single community presence-absence models. The multi-class model was performed using the Gradient Boosting Machines (GBM) package in R. The purpose of the modelling was to try to get a broad sense of where in the landscape different vegetation communities are most likely to occur. Specifically, the model identifies the vegetation community with the highest probability of occurrence on a pixel by pixel basis across the study area.

Second, we ran individual BRT presence-absence models for the vegetation communities that were identified as being representative of Tableland Snow Gum (see Section 3.2) using the R package DISMO. This uses the same algorithm as GBM (with a Bernoulli rather than multinomial distribution), but the parametrisation, tuning and model optimisation process differs between the two R packages. DISMO is accepted as the best package available for creating presence-absence species distribution models, while gbm is currently the only package available that can run a simultaneous multi-class model.

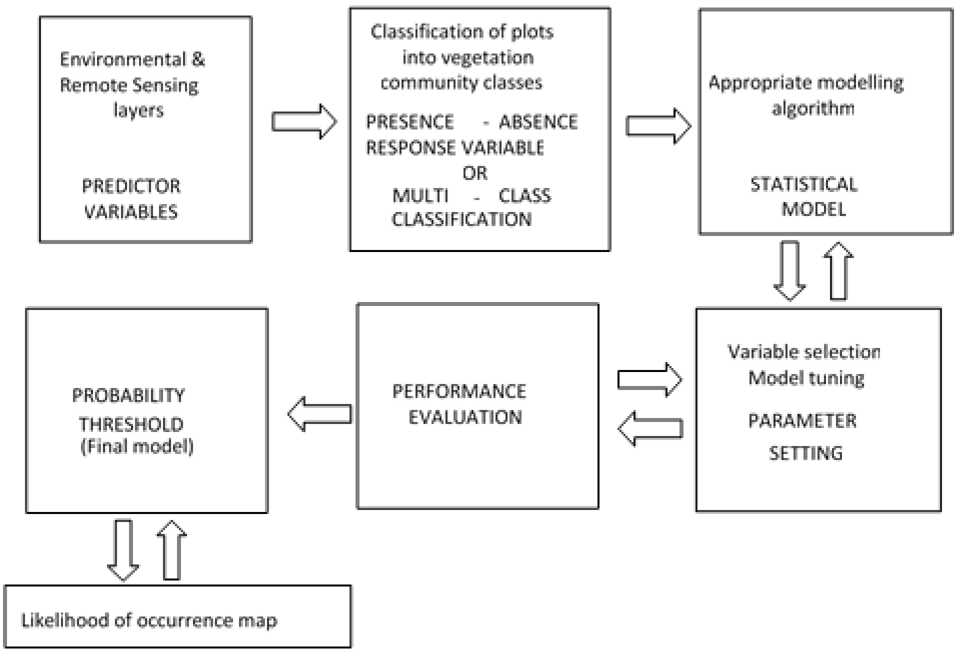
The individual presence-absence models were used as the final indicative map of the potential distribution of Tableland Snow Gum, as these models contained the best, most parsimonious set of predictor variables for each community, while the multi-community model used a set predictors that were relevant to the full set of communities.

Table 4: Thirty five vegetation communities included in a multi-class distribution model.

Community	No. sites	Community	No. sites	Community	No. sites	Community	No. sites
e24	46	MU11	28	p220	30	u118	19
e26	59	MU45	24	p23	78	u179	22
e59	60	OTHER	5034	p24	45	u21	66
g152	27	p14	370	p27	13	u22	207
g157	9	p15	38	p338	196	u23	19
g94	20	p17	9	p420	20	u27	15
m31	33	p19	61	p520	50	u28	42
m36	32	p20	29	p54	24	u78	28
m68	14	p22	9	p9	71	Unit5	28

Diagram 2 outlines the steps used to build a presence-absence distribution model. Each of these steps and processes are described briefly below, while site allocation/classification step is covered in section 2.7 above.

Diagram 2: Process for creating indicative TEC distribution maps



3.5.2 Environmental and remote sensing predictor variables

A total of 144 environmental and 28 remote sensing predictor variables were available for the South Coast study area. These consisted of raster grids, all with the exact same extent and pixel size (30 x 30 metres). The layers can be divided into 15 broad groups.

- **Location**: (five variables - distance to coast and four distance to various stream orders)
- **Climate - Radiation and Energy** (eight variables)
- **Climate - Temperature** (17 variables)
- **Climate - Rainfall** (17 variables)

- **Geology** (two variables)
- **Geophysics** (14 variables)
- **Landform and Terrain** (19 variables)
- **Landscape** (four variables)
- Nine soil variables derived from the **Great Soil Group soil mapping**
- **Soil Minerals** (six variables)
- **Soil Profile** (49 variables)
- **Soil NIR Spectra** (six variables)
- **Soil Weather Index** (one variable)
- **Single point in time imagery** (Remote Sensing) (three variables)
- **Time-series analysis** (Remote Sensing) (three variables)

3.5.3 Modelling algorithm

Boosted Regression Trees are an ensemble method for fitting statistical models. It differs fundamentally from more conventional techniques that aim to fit a single parsimonious model using as few uncorrelated variables as possible (e.g. GLM). A BRT model is a linear combination of many hundreds or thousands of regression trees, where a random subset of data is used to fit each new tree. Boosting works on the principal that it is easier to find and average many rough rules of thumb, than to find a single, highly accurate prediction rule. The final model is a linear regression model, where each term is a tree.

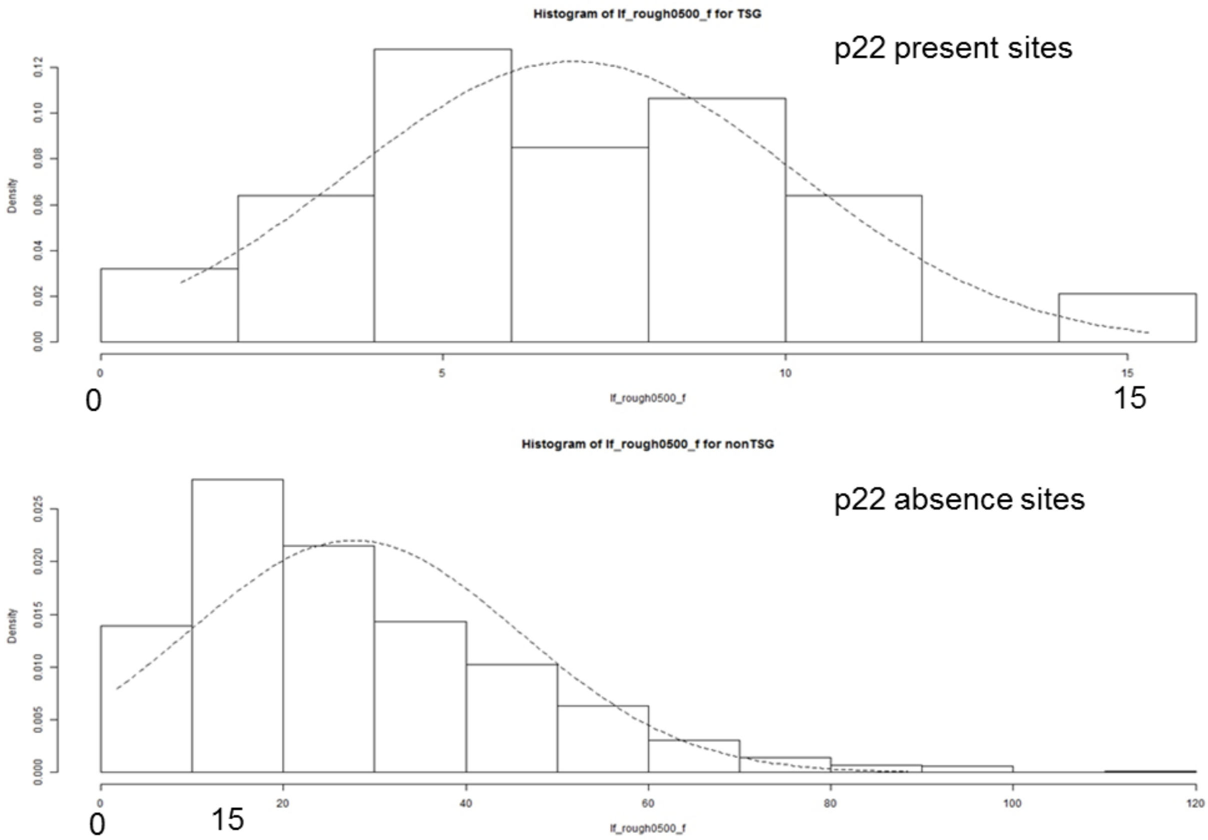
BRT was chosen as the preferred method for modelling because it can handle variables that are correlated with one another. No scaling or normalisation is necessary, and the method can handle missing values in the predictors. Out of ten methods trialled for our initial p22 presence-absence model (using the BIOMOD2) R package, BRT and Random Forest models (RF) were the most consistent. The BRT approach was chosen over RF because it can handle several types of loss functions including the Bernoulli logistic model for presence absence data, and multinomial models which produce a probability matrix for more than one class.

3.5.4 Variable selection and TEC-habitat relationships

The complete set of 144 predictors is far more than is practical for model building, however their relevance was not known in advance. A combination of automatic variable selection procedures and intuitive logic was used to identify different subsets of predictor variables for the multi-class and individual presence-absence models. This section describes how important TEC-habitat relationships were identified.

For individual presence-absence models, the first step was to run a BRT model and look at the relative influence values across all 144 predictors. The purpose of this was to screen out all the variables that if they were to be included in a model, would have such low influence that their contribution would be insignificant.

The predictors with a relative influence of 1% or greater were then examined for obvious TEC-habitat relationships by comparing the frequency histograms plots for all presence sites against all absence sites. For example, for the p22 community occurs in relatively flat, open landscapes above 600 metres. This is reflected in the very different frequency histogram plots for p22 present and absent sites using the roughness 500 variable, which is a measure of the topographical roughness calculated from the standard deviation of elevation in a circular 500 metre neighbourhood (Fig. 2). A final subset of predictors were selected on the basis of relative influence contributions and histogram plots.



<u>Figure 2:</u> Example of how frequency histogram plots help identify ecologically important habitat relationships that are reflected in the predictive distribution models

3.5.5 Performance evaluation

All models were calibrated and evaluated on the same set of survey sites, as there were too few representative sites to warrant splitting the data into separate training and test datasets. Model performance for the multiclass models was assessed on the basis of a confusion matrix where the numbers of correctly and incorrectly predicted occurrences are tallied across all the communities. For the individual presence-absence models, the predicted probability of occurrence values for all presence and all absence sites were ranked (highest to lowest), and the performance of the model was assessed on the basis of the shape of the two curves (see Section 3.3.1).

3.6 Operational TEC map

3.6.1 Existing API mapping

Mapping using FCNSW Forest Types (Baur 1979) is available for all state forests in our study area. This mapping is based on interpretation of aerial photographs, mostly at a scale of c. 1:15000, with varying degrees of field assessment. We considered that this mapping was suitable for delineating patterns of overstorey species composition based on dominant tree species but did not provide any detail of understorey composition or structure.

Vegetation mapping for Western Blue Mountains covered part of the study area (Newnes, Wolgan and the eastern part of Ben Bullen State Forests). This mapping was based on detailed aerial photo interpretation, field reconnaissance and analysis of site-environment data. Map units 11 and 15 defined in this study are explicitly cited in the Tableland Snow Gum final determination.

3.6.2 Use of the potential distribution models

The outputs from the presence-absence BRT models provided a broad indication of the potential distribution of Tableland Snow Gum across the study area. All state forests that had pixels with probability of occurrence values above a critical threshold were identified as having the potential to support Tableland Snow Gum, and were marked of interest for follow up surveys and API assessment.

3.6.3 New API mapping

API technicians, experienced in interpretation of NSW forest and vegetation types, used recent high resolution (50 centimetre GSD) stereo digital imagery, in a digital 3D GIS environment as per Maguire et al (2012), to delineate observable pattern in canopy species dominance, understorey characteristics and landform elements.

Interpreters adopted a viewing scale of 1:1000-1:3000 to mark boundaries and to infer changes in canopy and/or understorey composition. A minimum map polygon size of 0.25 hectares was used to inform the detection and delineation of image patterns. Interpreters were supplied with a range of environmental variables to accompany interpretation including existing vegetation community maps including (RN17), substrate maps, roads and trails and tenure boundaries. All relevant georeferenced floristic data held in OEH databases was extracted and supplied to aid interpretation. Floristic data was supplemented by interpreter field traverse using an iterative process to boost interpretation confidence by relating field observations to image patterns.

There are no clear criteria by which Tableland Snow Gum may be mapped using API. For the unmapped (western) part of Ben Bullen State Forest we used the same criteria and interpreter used to map units 11 and 15 of the Western Blue Mountains study. For southern tablelands, we mapped areas as potential Tableland Snow Gum if they met all of the following criteria: dominated by one or more of Tableland Snow Gum eucalypts or treeless; occupying lower slope positions, frost hollows or adjacent to frost hollows in generally undulating topography; understorey predominantly grassy or mixed grasses and shrubs but not predominantly heath shrubs.

3.6.4 Model integration

The initial API layer was cross-checked against the results of the predictive models developed as described in Section 2.5. In areas where the model predicted a probability which exceeded our threshold but no potential Tableland Snow Gum had been mapped, we re-assessed the imagery in relation to our criteria and mapped additional areas where necessary.

3.6.5 Derivation of an operational map

Southern Tablelands IFOA area

We assessed mapped areas of potential Tableland Snow Gum based on the extent to which floristic plots within each API map unit belonged to Tableland Snow Gum. This was a somewhat subjective process because the number of sample plots in mapped areas was low and in some areas it was also necessary to consider floristic relationships of nearby map units. We used a precautionary approach and assessed a mapped polygon as Tableland Snow Gum if the map unit to which it belonged contained any Tableland Snow Gum plot. If a unit was unsampled, we assessed it as Tableland Snow Gum unless plot data in nearby polygons in similar environments, with similar overstorey composition, indicated that it was most likely to be a related non-Tableland Snow Gum vegetation community. We also examined floristic relationships of all plots in existing FCNSW mapping of any Forest Type which included Tableland Snow Gum eucalypts among its dominant species and made an assessment of the likelihood that the type would contain Tableland Snow Gum. For unsampled Forest Types, we considered data in nearby and similar sampled types. Where insufficient relevant sample data were available, we assessed map units as Tableland Snow Gum in a precautionary manner.

Central Tablelands Non-IFOA area

In accordance with the final determination we assigned all areas mapped as either MU11 or MU15 as meeting the definition of the TEC.

4 Results

4.1 Survey effort

Within our study area, 884 of the 8638 plots are in state forest, including 45 which were surveyed specifically for this project, as described in Section 2.3.1.

4.2 Classification analyses

4.2.1 Relationships to existing classifications

There are 884 plots in state forest used in our analysis. Most of these (517) belong to communities which are floristically unrelated to Tableland Snow Gum and occur in different environments (e.g. coastal lowlands, wet escarpment forests, dry ridges). The remaining 367 plots belong to communities (listed in Table 4) which are related to Tableland Snow Gum either floristically or because they occur in similar environments (as explained in Section 2.5.1). Table 5 summarises the distribution of these 367 plots among communities defined by previous studies, based on the allocation rules described in Section 2.4.1. In some cases a plot is equally related to several different communities, or has a relatively low degree of relationship to any previously defined community. The former are plots which are transitional in some sense among different communities. The latter are usually plots which belong to a community not included in the analysis, which in some cases may be an additional, previously unrecognised communities which requires further data for definition.

Table 5: Vegetation communities (from Tozer et al. 2010; Gellie 2005; Armstrong et al. 2012; DEC 2006; Hunter 2002; NPWS 2003) in state forests which contain plots which are floristically or environmentally related to Tableland Snow Gum.

Community	Brief description	Number of plots in SF
p338	*E.fastigata - E.viminalis* with mesic, often shrubby, understorey	90
u22	*E.dalrympleana - E.pauciflora* forest, grassy understorey	83
p14	*E.macrorhyncha - E.rossii* with dry shrub/grass understorey	18
e26	*E. radiata* with shrubby understorey	16
u23	*E.pauciflora* with shrub understory (*Epacris breviflora*) in drainage depressions	15
p220	*E.viminalis - E.pauciflora* with grassy understorey	13
p520	*E.viminalis - E.pauciflora* with grassy understorey	13
MU11	*E.pauciflora - E.rubida - E.viminalis* tall forest, grassy ground cover	12
e59	Subalpine bog, mainly shrubland with scattered *E.pauciflora*	10
g94	*E.bridgesiana - E.macrorhyncha* with herb/grass understorey	8
g93	*E.macrorhyncha - E.robertsonii* with *Acacia dealbata* and grassy ground cover	8
p15	*E.dives - E.mannifera* with shrub/grass understorey	6
p20	*E.viminalis - E.radiata* with grass/herb understorey	4
p19	*E.bridgesiana - E.macrorhyncha* with grassy understorey	3
e24	*E.dalrympleana* with shrubby understorey	7
p23	*E.dives - E.macrorhyncha* with grassy understorey	2
p54	*E.ovata* with grass/forb understorey	2
p420	*E.viminalis* with grassy understorey	2

Community	Brief description	Number of plots in SF
other (MU15,MU45,p9, p17,m68,u28,u118 or ambiguous)		55
Total		367

Photo 1: The final determination for Tablelands Snow Gum TEC sources Frost Hollow Grassy Woodlands (p22) (Tozer et al. 2010) as a primary authority for the species assemblage and distributional data. We visited several sites used to define p22 in that study including here on the Kings Highway between Bungendore and Braidwood. It is dominated by *Eucalyptus pauciflora*. Characteristic of the ground cover is kangaroo grass *Themeda triandra* and the conspicuous yellow flowers of common everlasting *Chrysocephalum apiculatum.* We were unable to find strong similarities between 48 sites used to define Frost Hollow Grassy Woodlands and any of the 884 sites located in state forests in our study area.

4.2.2 Relationships with UMC communities

Pairwise comparisons of the communities regarded as being included in Tableland Snow Gum by Armstrong et al. (2012) are shown in Table 6. Community p22 is defined as both the broader SCIVI p22 which includes communities u179 and u78 of UMC and the segregate UMC p22 which excludes the latter two communities. These comparisons use only the plots allocated to the various communities by Armstrong et al. (2012) and do not consider additional allocations which we have made from our present study. Comparisons are ranked by increasing summed AIC/number of species ratio, which indicates decreasing similarity. The results indicate that the three segregates of SCIVI p22 and the pair MU11 and p220 are most similar to each other and u118 is relatively more similar to SCIVI p22 than other communities regarded as equivalent to Tableland Snow Gum. Of the communities regarded by UMG as Tableland Snow Gum, u118 is most similar to the p22 component of Tableland Snow Gum and p220 is most similar to the MU11 component. We have excluded p220, p420 and p520 from Tableland Snow Gum because they are all omitted from the final determination. On that basis, the results provide no evidence for including u27 in Tableland Snow Gum, because it is less similar than the three communities which are excluded. Relationships are less clear for u118. We have excluded it because it is less similar to any Tableland Snow Gum component than the excluded p220 is to the MU11 component of Tableland Snow Gum.

Table 6: Pairwise comparisons of communities from multivariate regression using ratio summed AIC/number of species

Community pair		SumAIC/number of species
p22UMC	u78	0.7
MU11	p220	0.9
u78	u179	1.2
p22UMC	u179	1.4
p22scivi	u118	1.4
u78	u118	1.8
u179	u118	2.3
p22scivi	p220	3.2
p22scivi	p520	3.6
u179	u27	5.0
u78	u27	5.4
p22scivi	u27	7.2

4.2.3 Comparison of Tableland Snow Gum assemblage with related communities

Based on proportion of Tableland Snow Gum assemblage species in equivalent-sized samples of plots, community p22 (SCIVI) is clearly most closely concordant with the Tableland Snow Gum assemblage list (Table 7), consistent with the threat assessment in the final determination being based almost entirely on this community. This table uses allocations which had been made at the time of the determination, or those made by Armstrong et al. (2012) for UMC communities, but doesn't include additional allocations made in our study. Numbers of plots listed in this table differ from those which result from additional allocations which we have made, but the relationships between the communities and the Tableland Snow Gum assemblage list are consistent with our other results. Table 8 clearly indicates the relatively disparate assemblages in the determination which have a more northerly distribution (MU11, MU15, MU44, MU45 and Unit5). Floristically related communities on the southern tablelands, not included in the determination, are much more closely concordant with the assemblage list than are these disparate elements.

Table 7: Proportion of Tableland Snow Gum assemblage species in equivalent-sized samples of plots

Community	Number of plots	Actual number Tableland Snow Gum species	Expected number of species	Actual/expected as proportion of Tableland Snow Gum list
p22	58	56	56	0.97
u78	27	50	53.8	0.9
p220	54	50	56	0.86
p520	42	47	55.6	0.82
p420	8	34	40.7	0.81

Community	Number of plots	Actual number Tableland Snow Gum species	Expected number of species	Actual/expected as proportion of Tableland Snow Gum list
u27	12	38	47.6	0.77
MU11	18	38	51.3	0.72
u118	14	36	49	0.71
MU15	3	20	29.2	0.66
MU44	2	12	21.6	0.54
Unit5	8	22	42.1	0.5
Mu45	4	14	32.2	0.42

4.2.4 Evidence of occurrence on state forest

We assessed ten plots in state forest as Tableland Snow Gum, five with a high degree of confidence and five which are also related to other communities and which we assessed as Tableland Snow Gum in a precautionary context. The ten plots are listed in Table 8, which shows membership of communities from the fuzzy clustering results of Analysis 2 described in Section 2.4.1. Of the state forests subject to assessment, only Ben Bullen State Forest has plots which unambiguously belong to any of the communities cited in the final determination. If it is assumed that all of communities MU11 and MU15 are Tableland Snow Gum, despite the uncertainty in the determination, then there is clear evidence that Tableland Snow Gum occurs in Ben Bullen State Forest. A single plot in Newnes State Forest provides evidence that Tableland Snow Gum may also occur in that State forest. On the Southern Tablelands, two plots in Tallaganda State Forest have ambiguous relationships to MU11, despite being geographically disjunct from the Central Tablelands where this community occurs. These plots are not closely related to any other community, but they have a low but potentially significant membership of p22 and thus we have assessed them as Tableland Snow Gum for the purpose of our project. In both cases the plots are close to the boundary between state forest and cleared land and they may represent a marginal expression of areas of Tableland Snow Gum which were formerly present in land adjacent to the state forest prior to clearing. We have no evidence that Tableland Snow Gum occurs in any other state forest.

Table 8: Relationships of plots in state forests which may belong to Tableland Snow Gum

State Forest	SiteNo	Com.1	Mem.1	Com.2	Mem.2	Com.3	Mem.3
Ben Bullen State Forest	CLN57A0F	MU15	1	p520	<0.01	MU11	<0.01
Ben Bullen State Forest	LTH79A0F	MU15	1	MU11	<0.01	p220	<0.01
Ben Bullen State Forest	LTH78P5L	MU11	0.97	p220	<0.01	p23	<0.01
Ben Bullen State Forest	CLN58P0L	MU11	0.94	p20	0.01	u22	0.01
Ben Bullen State Forest	CLN59N5L	MU11	0.81	p23	0.02	p54	0.02
Ben Bullen State Forest	BAALB05	MU45	0.28	p23	0.08	M9	0.07
Ben Bullen State Forest	CBL54A6L	MU11	0.25	u22	0.23	m31	0.07
Newnes State Forest	LTH72N0F	MU45	0.43	u22	0.11	p15	0.07
Tallaganda State Forest	TND01O8L	MU11	0.46	p520	0.15	p22	0.09
Tallaganda State Forest	TND04O5L	MU11	0.32	p220	0.14	p22	0.13

Note: Communities (Com.) and membership (Mem.) are shown, in order of decreasing membership left to right, from fuzzy clustering results, using analysis 2.

Photo 2: Ben Bullen State Forest near Lithgow on the Central Tablelands includes around 800 hectares of Tablelands Snow Gum TEC along drainage flats throughout the forest. The area includes reference sites used to define MU11 (DEC 2006), a vegetation community cited in the final determination as included in the TEC. At this site there are a number of eucalypts including *Eucalyptus pauciflora, E. viminalis, E. rubida, E. dives and E. bridgesiana.* The ground cover is grassy and dominated by *Poa sieberiana* and a scatter of *Themeda triandra* amongst other grasses. Small, low growing shrubs are also present.

Photo 3: Analysis of data from Tallaganda State Forest near Braidwood identified stands of *Eucalyptus pauciflora* with moderate floristic similarity to the central tablelands community MU11 (DEC 2006) but only a very weak association with Frost Hollow Grassy Woodlands (p22; Tozer et al. 2010). We adopted a precautionary approach and identified stands such as these as meeting the definition of the Tablelands Snow Gum TEC.

4.2.5 Relationships of Tableland Snow Gum with other vegetation with similar overstorey

The eucalypts listed as canopy dominants in Tableland Snow Gum in the final determination (one or more of *Eucalyptus pauciflora*, *E. rubida*, *E. stellulata* and *E. viminalis* either singly or in combinations) are widespread and common species within the Bioregions in which Tableland Snow Gum is defined to occur. These species also occur as dominants in many other communities which are not listed in the determination and which are regarded as not Tableland Snow Gum for this project. Of the 8638 plots used for analyses, 1004 non-Tableland Snow Gum plots had one of more of these species as canopy dominants. These 1004 plots were distributed among 39 non-Tableland Snow Gum communities. Twelve of these communities were each represented by 20 or more plots with Tableland Snow Gum eucalypts (Table 9) and include the communities which are floristically most similar to Tableland Snow Gum. There are some communities with a higher proportion of plots dominated by Tableland Snow Gum eucalypts than Tableland Snow Gum, including communities such as m31, u23 and u118, which are not particularly closely related floristically.

Communities with a relatively large mean difference in AIC will usually be distinguishable from Tableland Snow Gum with a high degree of confidence, based on key diagnostic species. For example, for p338 the presence of any three of the first five diagnostic species listed for this community in Table 9 below, in a 20 metre x 20 metre plot, will correctly diagnose p338 (compared to Tableland Snow Gum) on at least 88% of occasions and may incorrectly conclude that the area is not Tableland Snow Gum on no more than 4% of occasions. There is far less certainty of correct diagnosis for similar communities. For example, for p420, the most similar community, a plot with any three of the ten diagnostic species will be correctly diagnosed on 77% of occasions, but the risk of incorrectly concluding that the area is not Tableland Snow Gum rises to a maximum of 16%. For these and other similar communities, more detailed floristic analysis is needed for greater confidence.

Table 9: Communities which are often dominated by Tableland Snow Gum eucalypts (one or more of *Eucalyptus pauciflora, E. rubida, E. stellulata and E. viminalis*).

Community	Diagnostic species	Sum AIC	Plots with TSG eucalypts	Total plots
p520	*Lomandra longifolia, Rubus parviflorus, Carex appressa, Eucalyptus viminalis, Acaena novae-zelandiae, Adiantum aethiopicum, Stellaria pungensDichondra repens, Poa labillardieri, Echinopogon ovatus*	3.0	91	113
u22	*Asperula scoparia, Clematis aristata, Platylobium formosum, Lomandra longifolia, Eucalyptus dalrympleana, Coprosma hirtella, Stellaria pungens, Eucalyptus robertsonii, Olearia erubescens, Dianella tasmanica*	30.9	91	234
p338	*Pteridium esculentum, Viola hederacea, Dianella tasmanica, Lagenophora stipitata, Leucopogon lanceolatus, Clematis aristata, Lomandra longifolia, Poa meionectes, Eucalyptus fastigata, Eucalyptus radiata*	10.2	52	251
p220	*Eucalyptus viminalis, Senecio prenanthoides, Glycine clandestina, Lomandra longifolia, Poa meionectes, Pteridium esculentum, Acrotriche serrulata, Acacia melanoxylon, Asperula scoparia, Hovea linearis*	1.8	55	60
m31	*Cassinia longifolia, Chrysocephalum semipapposum, Acacia dealbata, Acacia rubida, Leucopogon fletcheri, Bossiaea buxifolia, Clematis leptophylla, Pultenaea procumbens, Exocarpos strictus, Ozothamnus conditus*	1.6	47	54
p420	*Hydrocotyle laxiflora, Eucalyptus viminalis, Carex incomitata, Pteridium esculentum, Einadia hastata, Rumex brownii, Austrostipa rudis, Eucalyptus mellidora, Clematis glycinoides, Cotula australis*	0.9	38	48

Community	Diagnostic species	Sum AIC	Plots with TSG eucalypts	Total plots
u21	*Eucalyptus dives, Hibbertia obtusifolia, Hovea linearis, Pultenaea procumbens, Brachylona daphnoides, Rytisperma pallida, Acacia rubida, Cassinia longifolia, Melichrus urceolatus, Leucopogon fletcheri*	5.1	33	93
u28	*Daviesia mimosoides, Daviesia ulicifolia, Perschap, Stellaria pungens, Lomandra longifolia, Senecio gunnii, Tetratheca bauerifolia, Derwentia perfoliata, Bossiaea foliosa, Ozothamnus thyrsoideus*	4.0	35	56
u23	*Epacris breviflora, Leptospermum myrtifolium, Baeckea utilis, Pratia pedunculata, Gonocarpus micranthus, Acaena novae-zelandiae, Hakea microcarpa, Blechnum pennamarina, Acrophyllum hookeri, Stylidium graminifolium (s.l.)*	3.7	25	33
u118	*Eucalyptus stellulata, Acrothamnus hookeri, Asperula scoparia, Pimelea pauciflora, Senecio gunnii, Stellaria pungens, Ranunculus scap, Acaena ovina, Acaena novae-zelandiae, Hakea microcarpa*	1.7	25	27
p23	*Goodenia hederacea, Gonocarpus tetragynus, Eucalyptus macrorhyncha, Lomandra filiformis, Hibbertia obtusifolia, Melichrus urceolatus, Hardenbergia violacea, Hypericum gramineum, Cheilanthes sieberi, Hydrocotyle laxiflora*	3.9	15	194
e59	*Empodisma minus, Hakea microcarpa, Baloskion australe, Epacris paludosa, Baeckea utilis, Asperula gunnii, Gonocarpus micranthus, Ranunculus pimpinellifolius, Carex gaudichaudiana, Epacris breviflora*	6.3	21	73

Note: Diagnostic species listed in this table are derived from all plots in a community, not just those with Tableland Snow Gum eucalypts. Only the ten species most strongly diagnostic of the community in each row are shown, in order of decreasing diagnostic value based on difference in AIC compared to a null model. Those in bold have a recorded frequency of <5% in Tableland Snow Gum plots and the presence of one of more of these species is strongly indicative of an area not being Tableland Snow Gum. Communities which are closely related to Tableland Snow Gum as indicated by sum AIC <3 (such as p420) may not always be readily distinguished from Tableland Snow Gum using just a few key diagnostic key species and may need more detailed analysis. For comparison, there is relatively greater difference (sum AIC = 3.6) between the p22 and MU11 components of Tableland Snow Gum, than between Tableland Snow Gum and some other communities.

Photo 4: There are many forests and woodlands on the Southern Tablelands that share the same eucalypt species with Tablelands Snow Gum TEC. Here, near Snowball in the southern areas of Tallaganda State Forest, a regenerating stand of ribbon gum *Eucalyptus viminalis* and snow gum *E. pauciflora* occupies cold air drainage flats. Our analysis concluded that these forests are most strongly related to Tablelands Flats Forest (p220 of Tozer et al. 2010), a community that is not cited in the final determination for Tablelands Snow Gum TEC.

Photo 5: The margins of tableland peatlands and bogs are habitats where *Eucalyptus pauciflora*, *E. stellulata* and *E. viminalis* are commonly encountered. Here in Glenbog State Forest the open woodland also includes *E. dalrympleana*. We have excluded these communities from Tablelands Snow Gum TEC because they share more in common with Western Montane Wet Heath/Herb Grass Woodland (g124) of Gellie (2005). This community is not cited in the final determination.

4.2.6 Communities in mapped forest types dominated by Tableland Snow Gum eucalypts

Mapped Forest Types (FCNSW RN17) in which Tableland Snow Gum eucalypts are dominant or co-dominant cover approximately 43,500 hectares of state forest in the study area. Nineteen communities are represented by plot data in these forest types as mapped (Table 10). The most extensive communities are u22, predominantly in Forest Type 140 in which *Eucalyptus dalrympleana* and *E. pauciflora* are co-dominant and p338, mostly in Forest Type 159 in which *E. dalrympleana* or *E. viminalis* is dominant. From plot data, Tableland Snow Gum occurs only in mapped Forest Types 140d and 141, but some Forest Types of restricted extent have not been sampled by floristic plots and may include Tableland Snow Gum. These are listed in Table 11 with our subjective assessment of the likelihood of these types containing Tableland Snow Gum based on consideration of location, landform and nearby plot data is briefly described below.

Table 10: Distribution of plots among Forest Types with Tableland Snow Gum eucalypts.

Forest Type	Main dominant eucalypts	Number of polygons	Total area (ha)	Number of Plots	Plot allocations
136	*E.pauciflora - E.stellulata*	13	247	2	u23
137	*E.stellulata*	20	431	0	
137/220	*E.stellulata*	2	16	0	
138	*E.pauciflora*	126	2082	9	three in u22; one in each of e24, g95, p220, p520, u118, u23
138/143	*E.pauciflora/E.ovata/ E.aggregata/E.camphora*	2	26	0	
138/234	*E.pauciflora*	1	23	0	
138n	*E.pauciflora*	7	72	0	
140	*E.pauciflora – E.dalrympleana/E.viminalis*	279	20113	39	30 in u22; four in u23; one in each of g82, p338, u118, u28
140d	*E.pauciflora – E.dalrympleana/E.viminalis*	26	384	2	one in each of MU11, u118
140n	*E.pauciflora – E.dalrympleana/E viminalis*	4	32	0	
140r	*E.pauciflora – E.dalrympleana/E.viminalis*	1	25	1	p520
140v	*E.pauciflora – E.dalrympleana/E viminalis*	12	60	1	p220
141	*E.rubida*	8	82	2	one in each of e24, MU11
143	*E.ovata/E.aggregata/ E.camphora*	95	1039	2	one in each of M10, u22
143/159	*E.ovata/E.aggregata/ E.camphora/ E.dalrympleana/E.viminalis*	6	96	0	
143/231	*E.ovata/E.aggregata/ E.camphora*	5	137	0	

Forest Type	Main dominant eucalypts	Number of polygons	Total area (ha)	Number of Plots	Plot allocations
143+214	*E.ovata/E.aggregata/ E.camphora*	1	10	0	
143+224	*E.ovata/E.aggregata/ E.camphora*	1	10	0	
144	*E.pauciflora - E.dives*	3	18	0	
159	*E.dalrympleana/E viminalis*	461	10895	31	10 in p338; six in u22; two in each of g82, p220, u23; one in each of e17, e26, e59, g23, M5, p15, p520
159/165	*E.dalrympleana/ E.viminalis/E smithii*	2	32	0	
159/166	*E.dalrympleana/E.viminalis/E.elata*	8	69	0	
159+214	*E.dalrympleana/E.viminalis*	2	15	0	
159d	*E.dalrympleana/E.viminalis*	119	4890	8	three in e24; two in each of p338, p520; one in u23
159r	*E.dalrympleana/E.viminalis*	1	4	1	p220
159v	*E.dalrympleana/E.viminalis*	175	2655	17	seven in p338; three in p520; two in p220; one in each of e24, e59, e85, M5, u23

Table 11: Assessment of likelihood of Tableland Snow Gum occurring in Forest Types with Tableland Snow Gum eucalypts not sampled by floristic plots.

Forest Type(s)	Likelihood of Tableland Snow Gum
137 and 137/220	Very unlikely in Bondo, Bago and Maragle SFs, where there is no evidence of the occurrence of Tableland Snow Gum and five plots in which *E.stellulata* is dominant belong to u22, u23 and u118. There is a single patch in Glenbog SF, about 100m from a plot allocated to p520. This patch is on a mid-slope and no Tableland Snow Gum has been modelled in the near vicinity. It is very unlikely to be Tableland Snow Gum.
138/143	Very unlikely. A single patch split by a road, in Maragle SF, where there is no evidence of the occurrence of Tableland Snow Gum. Nearby plots belong to u22.
138/234	Very unlikely. A single patch on a steep rocky ridge and adjacent slope.
138n	Very unlikely. All on ridges or moderately steep slopes, with very low modelled probability of Tableland Snow Gum (<0.08). Mapped areas outside SF are sampled by two plots which belong to e24, consistent with the landscape position occupied by this map type.
140n	Very unlikely. All on ridges or moderately steep slopes, with very low modelled probability of Tableland Snow Gum (<0.08).
143/159	Very unlikely, undulating topography but very low modelled probability of Tableland Snow Gum and other communities sampled nearby. Large but poorly sampled patch in Bungongo SF field checked and found to not be Tableland Snow Gum.
143/231	Not Tableland Snow Gum. Yambulla and Nungatta SFs at 350-400 m elevation.
143+214	Not Tableland Snow Gum. E. ovata in Nadgee SF at elevation of 50m.
143+224	Not Tableland Snow Gum. E. ovata in Nadgee SF at elevation of 80m.
144	Not Tableland Snow Gum. Ridge crests in moderately steep topography.

Forest Type(s)	Likelihood of Tableland Snow Gum
159/165 and 159/166	Not Tableland Snow Gum. Mapped in gullies in areas of steep topography below 450 m elevation.
159+214	Not Tableland Snow Gum. *E.viminalis* in Nadgee SF at elevation of 50m.

We assessed other areas mapped as 140d and 141 for the likelihood of Tableland Snow Gum. Forest Type 140d is mapped in Glenbog and Tallaganda State Forest, but the single patch in Tallaganda State Forest which contains the plot allocated to MU11 is the only patch where the modelled probability is >0.1. Otherwise, this mapped type is most likely to contain u118 or p338, consistent with most nearby plots. Forest Type 141 is mapped only in Tallaganda State Forest. Mapped areas were carefully checked with API and candidate areas of Tableland Snow Gum delineated.

4.2.7 Field key and defining floristic attributes

The combination of several relatively distinct floristic elements in Tableland Snow Gum, as described by the final determination, increases the difficulty of devising a field identification key for Tableland Snow Gum as a whole. The inclusion of the geographically isolated and floristically disparate Unit 5 is a particular problem for identifying diagnostic floristic characteristics, because the resulting composite is such a floristically heterogeneous mixture. Because Unit 5 may be distinguished by its location (there is no evidence that it occurs beyond the immediate vicinity of Mount Canobolas) and because it is outside our study area, we have excluded it from analyses to determine diagnostic species. In all cases, field diagnosis should be based on samples in 20 metre x 20 metre plots or an equivalent area.

We have investigated floristic diagnostics for field identification in two different contexts. Firstly, we have considered a narrow interpretation based solely on plots allocated to p22 by Tozer et al. (2010). This may be appropriate if Tableland Snow Gum is interpreted primarily by reference to the assemblage list in the final determination, as that list appears to be derived almost entirely from p22. Tozer et al. (2010) suggest that p22 can be correctly diagnosed, when it is present, with a confidence of 95% if eight or more of their 61 positive diagnostic species occur in a plot, provided the plot contains at least 16 native species in total. From our pool of 8638 plots, this rule will result in a plot being correctly attributed to p22 with a likelihood of only 0.04, relative to the plots in other communities which also meet the criterion (i.e. 96% of the 1359 plots which meet this criterion are not p22, but belong to other, related or not closely related, communities). It is possible to increase the likelihood of correctly diagnosing p22 without affecting the likelihood of incorrectly concluding that it was absent by using a smaller pool of the most strongly diagnostic species.

For example, the presence of at least five of the 20 most strongly diagnostic species (*Themeda australis*, *Chrysocephalum apiculatum*, *Calocephalus citreus*, *Eucalyptus pauciflora*, *Leptorhynchos squamatus*, *Eryngium rostratum*, *Tricoryne elatior*, *Asperula conferta*, *Haloragis heterophylla*, *Leptospermum squarrosum*, *Microtis unifolia*, *Eucalyptus rubida*, *Hypericum gramineum*, *Plantago gaudichaudiana*, *Gonocarpus tetragynus*, *Dichopogon fimbriatus*, *Aristida ramosa*, *Scleranthus biflorus*, *Elymus scaber*, *Kunzea parviflora*) increases the likelihood of correctly identifying p22 to 0.1. However, the fact remains that there are many similar communities which will be incorrectly identified as p22 using any simple criterion.

Secondly, we have attempted to diagnose Tableland Snow Gum as a single entity including all of the elements p22, MU11, MU15, MU44 and MU45 (but not Unit 5) in the context of all samples. Appendix B provides an example of a field key using the most strongly diagnostic species. The best result comes from using a combination of species diagnostic of Tableland Snow Gum with species diagnostic of communities other than Tableland Snow Gum.

The likelihood of correctly diagnosing Tableland Snow Gum would increase if it were defined to be more floristically homogeneous than is currently the case. Much of the confusion arises because the final determination includes several relatively heterogeneous elements but omits communities most closely related to each of these elements.

In all cases, selecting rules around diagnostic species which minimise the likelihood of incorrectly concluding that Tableland Snow Gum is absent will always result in a relatively high likelihood that an area will be identified as Tableland Snow Gum when it is not, due to the substantial floristic overlap between Tableland Snow Gum and related communities. This may be appropriate if a conservative outcome is desired, or if the key is used as a preliminary filter, to distinguish areas which are most likely not Tableland Snow Gum from those which could belong to Tableland Snow Gum and are worthy of more detailed survey or further investigation.

4.3 Indicative TEC mapping

4.3.1 Validation and final indicative maps

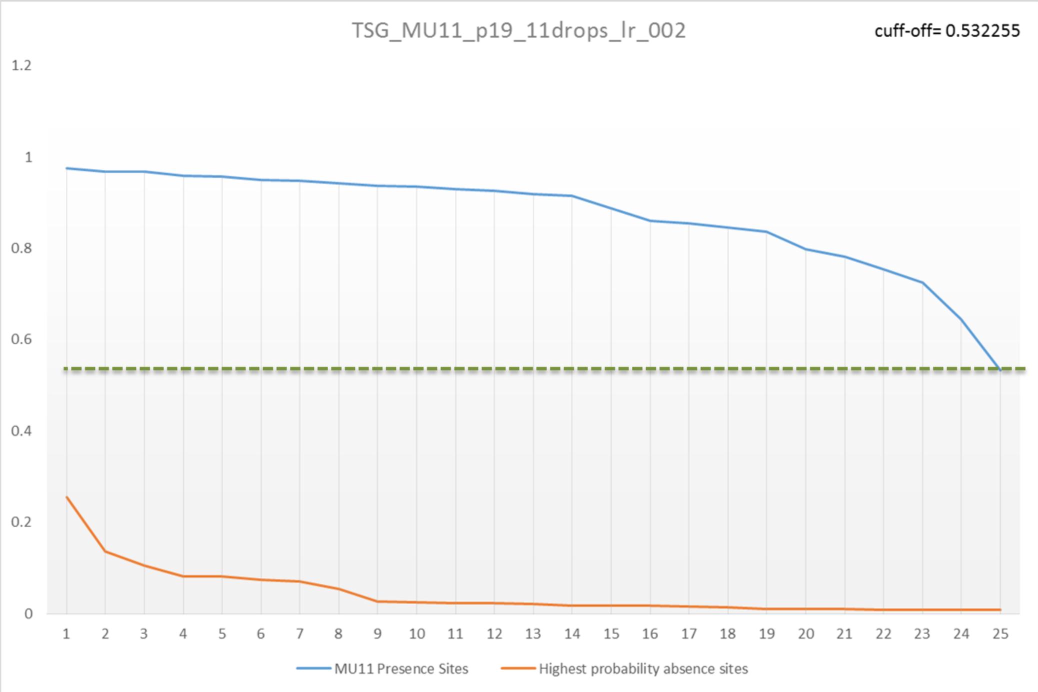
We used the niche-based modelling approaches described in section 2.5 to identify the potential distribution of the vegetation types that are presentative of Tableland Snow Gum, as well as other non-related types in a multi-class distribution model. The predicted distributions for the Tableland Snow Gum classes of interest in the multi-class model were generally very similar to the individual presence-absence models. Since the multi-class models were not used for any prescriptive assessment, they are not considered further in this report, other than as a summary of the overall model performance (Fig. 3).

Figure 4 shows the ranked probability of occurrence (PoO) values at all sites representative of MU11 and P22 plotted along-side the ranked PoO values of the corresponding number of highest ranked absence sites. PoO values for presence sites are generally much higher than those of absences sites (with very minor overlap in the p22 model), indicating that the model performance is good. In the case of MU11, a clear PoO cut-off of 0.55 can be set, where we are confident of not over predicting false absences. In the case of p22, a somewhat obituary judgement needs to be made as to what threshold predicts near 100% of known TEC sites, while minimising the overall rate of false absence predictions. Here a threshold of 0.16 was set, which in effect incorrectly predicts two of the 48 known p22 sites (both of which are actually marginal examples of the community). The p22 model incorrectly predicts as presences, just 10 of the 7000 or so absence sites. The predicted distributions for the P22 and MU11 communities are shown in maps 3-6.

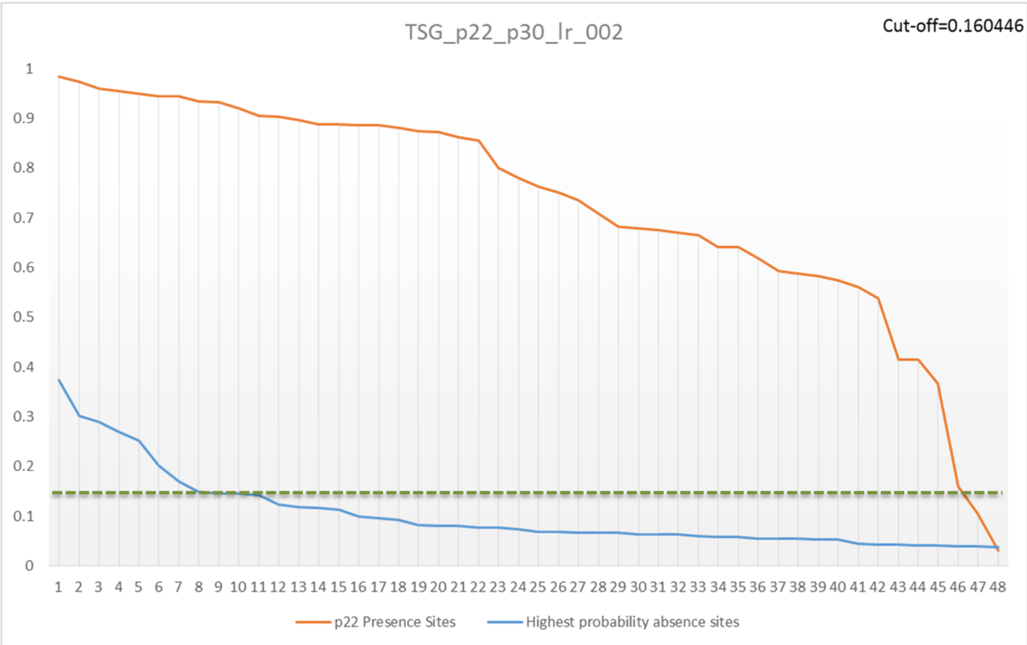
	e24	e26	e59	g152	g157	g94	m31	m36	m68	MU11	MU45	OTHER	p14	p15	p17	p19	p20	p22	p220	p23	p24	p27	p338	p420	p520	p54	p9	u118	u179	u21	u22	u23	u27	u28	u78	Unit5
e24	**26**	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0
e26	0	**35**	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0
e59	1	0	**33**	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
g152	0	0	0	**22**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
g157	0	0	0	0	**9**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
g94	0	0	0	0	0	**19**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
m31	1	0	0	0	0	0	**29**	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0
m36	0	0	0	0	0	0	0	**31**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
m68	0	0	0	0	0	0	0	0	**8**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MU11	0	0	0	0	0	0	0	0	0	**23**	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MU45	1	0	0	0	0	0	0	0	0	0	**17**	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
OTHER	14	22	22	3	0	0	2	0	6	5	4	**4958**	47	13	2	16	8	0	5	22	4	0	77	2	16	9	17	1	1	7	14	0	1	3	3	0
p14	0	0	0	2	0	1	1	0	0	0	2	16	**303**	0	0	20	4	0	0	14	3	0	0	1	1	0	5	0	0	5	1	0	0	0	2	0
p15	0	0	0	0	0	0	0	0	0	0	0	0	0	**25**	0	0	0	0	0	1	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
p17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**7**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
p19	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	**24**	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
p20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**16**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
p22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**8**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
p220	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**24**	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
p23	0	0	0	0	0	0	0	0	0	0	0	1	3	0	0	0	0	0	0	**39**	2	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
p24	0	0	0	0	0	0	0	0	0	0	0	2	3	0	0	0	0	0	0	0	**36**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
p27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**13**	0	0	0	0	0	0	0	0	0	0	0	0	0	0
p338	3	2	1	0	0	0	0	0	0	0	0	16	0	0	0	0	1	1	1	0	0	0	**104**	0	1	0	0	0	0	0	0	0	0	0	0	0
p420	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**17**	0	0	0	0	0	0	0	0	0	0	0	0
p520	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1	0	0	0	0	0	0	0	0	**28**	0	0	0	0	0	1	0	0	0	0	0
p54	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**15**	0	0	0	0	0	0	0	0	0	0
p9	0	0	0	0	0	0	0	0	0	0	0	12	2	0	0	0	0	0	0	2	0	0	0	0	0	0	**46**	0	0	0	0	0	0	0	0	0
u118	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**18**	0	0	0	0	0	1	0	0
u179	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**21**	0	0	0	0	0	0	0
u21	0	0	0	0	0	0	1	0	0	0	0	3	7	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	**50**	0	0	0	0	0	0
u22	0	0	3	0	0	0	0	0	0	0	1	11	4	0	0	0	0	0	0	0	0	0	10	0	1	0	0	0	0	0	**188**	5	0	0	0	0
u23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**12**	0	0	0	0
u27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**14**	0	0	0
u28	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1	0	**38**	0	0
u78	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**23**	0
Unit5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**28**
N	46	59	60	27	9	20	33	32	14	28	24	5034	370	38	9	61	29	9	30	78	45	13	196	20	50	24	71	19	22	66	207	19	15	42	28	28
CorrectPredictions	0.5652	0.5932	0.55	0.8148	1	0.95	0.8788	0.9688	0.57	0.82	0.71	0.985	0.82	0.66	0.78	0.39	0.55	0.89	0.8	0.5	0.8	1	0.53	0.85	0.56	0.63	0.65	0.95	0.95	0.76	0.91	0.63	0.93	0.9	0.82	1

Figure 3: Example of confusion matrix used to evaluate the performance of a multiclass model with 37 predictor variables. The communities that were originally of specific interest are highlighted in grey. Note the TEC project panel subsequently made a decision only MU11 and P22 were representative of the TEC.

a)

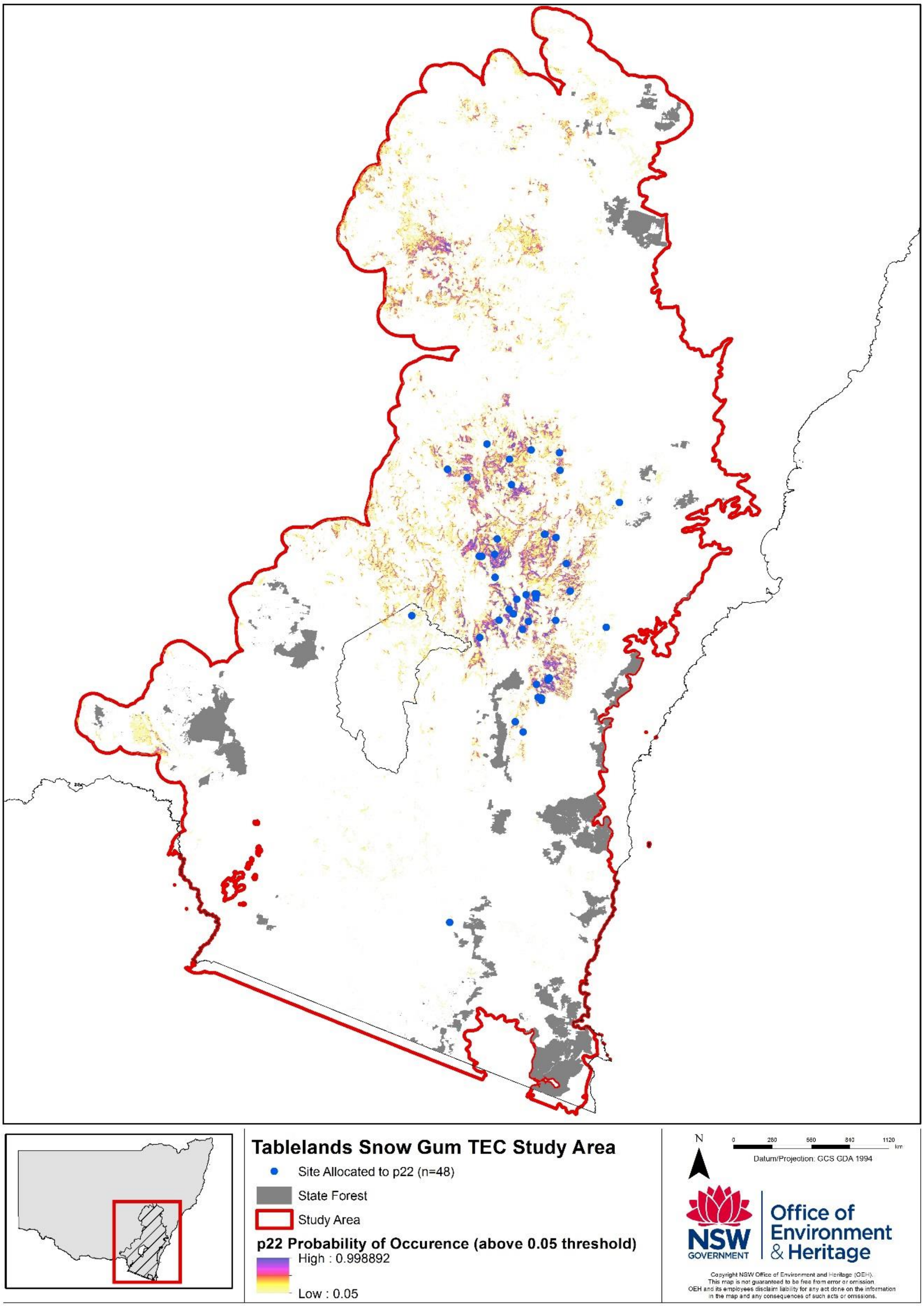


b)

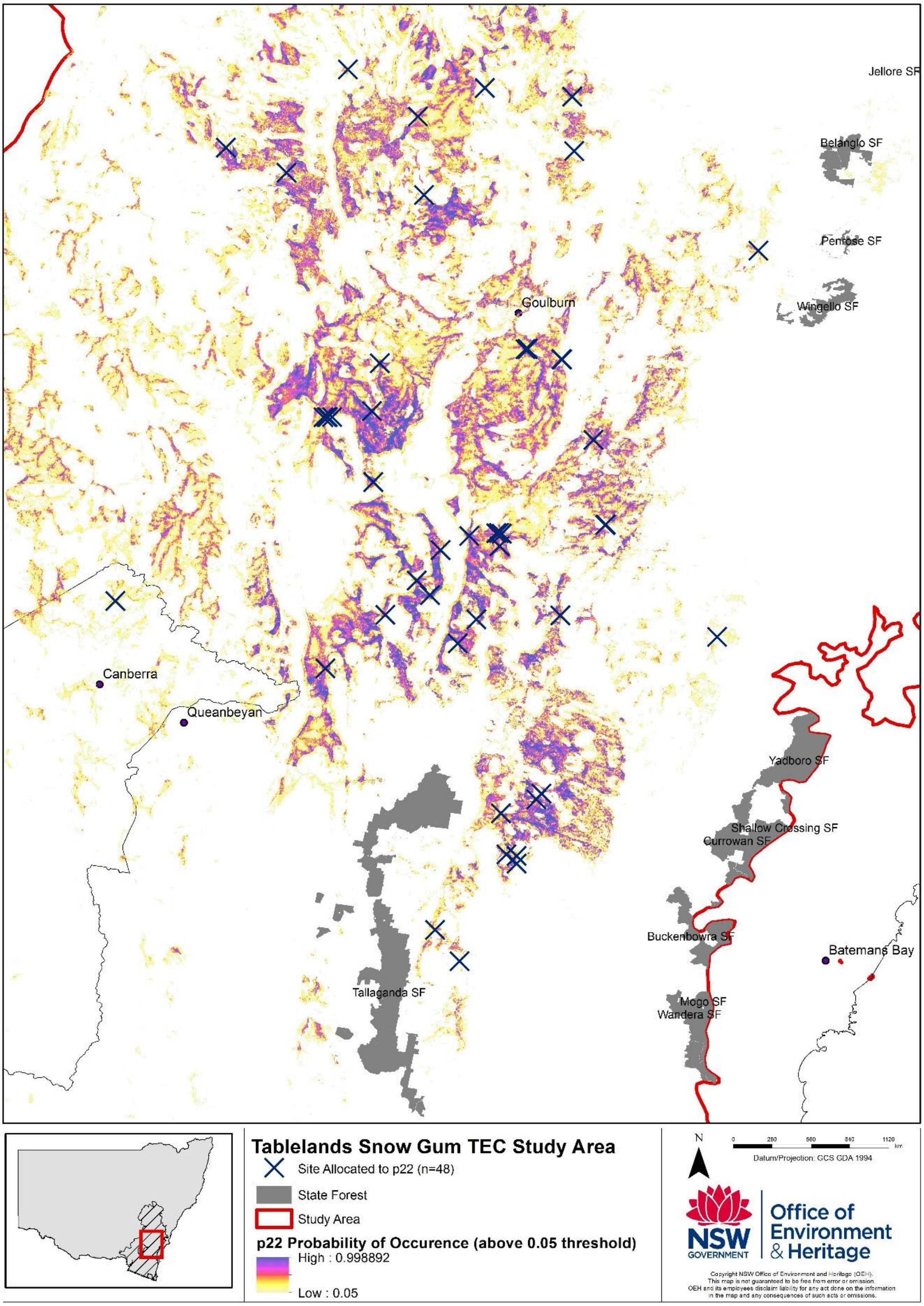


<u>Figure 4:</u> Process used to select a probability threshold above which, if the model predicts into a state forest, then we consider that state forest to be a TEC candidate. Further investigations are then required using field surveys and API mapping techniques.

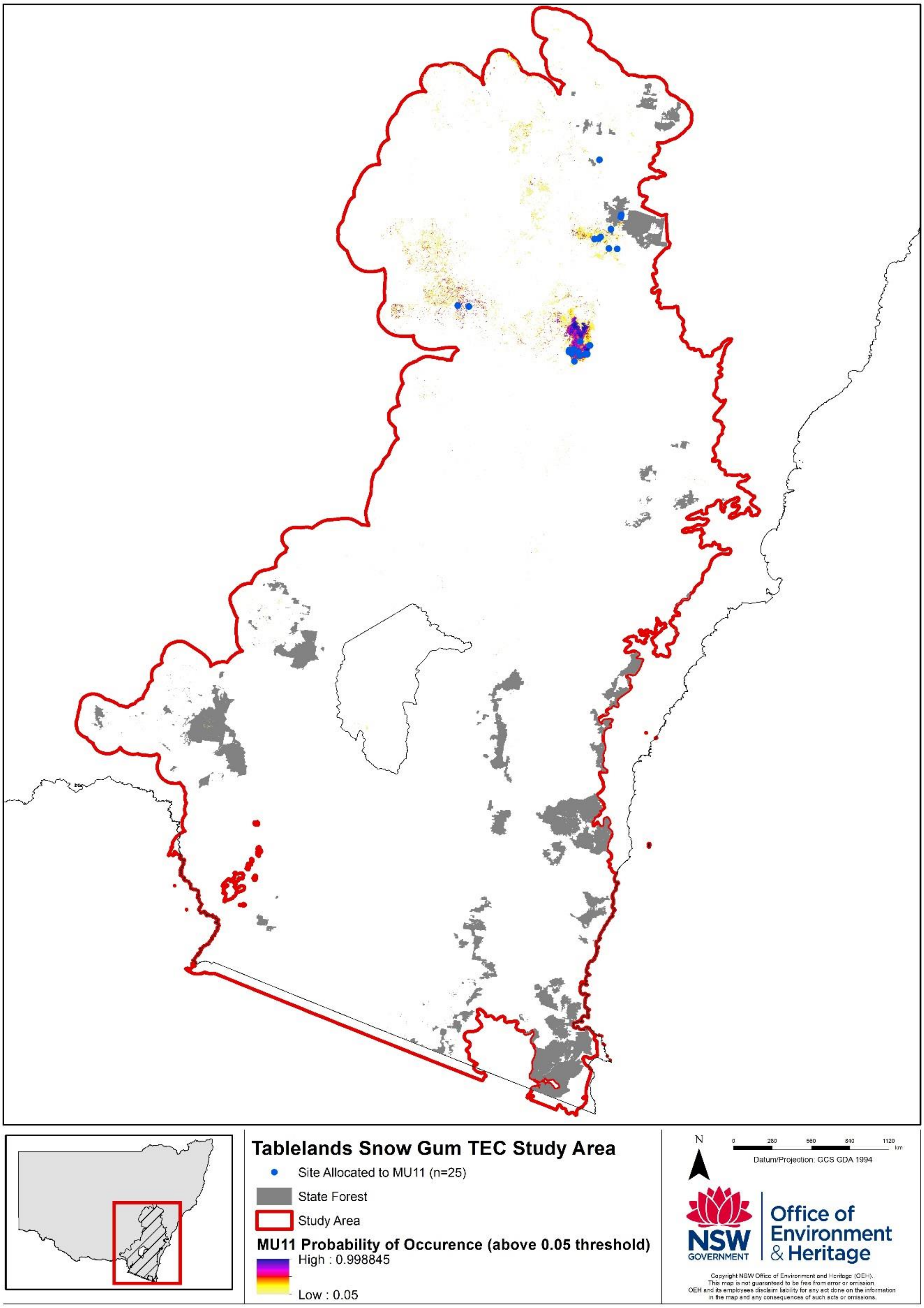
Map 3: **Predicted occurrence of p22 based on presence-absence model.**



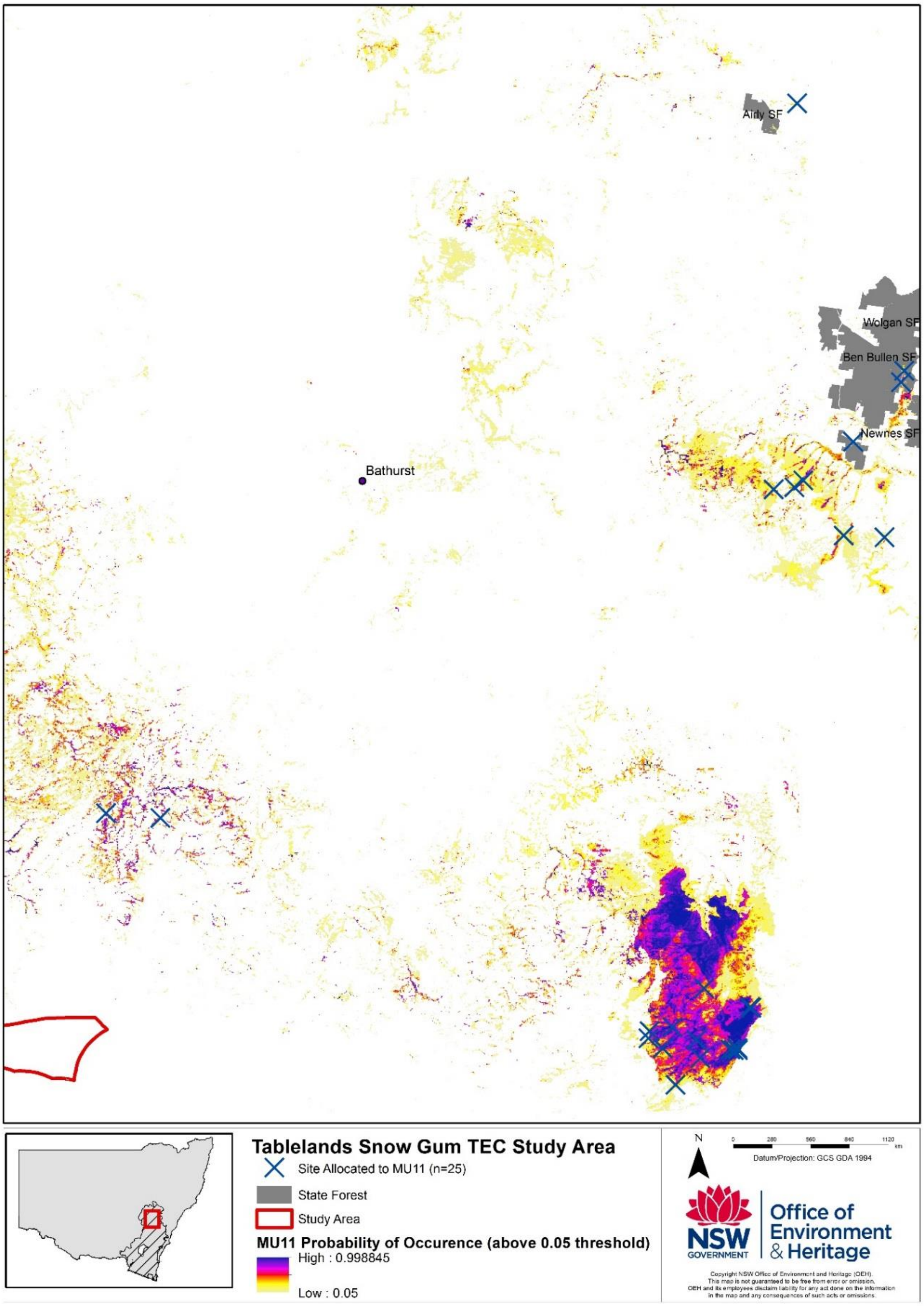
Map 4: **A close-up view of the modelled distribution of p22 in the Queanbeyan-Braidwood Area.**



Map 5: Predicted occurrence of MU11 based on presence-absence model.



Map 6: A close-up view of MU11 nears state forests on the Central Tableland.



4.4 Operational TEC mapping

We mapped approximately 769.1 hectares (in 150 patches) of Western Blue Mountains map units 11 and 15 in Ben Bullen and Newnes State Forests on the central tablelands. We assessed all of this area as Tablelands Snow Gum, in the absence of any information on which components of these map units do not belong to the TEC.

Based on available plot data, there is no clear evidence of Tablelands Snow Gum occurring in Southern Tablelands state forests, but a few small areas in Tallaganda State Forest are related to both Frost Hollow Grassy Woodland and MU 11 and we have included them in Tablelands Snow Gum for the purpose of our assessment. We initially mapped approximately 160 hectares of potential Tableland Snow Gum in southern tablelands state forests. Following assessment of plot data in mapped areas and nearby areas in similar environments, of the 160 hectares, we identified approximately 72.4 hectares, all in Tallaganda State Forest, distributed among 19 patches, as Tablelands Snow Gum TEC.

5 Discussion

5.1 Summary

5.1.1 Cited communities and determination species assemblage

Application of the TEC reference panel interpretation principles to Tablelands Snow Gum TEC identified several conflicting sources of information used to define the species assemblage in the final determination. Firstly we found that several of the cited vegetation communities from the Central Tablelands region (MU44, 45 and MU5) were not strongly related to the characteristic species list with primary similarities associated only with canopy species. Secondly we identified that there are at least 39 communities in the region circumscribed by the determination that also share all or some of the characteristic eucalypt species and these have not been included. The strength of the relationship of these communities to the determination species list is variable. For this project we resolved the conflict by assuming that all cited communities met the definition. As these communities do not occur on the state forests identified for assessment we consider they do not impact the outcomes of our project however these conflicts may pose interpretation difficulties on other tenures.

Our analysis also suggests that there are several vegetation communities on the Southern Tablelands that are not cited in the final determination but share a strong association with the characteristic species list. Three of these communities (p220, p420, p520) are described in Tozer et al. (2010); the source that is used as a primary authority for the species data and distribution figures used in the threat assessment based on the included unit p22. There are no statements in the determination that indicate which communities were reviewed and excluded, particularly in this instance where we found relationships with alternate classification units within the same cited source. We found this uncertain as we were required to assume for the purposes of our interpretation, the implicit absence of communities from the determination gave greater weight than our ecological evidence. We excluded them using a key principle of the TEC reference panel where the inclusion of additional communities would substantially expand the current distribution beyond that stated in the threat assessment in the determination.

Several additional findings also added to the difficulties identifying the key floristic attributes of Tablelands Snow Gum. Two Central Tablelands vegetation communities (MU11 and 15) cited in the final determination supported stronger relationships with those excluded vegetation communities (p220, p520) than the primary vegetation classification units cited in the determination. These excluded communities are often found in proximity with Tablelands Snow Gum and can closely resemble each other using visual cues and comparisons of measured species inventories.

We also assessed a recent vegetation classification study from the Upper Murrumbidgee Catchment (Armstrong et al. 2012) which was published after the date of the final Tablelands Snow Gum determination. This study suggested that nine communities from the region were referable to Tablelands Snow Gum. However our analysis suggested that only three of these communities (p22, u78 and u179) were strongly related to the primary vegetation classifications used to define the TEC.

5.1.2 Distribution and habitat descriptors

Our indicative habitat model indicates that the primary distribution of the final determination species assemblage is found across private tenures across the Southern Tablelands between the Braidwood area, Yass and Goulburn with a disjunct area around Bathurst and Orange in the Central Tablelands. There are more than 39 communities that we identified that are also found in this environmental envelope.

Indirectly we could find no evidence that the primary assemblage (p22) occurs above 1000 metres above sea level. Our data indicates that the core distribution lies between 600 to 900 metres above sea level. However with the inclusion of the additional Central Tablelands units MU11, 15 and 5 are added to the interpretation of the determination then the elevation thresholds rise above 1000 metres with MU5 at Mt Canobolas situated at 1390 metres above sea level. However the floristic assemblage of sites on this Central Tablelands peak are very weakly related to the characteristic species list.

We also found that locations of the species assemblage are most strongly associated with landscapes marked by wide open valleys and open exposed gentle undulating hills on the Southern Tablelands. We rarely found it associated with narrow drainage flats or swamp margins located within steeper hills and elevated ranges. However the inclusion of MU11 and 15 is contrary to the patterns on the southern tablelands. These communities are more commonly associated with narrow drainage flats and frost hollows. The inclusion of MU5 from Mt Canobolas is a significant outlier that is not associated with these landscapes and instead is a prominent basalt peak rising above the Central Tablelands.

5.2 TEC Panel review and assessment

5.2.1 Summary of discussions

A summary paper of issues was presented to the TEC Panel and discussed at the meeting held on 14 October 2015. The issues and comments from the Panel are shown in Table 12.

Table 12: Summary of issues and Panel review of Tablelands Snow Gum, meeting held 14 October 2015.

Determination	TEC Panel Principles	Our Project	TEC Panel Review
Occurs in '….South Eastern Highlands, Sydney Basin, South East Corner & NSW South Western Slopes Bioregions'	Accept Bioregional Qualifiers	Adopted	Accepted.
'…typically forms an open-forest, woodland or open woodland that transitions into grassland at low tree cover'	Assess vegetation structure descriptors that may constrain or allow a range of structural forms	Sample plots include grassland with no eucalypts; vegetation structure not used to constrain interpretation of the TEC.	Accepted that structure does not constrain interpretation.
Mainly occurs on "… on valley floors, margins of frost hollows, footslopes and undulating hills between approximately 600 and 1400 m in altitude."	Assess habitat descriptors and whether these constrain or define the limits of the TEC which otherwise may have a broader distribution	Habitat used to guide target areas for API	Noted.
Occurs on '…a variety of substrates including granite, basalt, metasediments and Quaternary alluvium.	Assess habitat descriptors and whether these constrain or define the limits of the TEC which otherwise may have a broader distribution	Sample plots occur on a range of substrates; substrate not used to constrain interpretation of the TEC.	Noted and accepted.
TEC 'includes' cited vegetation sources Frost Hollow Grassy Woodlands (Tozer et al. 2010) and Tablelands and Slopes Herb/Grassland/Woodland VG 153 (Gellie 2005) and '…is included in…' Map	Assess references to existing vegetation classification sources in the determination. The panel will note whether the existing classifications are "included within" are "part of" or	Analysed relationships between all plots, including new samples collected on state forest, and samples used to define source classifications. In the absence of guiding qualifiers, adopted all of MU 11, 15, 44 and 45, and community 5, as TEC. Regarded BVT 25 as too broad to be	Accepted broad interpretation which includes all of the communities for which the determination cites that only an

Determination	TEC Panel Principles	Our Project	TEC Panel Review
Units 44 and 45 (NPWS 2003), Broad Vegetation Type (BVT) 25 (DEC 2006a and 2006b), Map Units 11 and 15 (DEC 2006c), and community 5 (Hunter 2002)	"component of" the determination. Classifications developed using traceable quantitative data will be recognised as primary data upon which to assess floristic, habitat and distributional characteristics. Where data has been sourced and used in alternate regional or local classification studies the results will be considered by the panel to assist in the development of the TEC definitional attributes.	informative without qualifying information.	unspecified part is included
Characterised by the list of 58 plant species	Be guided by the species lists presented in the determination Assess references to existing vegetation classification sources in the determination.	Compared species assemblage data drawn from source classifications with that presented in the determination. Found that the determination species list is strongly associated with Frost Hollow Grassy Woodlands (p22) and more weakly associated with MU 11 and 15 (central tablelands) than it is with other southern tablelands communities which share TEC eucalypt dominants or occur in areas conforming with TEC environmental descriptors (e.g. p220, p420, p520). It is very weakly associated with MU 44, 45 and community 5. The inclusion of disparate floristic elements, when considered in the context of the assemblage list and the omission of floristically related communities, creates inconsistency in the determination. Floristically related communities p220, p420 and p520 excluded from TEC because they were not cited in the determination. Several map units described in Armstrong et al. (2012) were published after the date of the determination. In their study they suggest that four of these additional Map Units are equivalent to Tableland Snow Gum. However we found that of these, only u78 and u179 (in part) could be considered referable to the determination assemblage. These are based on segregates from Frost Hollow Grassy Woodlands	Inconsistencies noted. The Panel agreed that floristically related communities p220, p420 and p520 be excluded from Tableland Snow Gum, based on their exclusion from explicit citation in the determination and on their exclusion from the assessment of threat status made by the determination. The Panel agreed that it was appropriate to regard the communities cited by the UMC study as being ‘equivalent to’ Tableland Snow Gum as potentially including Tableland Snow Gum rather than being equivalent. The Panel further accepted that the results of our project indicated that at least some of

Determination	TEC Panel Principles	Our Project	TEC Panel Review
		(p22) and we regarded plots in these map units as Tableland Snow Gum, except where they were more closely related to other previously defined communities. The other two units, u118 and u27 were found to support weaker relationships to the determination assemblage than other Tablelands grassy woodland communities (p220, p420, p520). We excluded these from Tableland Snow Gum.	these communities are most appropriately assessed as not being referable to Tableland Snow Gum.

5.3 Final TEC area mapped in state forests

We mapped a total of 901.6 hectares of Tablelands Snow Gum Woodland TEC in state forests in our study area. Table 13 presents the total area of Tableland Snow Gum TEC which we mapped within each state forest within the study area in which this TEC is present. We did not map Tableland Snow Gum in any other state forest (refer to Table 2 for a list of all assessed state forests).

Table 13: Total area of Tableland Snow Gum mapped across all state forests in the study area.

IFOA	State Forest (SF)	SF Area (ha)	Area of Tableland Snow Gum Mapped in State Forest (ha)
Non-IFOA	Ben Bullen SF	8252	737.6
Non-IFOA	Newnes SF	22575	91.7
Southern IFOA	Tallaganda SF	23909	72.3

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Appendix A

Field key for identification of Tablelands Snow Gum, Black Sallee, Candlebark and Ribbon Gum Grassy Woodland in the South Eastern Highlands, Sydney Basin, South East Corner and NSW South Western Slopes Bioregions TEC

This key assumes the vegetation to be assessed is in one of the bioregions listed in the title. Assessment should be done in 20 metre x 2 metre plots or areas of similar size. The more plots assessed, the more reliable the result. Likelihoods given below use a 95% confidence interval and are for a single plot.

Using this key, there is a high likelihood of incorrectly concluding that Tableland Snow Gum is present, especially in the context of related vegetation. The key is most appropriate if a conservative outcome is desired, or if the key is used as a preliminary filter, to distinguish areas which are most likely not Tableland Snow Gum from those which could belong to Tableland Snow Gum and are worthy of more detailed survey or further investigation. More specific keys may assist in distinguishing Tableland Snow Gum from particular related communities.

Key

1. Are at least two of the species *Eucalyptus pauciflora*, *Themeda australis*, *Chrysocephalum apiculatum*, *Asperula conferta*, *Poa sieberiana*, *Calocephalus citreus*, *Eucalyptus rubida*, *Poa labillardieri*, *Eucalyptus dalrympleana* or *Scleranthus biflorus* present:

   If YES, the vegetation is Tableland Snow Gum with a likelihood of 6-8%; go to 2.
   If NO, the vegetation is NOT Tableland Snow Gum, with a likelihood of incorrect diagnosis of 0-2%.

2. Are any of the species *Lepidosperma laterale*, *Tylophora barbata*, *Pomax umbellata*, *Pandorea pandorana*, *Geitonoplesium cymosum*, *Smilax australis*, *Platysace lanceolata*, *Pratia purpurascens*, *Stellaria flaccida* or *Oplismenus imbecillus* present:

   If YES, the vegetation is NOT Tableland Snow Gum, with a likelihood of incorrect diagnosis of 0-2%.
   If NO, the vegetation is Tableland Snow Gum, with a likelihood of 7-10%; go to 3.

3. Are any of the species *Pratia pedunculata*, *Veronica derwentiana*, *Polyscias sambucifolia*, *Microseris lanceolata*, *Acacia gunnii*, *Senecio gunnii*, *Polystichum proliferum*, *Picris angustifolia*, *Grevillea lanigera*, *Olearia megalophylla*, *Leucopogon fletcheri*, *Arthropodium* species A, *Eucalyptus goniocalyx*, *Eucalyptus delegatensis*, *Geranium neglectum*, *Ranunculus plebeius*, *Pultenaea procumbens*, *Adiantum aethiopicum*, *Poa helmsii* or *Wahlenbergia gloriosa* present:

   If YES, the vegetation is NOT Tableland Snow Gum, with a likelihood of incorrect diagnosis of 0-2%.
   If NO, the vegetation is Tableland Snow Gum, with a likelihood of 12-16%.