Assessment of Montane Peatlands and Swamps EEC on NSW Crown Forest Estate

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

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Environment Protection Authority

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1 Overview

Montane Peatlands and Swamps is a threatened ecological community (TEC) found at mid to high elevations in the coastal, tableland and montane regions of eastern NSW. It is a complex aggregate of a number of previously described freshwater wetland communities that are generally treeless and associated with poorly drained soils. The assemblage forms scattered to dense shrubs characterised by the genera *Epacris*, *Callistemon,* and/or *Hakea* and a ground layer of grasses, sedges and herbs.

The treeless structure of peatlands and swamps often makes them readily identifiable both in the field and using aerial imagery. Which particular assemblages within this broad vegetation formation meet the final determination (the determination) of Montane Peats and Swamps TEC is more complex. For the purposes of our project we considered that the identification of all treeless native vegetation on poorly drained soils within state forests at or above the prescribed elevation threshold would encompass all potential areas of the TEC. We applied a tree cover threshold of less than ten percent to identify candidate treeless native vegetation located at or above 400 metres in elevation. Vegetation attributes encompassed by the mapping criteria included a wide variety of assemblages associated with impeded drainage including swamps, bogs, marshes, fens, meadows, grasslands and herb fields.

We assessed over 828,000 hectares of state forest occurring within the bioregional and elevation qualifiers of the determination. We excluded a number of state forests (or parts of state forest) from assessment because they fell below the elevation threshold or were underlain by Triassic sandstone sediments which are explicitly excluded in the determination and are covered by separate TEC determinations.

Our mapping identified 1792.5 hectares of candidate Montane Peatland and Swamps on State Forest across eastern NSW. The distribution of these wetlands is more extensive across the Southern Tablelands covering more than 60% of the total mapped on state forest. Patch sizes varied with more than 200 patches smaller than 0.1 hectare and around 50 greater than 30 hectares. The largest areas of the candidate TEC were mapped in Bago, Glenbog and Badja State Forests in the south, and Boonoo and Girard State Forests in the north.

We validated the mapping by undertaking an independent mapping assessment of 225 sites located in state forests on the southern tablelands. We examined the level of agreement achieved between two experienced aerial photo interpreters and compared the spatial precision of the mapping boundaries of candidate TEC. Almost 90% of sites achieved agreement between interpreters. An additional four per cent of candidate TEC was mapped by the validating interpreter. Differences were greatest in the assessment of tree cover thresholds. Areas of difference were marked, reassessed then reviewed across the complete coverage. The interpretation of the boundaries of candidate TEC were located on average within eight metres of each other, although we experienced difficulties with our chosen method of accuracy assessment.

The broad mapping criteria applied to the interpretation of this TEC will encompass a high diversity of floristic assemblages across the mapped area. Not all of these assemblages will conform to the determination, and the number and extent of them has not been measured. The mapping outputs are also highly likely to encompass two additional related wetland TECs due to overlapping environmental gradients and vegetation structural attributes. These TECs: Upland wetlands of the drainage divide of the New England Bioregion and Carex Sedgeland of the New England Tableland, Nandewar, Brigalow Belt South and NSW North Coast Bioregions, are both candidate TECs within state forests although these have not been explicitly addressed by this project.

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

Montane Peatlands and Swamps EEC is one of several wetland TECs associated with tableland and montane environments in eastern NSW. Paragraph 1 of the final determination (NSW Scientific Committee 2004) states that the community 'comprises a dense, open or sparse layer of shrubs with soft-leaved sedges, grasses and forbs'. In addition, 'small trees may be present as scattered emergents or absent from the community'. Although scattered emergent is not defined, this statement implies that stands with more than a ‘sparse’ cover of small trees do not belong to the community. Three eucalypt species are included in the assemblage list set out in Paragraph 2. These are *Eucalyptus ovata*, *E. pauciflora* and *E. stellulata*.

Paragraph 4 reiterates the structural characteristics of Montane Peatlands and Swamps as typically supporting 'an open to very sparse layer of shrubs, 1-5 metres tall, including species of *Baeckea, Callistemon* and *Leptospermum*. Species of *Epacris* and *Hakea microcarpa* are also common shrubs. In some peatlands and swamps, particularly those with a history of disturbance to vegetation, soils or hydrology, the shrub layer comprises dense thickets of *Leptospermum* species. In other peatlands and swamps with a history of grazing by domestic livestock, the shrub layer may be very sparse or absent. Montane Peatlands typically have a dense groundcover of sedges, grasses and forbs, except where a dense cover of tall shrubs casts deep shade.

Paragraph 8 of the determination (NSW Scientific Committee 2004) refers to communities or map units described by previous studies, which ‘are ‘included’ or are otherwise related to Montane Peatlands and Swamps.

Paragraph 10 provides some supportive information about the distribution of Montane Peatlands in conservation reserves. This helps to provide some corroborative evidence on the habitat criteria and landscape descriptors useful in locating the extent of the TEC.

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 Montane Peatlands and Swamps is restricted to the IBRA Bioregions stated in the final determination. The Panel considered the characteristic species list but reached agreement that insufficient information was included to diagnose candidate areas at a site scale across the expansive latitudinal gradient circumscribed by the determination.

The Panel agreed that the statements used to define the structural characteristics of Montane Peatlands and Swamps provided a useful diagnostic tool when used in combination with the identified bioregions and minimum elevation thresholds. It considered that the application of precautionary mapping criteria using broad mapping thresholds was likely to result in a more inclusive definition of Montane Peatland and Swamps than efforts to assign individual sites to the determination species assemblage list. The Panel considered that the altitudinal, latitudinal and moisture gradients encompassed by the TEC would underpin a large variation in species composition that would demand a significant sampling effort in order to discriminate

candidate wetlands with confidence. The Panel indicated an equivalent outcome could be achieved by relying on the mapping of the distinctive structural pattern of the vegetation and readily identifiable habitat if the inclusion of a higher proportion of non-target treeless floristic assemblages could be tolerated. The Panel noted that the adoption of such a definition would most likely include other related TECs, including the Upland wetlands of the drainage divide of the New England Bioregion and Carex Sedgeland of the New England Tableland, Nandewar, Brigalow Belt South and NSW North Coast Bioregions, but that these would require separate Panel assessments.

The Panel noted that there are no minimum patch size criteria described in the final determination but highlighted that the spatial characteristics of the TEC is likely to be patchy, small in area and widely distributed.

Table 1 summarises the key determining features of Montane Peatlands and Swamps and how they have been used in the assessment reported here, based on the interpretation of the features by the Panel.

Table 1: Key features of Montane Peatlands and Swamps of potential diagnostic value, Numbers in the left-hand column refer to paragraph numbers in the final determination.

	Feature	Diagnostic value and use for this assessment
1	NSW occurrences fall in New England Tableland, NSW North Coast, Sydney Basin, South East Corner, South Eastern Highlands and Australian Alps bioregions.	Explicitly diagnostic
1	Associated with accumulated peaty or organic-mineral sediments on poorly drained flats in the headwaters of streams.	Indicative, not used. Panel noted that the natural spatial pattern of the assemblage is often represented by small disjunct patches as small as 0.1 hectares.
1	Occurs on undulating tablelands and plateaus, generally in catchments with basic volcanic or fine-grained sedimentary substrates or, occasionally, granite.	Indicative; used to separate coarse grained Triassic sandstone sediments of the Sydney Basin (subject to separate TEC listings).
1	Above 400-500 metre elevation	Implicitly diagnostic; greater than or equal to 400 metres elevation used as a threshold.
1,4	Comprises a dense, open or sparse layer of shrubs with soft-leaved sedges, grasses and forbs. Small trees may be present as scattered emergents or absent from the community.	Indicative only; used to include scattered emergent canopy layer up to 10% crown canopy cover (crown separation > 2)
1	Characterised by the listed 83 plant species, including 3 eucalypts.	Indicative. The panel concluded for the purposes of this assessment that any treeless vegetation (≤10% tree cover) dependent on impeded drainage represented candidate TEC subject to stated elevation thresholds.
2	Known from 23 LGAs but may occur elsewhere.	Indicative, not used.
4	Typically has an open to very sparse layer of shrubs, 1-5 metres tall, including species of *Baeckea, Callistemon* and *Leptospermum*. Species of *Epacris* and *Hakea microcarpa* are also common shrubs. In some peatlands and swamps, particularly those with a history of disturbance to vegetation, soils or hydrology, the shrub layer comprises dense thickets of *Leptospermum* species. In other peatlands and swamps with a history of grazing by domestic livestock, the shrub layer may be very sparse or absent.	Indicative, Panel noted that woody shrubs are explicitly included within the assemblage
4	Montane Peatlands typically have a dense groundcover of sedges, grasses and forbs, except	Indicative, not used

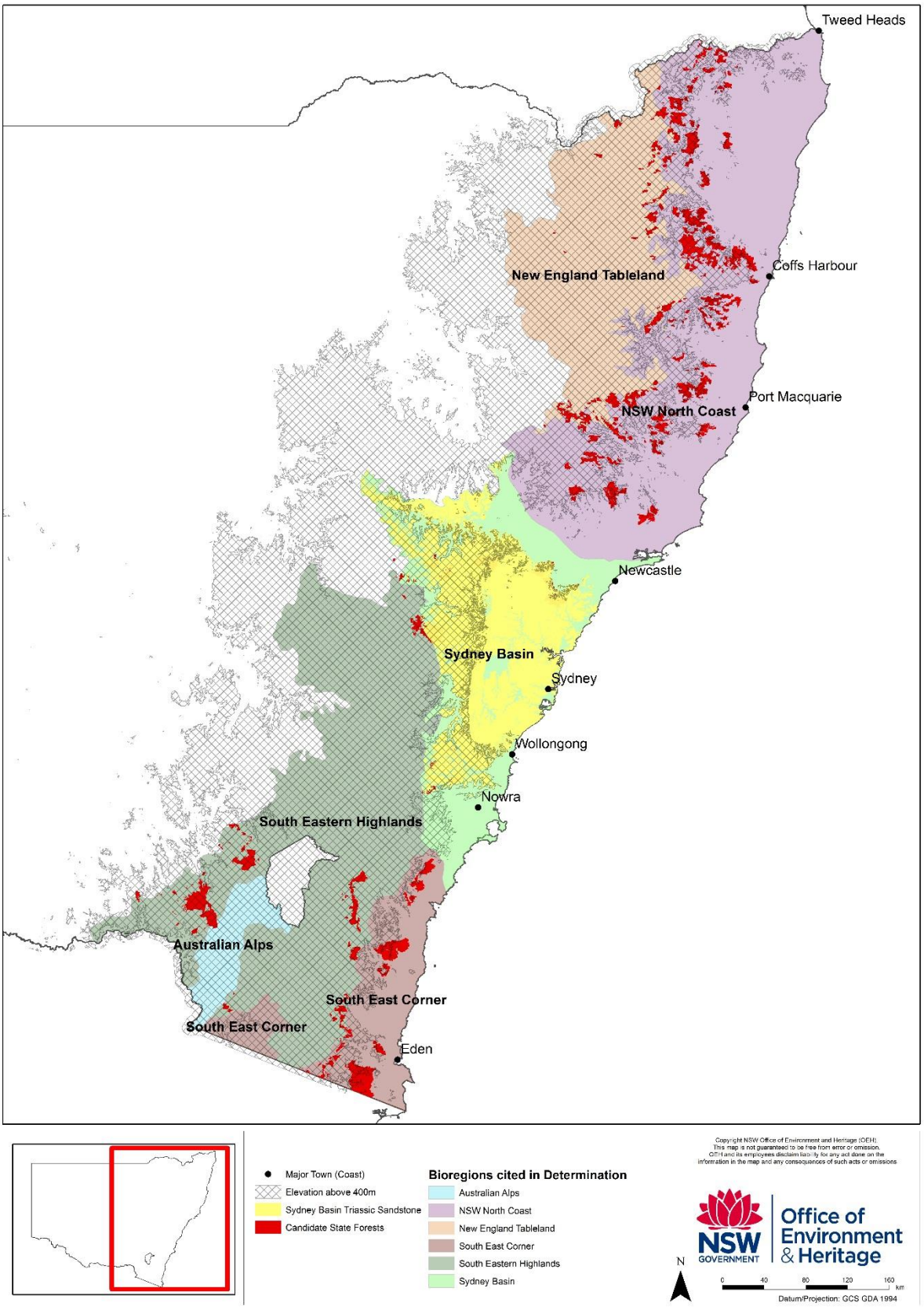
	Feature	Diagnostic value and use for this assessment
	where a dense cover of tall shrubs casts deep shade. Soft-leaved species of *Carex* and *Poa* typically make up most of the groundcover biomass, while other common sedges include *Baloskion* spp*., Baumea rubiginosa, Empodisma minus*, *Juncus* spp. and *Schoenus apogon*. Forbs growing amongst the sedges include *Drosera* spp., *Geranium neglectum*, *Gratiola* spp., *Mitrasacme serpyllifolia, Ranunculus* spp. and *Viola* spp. Hummocks of *Sphagnum* moss may occur amongst other components of the ground layer.	
5	Description of differences from Upland Wetlands of the Drainage Divide of the New England Tableland using woody plant cover, aquatic herbs, substrate and water seepage descriptors to separate.	Indicative not used, no attempt to distinguish the two EECs
8	Cites 27 existing vegetation communities descriptions included within the definition of the TEC.	Indicative; used to diagnose vegetation assemblages and substrate characteristics. Noted related swamp assemblages not included (viz Triassic sandstone sediments of the Sydney Basin)
10	Occurrence in conservation reserves	Indicative, confirmed the absence of the TEC from large triassic sandstone reserves in the Sydney Basin

2.4 Assessment area

2.4.1 Location and study area boundaries

We defined our study area (Map 1) for this assessment to include all eastern RFA regions (including parts of non-IFOA central tablelands forests), at or above 400 metres elevation and situated within any of the stated bioregions: New England Tableland, NSW North Coast, Sydney Basin, South East Corner, South Eastern Highlands and Australian Alps.

Map 1: **Study area showing bioregions and elevation thresholds and assessable state forests. The area excluded by our mapping covers the Sydney Basin Triassic Sandstones and is shown in yellow.**



2.4.2 State forests subject to assessment

The study area includes Crown Forest estate situated within Upper North East, Lower North East, Southern and Eden Integrated Forestry Operations Approval (IFOA) regions. We excluded 11 state forests located on triassic sandstone sediments of the Sydney Basin through Panel interpretation of qualifying substrate criteria in Paragraph 6 of the final determination.

A total of 159 state forests were included in this assessment (Table 2) covering 828,232 hectares. 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.

Table 2: List of candidate state forest assessed in the Upper North East IFOA region

State Forest	Hectares
Upper North East IFOA	277,933
Bagawa SF	5,275
Bald Knob SF	1,695
Beaury SF	4,513
Billilimbra SF	3,853
Bookookoorara SF	915
Boonoo SF	4,293
Boorook SF	2,990
Boundary Creek SF	2,539
Brother SF	6,539
Butterleaf SF	1,748
Chaelundi SF	18,238
Clouds Creek SF	10,240
Curramore SF	84
Dalmorton SF	27,911
Donaldson SF	2,331
Donnybrook SF	2,926
Edinburgh Castle SF	949
Ellis SF	9,736
Ewingar SF	18,367
Forest Land SF	8,159
Gibraltar Range SF	3,113
Gilgurry SF	9,521
Girard SF	18,840
Glen Elgin SF	687
Grange SF	7,791
Gundar SF	119
Hyland SF	4,577
Kangaroo River SF	11,383
Koreelah SF	688
Little Spirabo SF	15
London Bridge SF	118
Malara SF	3,352
Marara SF	5,347
Marengo SF	10,128
Moogem SF	1,284
Moonpar SF	1,817
Mount Belmore SF	7,778
Mount Lindesay SF	3,039
Mount Mitchell SF	2,323
Mount Topper SF	259
Muldiva SF	172
Nana Creek SF	1,793
New Valley SF	317
Oakwood SF	3,774
Orara West SF	4,250
Paddys Land SF	907
Richmond Range SF	5,588
Sheas Nob SF	4,333
Spirabo SF	4,256
Toonumbar SF	1,360
Torrington SF	1,672
Tuckers Nob SF	738
Unumgar SF	3,560
Warra SF	886
Washpool SF	2,961
Wild Cattle Creek SF	6,961
Willsons Downfall SF	317
Woodenbong SF	306
Yabbra SF	8,302

Table 2: List of candidate state forest assessed in the Lower North East IFOA region

State Forest	Hectares
Lower North East IFOA	267,047
Avon River SF	5,061
Barrington Tops SF	12,588
Bellangry SF	6,360
Ben Halls Gap SF	351
Boonanghi SF	3,660
Bowman SF	3,187
Brassey SF	745
Buckra Bendinni SF	1,766
Bulga SF	14,254
Carrai SF	3,028
Chichester SF	20,539
Cochrane SF	231
Comboyne SF	2,423
Coneac SF	771
Diehappy SF	1,275
Dingo SF	3,555
Doyles River SF	7,743
Enfield SF	13,105
Enmore SF	169
Fosterton SF	823
Giro SF	9,931
Gladstone SF	5,501
Heaton SF	1,441
Irishman SF	2,730
Kerewong SF	3,661
Kippara SF	5,492
Knorrit SF	4,656
Lorne SF	1,907
Lower Creek SF	1,268
Masseys Creek SF	3,127
Mernot SF	4,338
Mistake SF	5,614
Mount Boss SF	17,165
Mount Seaview SF	1
Muldiva SF	515
Myall River SF	12,800
Nowendoc SF	4,094
Nulla-five Day SF	3,065
Nundle SF	6,807
Oakes SF	7,630
Riamukka SF	12,536
Roses Creek SF	1,789
Scotchman SF	3,152
Stewarts Brook SF	2,417
Styx River SF	17,425
Terrible Billy SF	1,090
Thumb Creek SF	3,944
Tomalla SF	2,107
Tuckers Nob SF	35
Tuggolo SF	14,051
Upsalls Creek SF	923
Wild Cattle Creek SF	2,700
Yessabah SF	1,501

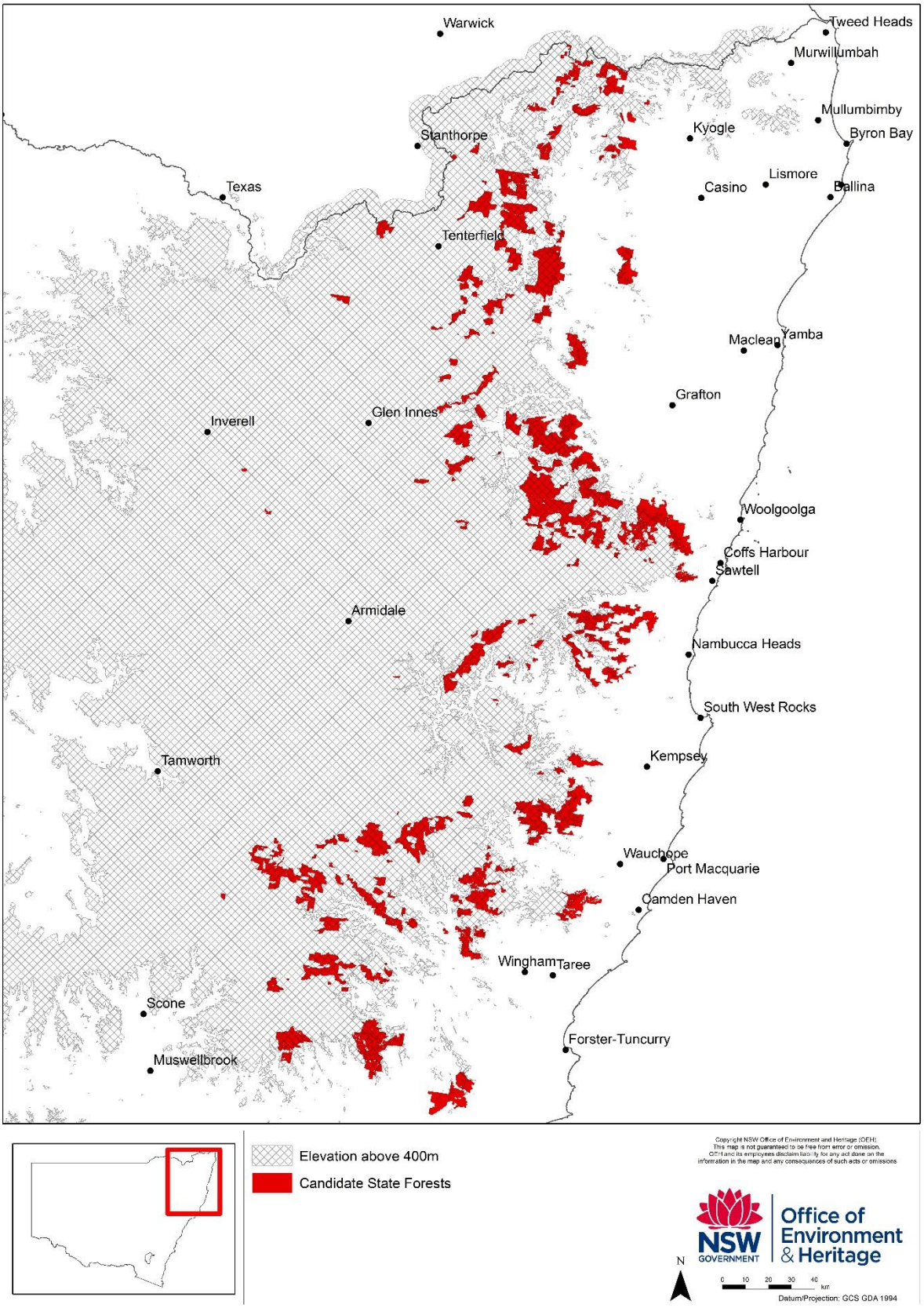
Table 3 List of candidate state forest assessed in the Southern and Eden IFOA regions

State Forest	Hectares
Southern IFOA	186,600
Badja SF	7,695
Bago SF	36,031
Belanglo SF	2,835
Billapaloola SF	726
Bondo SF	16,563
Buckenbowra SF	4,845
Bungongo SF	2,846
Carabost SF	2,642
Currowan SF	7,743
Dampier SF	32,985
Green Hills SF	1,017
Ingebirah SF	2,653
Jellore SF	1,409
Mannus SF	629
Maragle SF	14,216
Meryla SF	4,350
Micalong SF	3,177
Mowamba SF	162
Penrose SF	458
Red Hill SF	10
Tallaganda SF	23,909
Wandella SF	5,470
Wee Jasper SF	1,435
Wingello SF	2,463
Yadboro SF	10,153
Yarrawa SF	179
Eden IFOA	80,122
Bombala SF	339
Bondi SF	6,734
Cathcart SF	1,725
Coolangubra SF	2,193
Glen Allen SF	1,454
Glenbog SF	8,852
Gnupa SF	1,316
Nalbaugh SF	2,277
Nullica SF	4,006
Nungatta SF	857
Tantawangalo SF	3,404
Towamba SF	20
Yambulla SF	46,098
Yurammie SF	848

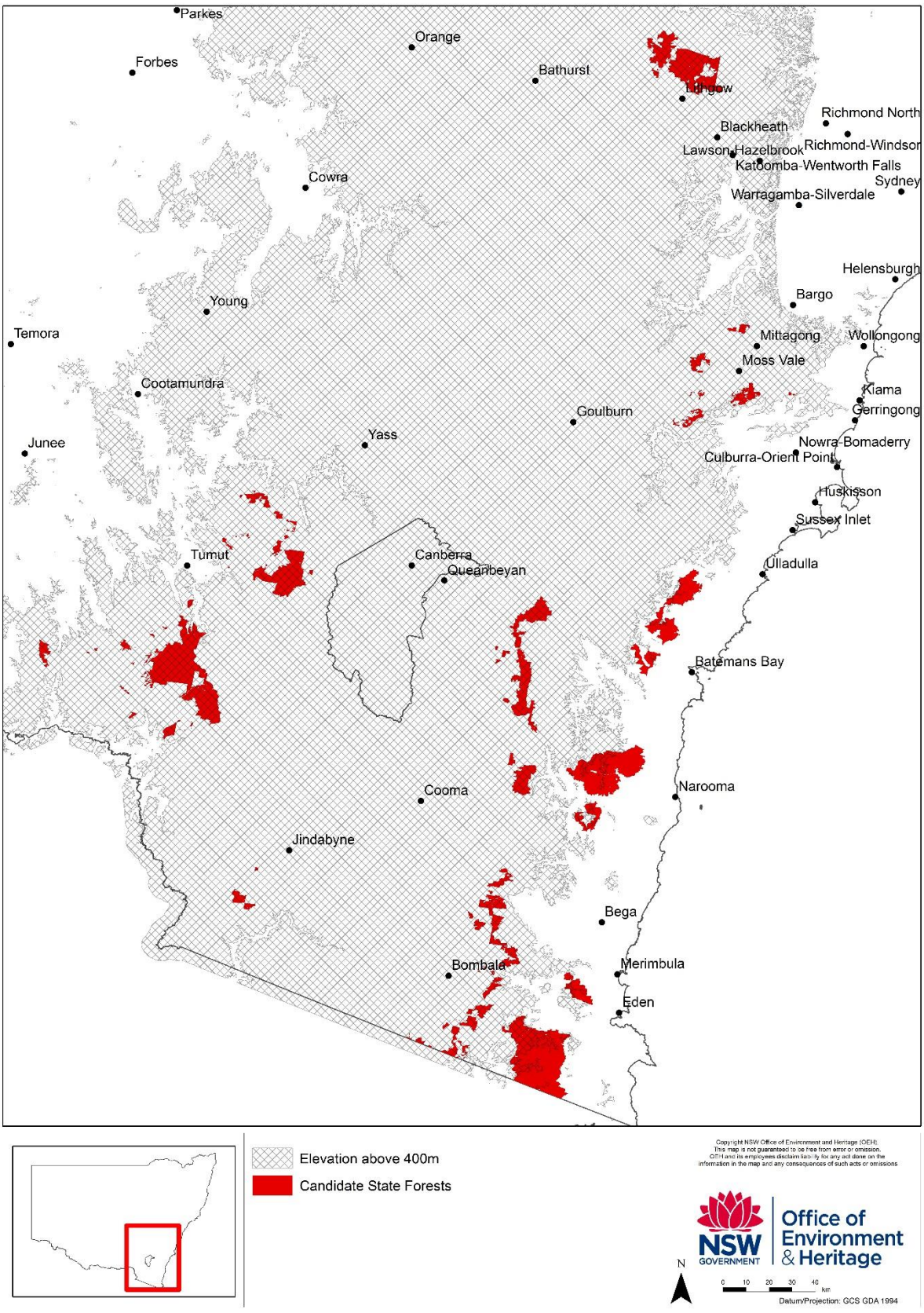
Table 4 List of candidate state forest assessed in the Non IFOA Central Region

State Forest	Hectares
Non-IFOA	16,530
Ben Bullen SF	8,252
Bylong SF	621
Clandulla SF	1,561
Coricudgy SF	7,582
Kandos SF	1,396
Nullo Mountain SF	5,370

Map 2: **Candidate state forests assessed in Upper and Lower IFOA regions**



Map 3: **Candidate state forests assessed on Southern and Eden IFOA Regions and Non IFOA areas of the Central Tablelands.**



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. Owen Maguire undertook API mapping using 3D stereo imagery across the study area. Allen McIlwee prepared the assessment of accuracy and project maps. Dan Bowles provided GIS, mapping and technical support. The report was prepared by Daniel Connolly, Allen McIlwee, Doug Binns and Owen Maguire.

3 Methodology

3.1 Approach

Our approach avoided the assessment of the floristic assemblage described in the final determination by agreeing that any treeless native vegetation cover on poorly drained soils on state forest is considered candidate Montane Peatlands and Swamps. This approach results in the inclusion of some native vegetation which is unlikely to meet the definition of the TEC, but does not exclude areas that meet our agreed interpretation.

3.2 Aerial photograph interpretation

We used stereoscopic interpretation of digital aerial photography to identify candidate treeless native vegetation cover across assessable state forests. Candidate vegetation included any treeless cover (up to 10% crown cover - crown separation greater than two - to include the emergent criteria in the final determination). Vegetation features assessed included non-woody and woody shrub swamps, bogs, peatlands, fens, soaks, herb fields, grasslands and riparian vegetation associated impeded drainage lines. These were assessed using two mapping classes to identify either non-woody or woody cover. Treeless vegetation features excluded from mapping included dry heaths situated away from drainage lines, grasslands associated with agricultural clearing or timber harvesting. A standard set of map attributes (Table 5) was applied to generate a consistent interpretation across all assessable state forests identified in section 2.4.2.

Table 5 API attribute table

Feature	Attribute Code
Candidate Montane Peatlands and Swamp (Where eucalypt/tree cover is less than 10% crown canopy cover/ tree crown cover separation >2)	Code 52 Woody shrubs dominant (>50% polygon)
	Code 53 Graminoids dominant (>50% polygon dominated by grass, sedges and herbs).
Interpretation Confidence	1.Very High
	2.High
	3.Medium
	4. Low

An API technician experienced in interpretation of NSW forest and vegetation types used recent high resolution (50 centimetre ground sample distance) stereo digital imagery in a digital 3D GIS environment, as per Maguire et al. (2012), to delineate observable structural characteristics and landform elements. A viewing scale between 1:1000 and 1:3000 was used to mark boundaries to infer the extent of treeless native vegetation cover.

A minimum map polygon size of 0.1 hectares was used to identify and delineate candidate image patterns. Interpreters were supplied with a range of environmental variables to accompany interpretation including substrate and existing vegetation maps. These map layers included Southern and Northern CRAFTI (National Parks and Wildlife Service 2000; NPWS 1999), Southern CRA (Thomas, Gellie & Harrison 2000), Gellie (2005), SCIVI (Tozer et al. 2010) and RN17 (Forestry Commission of NSW 1989). Additional spatial data was also used to supply layers such as roads, trails and tenure boundaries. All relevant georeferenced floristic data supporting assignments about cited vegetation communities in the determination was extracted from OEH VIS flora survey databases and supplied to aid interpretation.

3.3 Validation

We identified two approaches to the validation of our mapped layer:

3.3.1 Thematic validation of mapped polygons

Independent sampling within mapped polygons would provide an unbiased estimate of the extent of Montane Peatlands and Swamps in mapped areas. However, substantial effort is required to provide a reasonably accurate unbiased estimate. Instead we chose to provide an independent assessment of the aerial photograph interpretation by using an independent interpreter to assess a random sample of the study area, and identify the level of agreement between the two interpretation maps. By looking at the level of agreement between where two observers identified candidate vegetation patterns, we were able to assess the thematic accuracy of the mapped polygons, but also the extent to which areas of candidate TEC may have been overlooked by the initial mapping work (that is, the level of false negatives, as defined below).

For this assessment, 400 points were randomly allocated across the full extent of all state forests on the Southern Tableland (as these covered the largest mapped areas of candidate TEC), with a 100 metre buffer between points to avoid serious clumping. Overlaying the random points were 'fishnets' of 50 metre x 50 metre. All the 50 metre x 50 metre plots where random points fell were assigned a candidate TEC present or absence score depending on whether any part of the plot intersected with mapped polygon. The full set of 400 plots were sent to an independent interpreter and they were asked to record whether the plot fell on vegetation that met the mapping criteria for candidate TEC. If both observers recorded candidate TEC as being present, the plot was assigned a true positive score, likewise a double absence was regarded as a true negative. Where Observer 2 recorded a presence, and Observer 1 an absence, the plot was deemed a false negative, and where Observer 2 recorded an absence, and Observer 1 a presence, the plot was deemed a false positive.

3.3.2 Determination of spatial accuracy of boundary lines

We assessed the spatial precision of the mapped candidate TEC boundaries by using an independent interpreter to mark the boundaries of a random set of candidate TEC polygons identified by the initial mapping. The difference between the two boundaries was calculated and the average across all randomly assessed areas was identified to give an estimate of spatial precision with minimum and maximum differences.

For this assessment, one by one kilometre squares were randomly generated across all assessable state forests on the Southern Tablelands. For each square a diagonal line was placed running from the south west to the north east corner. A point was generated at each location along the line where it intersected the outside edge of a mapped polygon. If the line did not intersect any polygons, it was deleted and a new random square and diagonal line created. This process continued until 50 diagonal lines were created, each with at least two intersection points. The complete set of lines were then sent to an independent observer, who without knowledge of the intersection points or existing mapped polygons, was asked to mark on the line the edge of every candidate TEC they could see using identical mapping criteria. The distance between where the two observers independently marked the boundary was then measured, and average distance between points used as measure of line accuracy.

4 Results

4.1 Aerial photograph interpretation

A total of 1792.5 hectares of candidate Montane Peatlands and Swamps has been mapped within state forests of our study area. Tables 6 shows the size classes of mapped patches of candidate Montane Peatlands and Swamps. Over 60% of our mapped polygons were less than 0.5 hectares in size. The greatest proportion was identified in state forests located on the Southern Tableland with over 60% of the total mapped. The largest areas of candidate TEC were mapped in Bago State Forest in the Tumut region while the single largest individual patches were recorded in Coolangubra, Badja, Tantawangalow and Boonoo State Forests.

Table 6: Patch size classes of candidate Montane Peatlands and Swamps on state forests within our study area.

Polygon size (Ha)	Total Area (Ha)	Proportion of Total Area	Number of Polygons	Proportion of total polygons
<=0.1	17.9	1%	287	14%
>0.1 to 0.5	258.4	14%	984	49%
>0.5 to 1.0	234.2	13%	334	17%
>1.0 to 5.0	660.6	37%	336	17%
>5.0 to 10.0	309.1	17%	44	2%
>10.0	312.3	17%	16	1%
Grand Total	1792.5	100.00%	2001	100.00%

4.2 Validation

4.2.1 Interpretation agreement

Of the 400 plots, 225 were assessed by the second observer. A further 38 sites were excluded because they met the treeless vegetation threshold, but were mapped by the first observer as native or derived grasslands, which are not included as the Montane Peatlands and Bogs TEC. For the remaining 187 plots assessed, 67.9% were regarded by both observers as containing the EEC (true positive) and 19.25% we regarded as true negatives. Thus there was a matching agreement between observers for 163 of the 187 plots (87.17%). Sixteen plots were regarded as the EEC by Observer 1 but not Observer 2 (8.56%) and eight plots were regarded as the EEC by Observer 2, but not Observer 1 (4.28%).

Based on these results, we argue that the final EEC operational map captures most candidate Montane Peatlands and Swamps over the study area, with the second observer assigning the EEC as present in eight of the 187 (4%) random 50 metre x 50 metre plots that did not contain any mapped candidate EEC. The result is a small number of disagreements in the interpretation of the mapping criteria. We used the results to check and revise the final mapping and expect that the level of agreement is likely to exceed that derived in the validation.

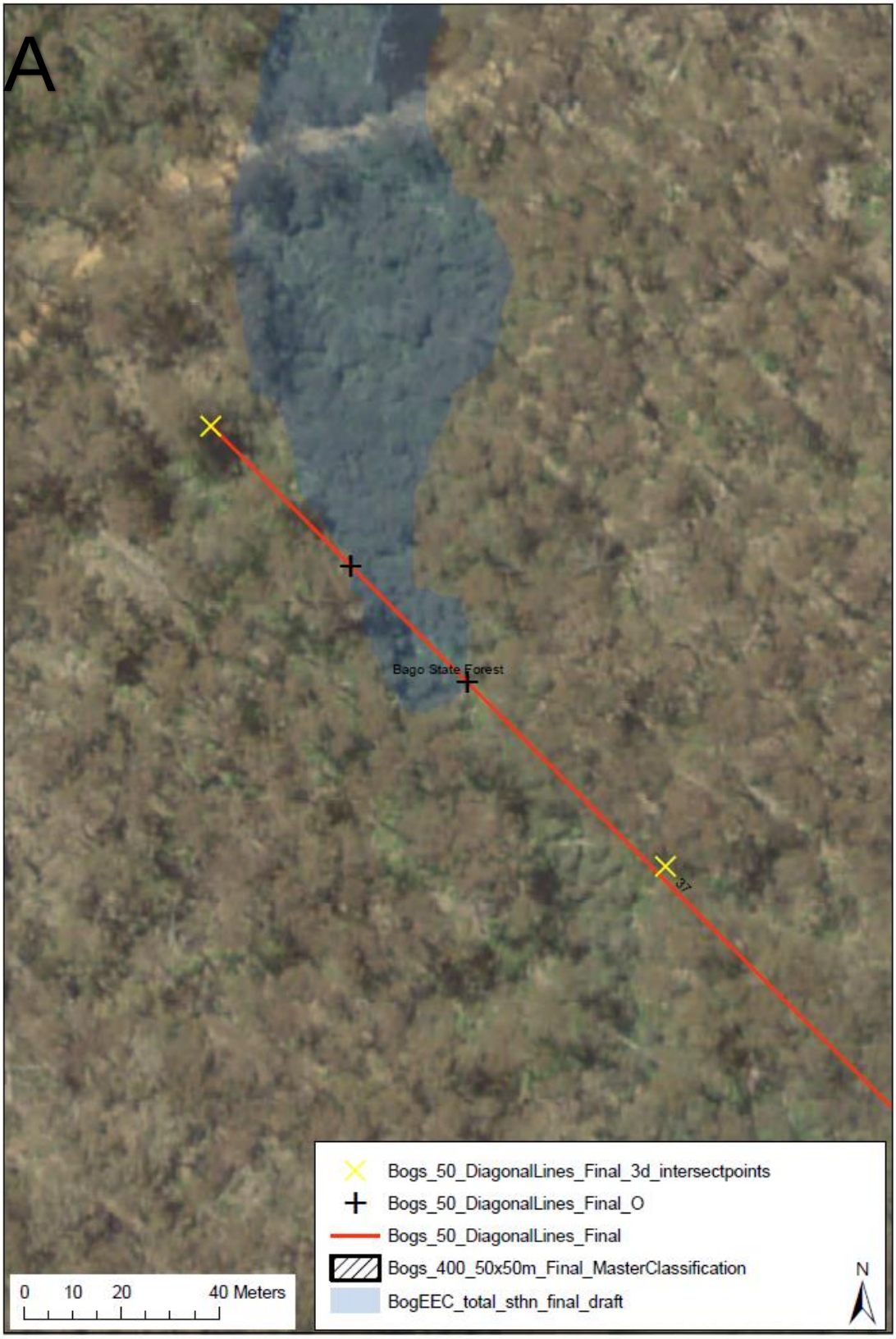
We note that most of the discrepancies between observers related to the interpretation of whether the 10% eucalypt threshold was exceeded4

4.2.2 Spatial precision

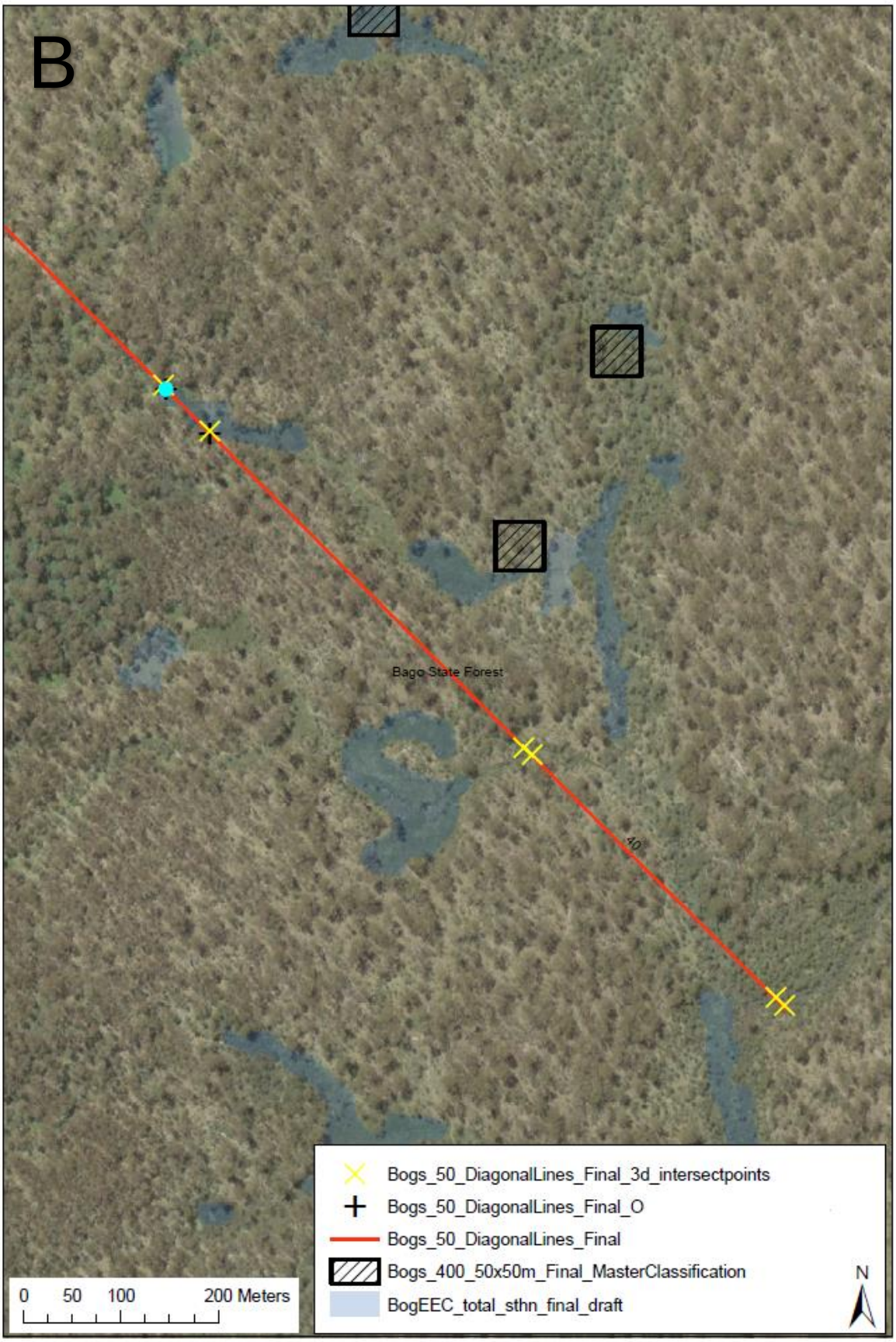
For the 50 random diagonal lines there were 184 intersection points with candidate TEC polygon. Most lines intersected only one or two polygons, but often their convoluted shape meant that a single polygon often intersected the line at multiple locations. Across 111 intersection points, the average distance error between observers was 8.4 metres, with a standard deviation of 9.94. Here the minimum distance was 0.23 metres and maximum 56.3 metres. However in 73 cases (39.7%), the second observer failed to mark any boundary within 60+ metres of a swamp intersection point mapped by the first observer.

There are several reasons why there was relatively poor consensus about the precise boundaries of swamps. Maps 4a-4c and Maps 5 to 7 illustrate some of the difficulties in interpretation when marking out boundaries along a single diagonal line. Map 4a shows how the distance between marked intersection points recorded by two observers can easily become greatly inflated if the direction of water flow runs in a north-south or northwest-southeast direction. Map 4b shows how slight differences in interpretation of the extent can show up as major differences when plotted on a single diagonal line. Map 4c shows a typical example of where the edges of swamps appear to just cut the diagonal line, so only one of the two observers records a set of intersection points, while the other misses it entirely.

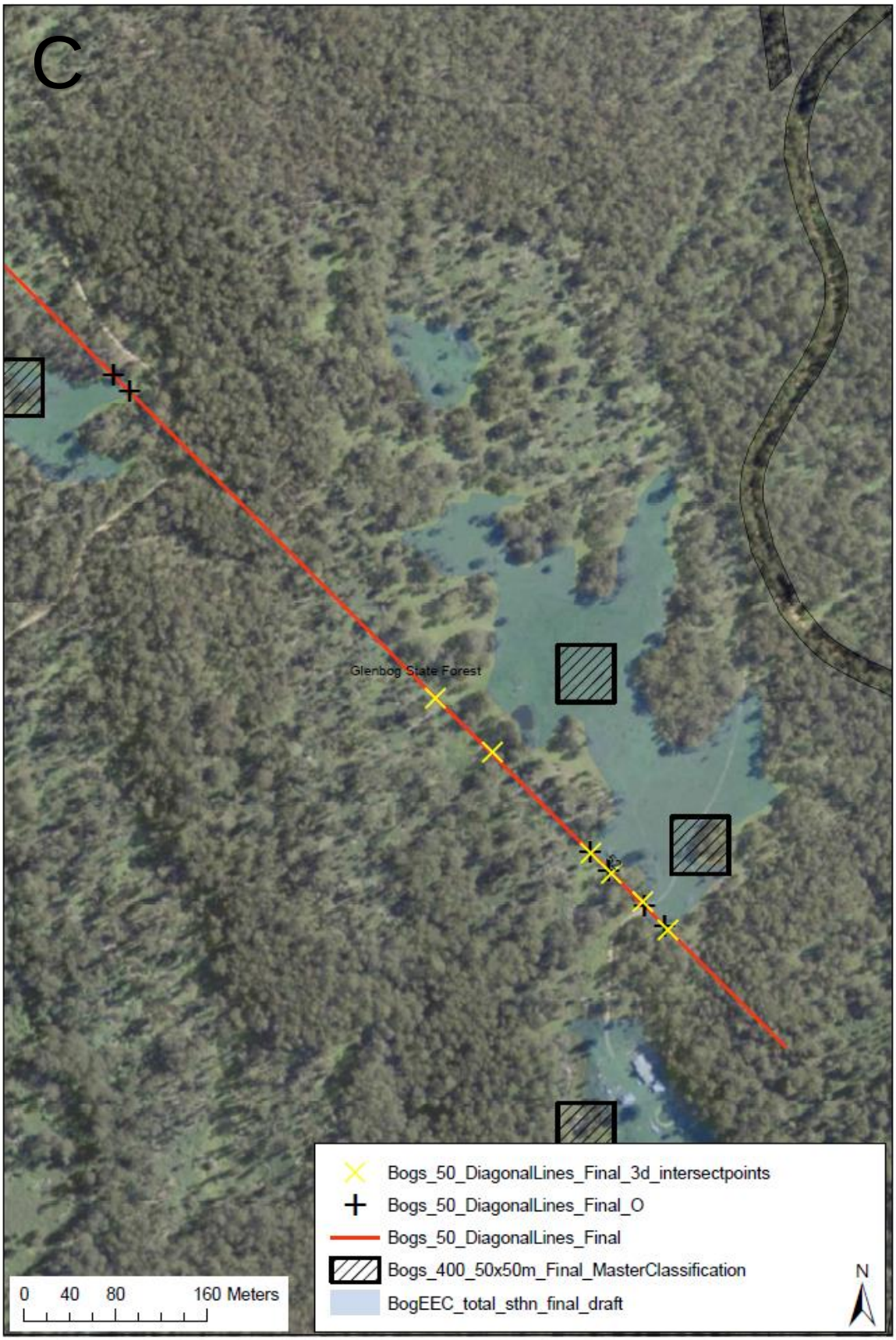
Map 4a: **Example spatial accuracy assessment of candidate Montane Peatlands and Swamps TEC mapping using line intersects.**



Map 4b: **Example spatial and thematic accuracy assessment using random locations for independent interpretation of mapped polygons and line intersects.**



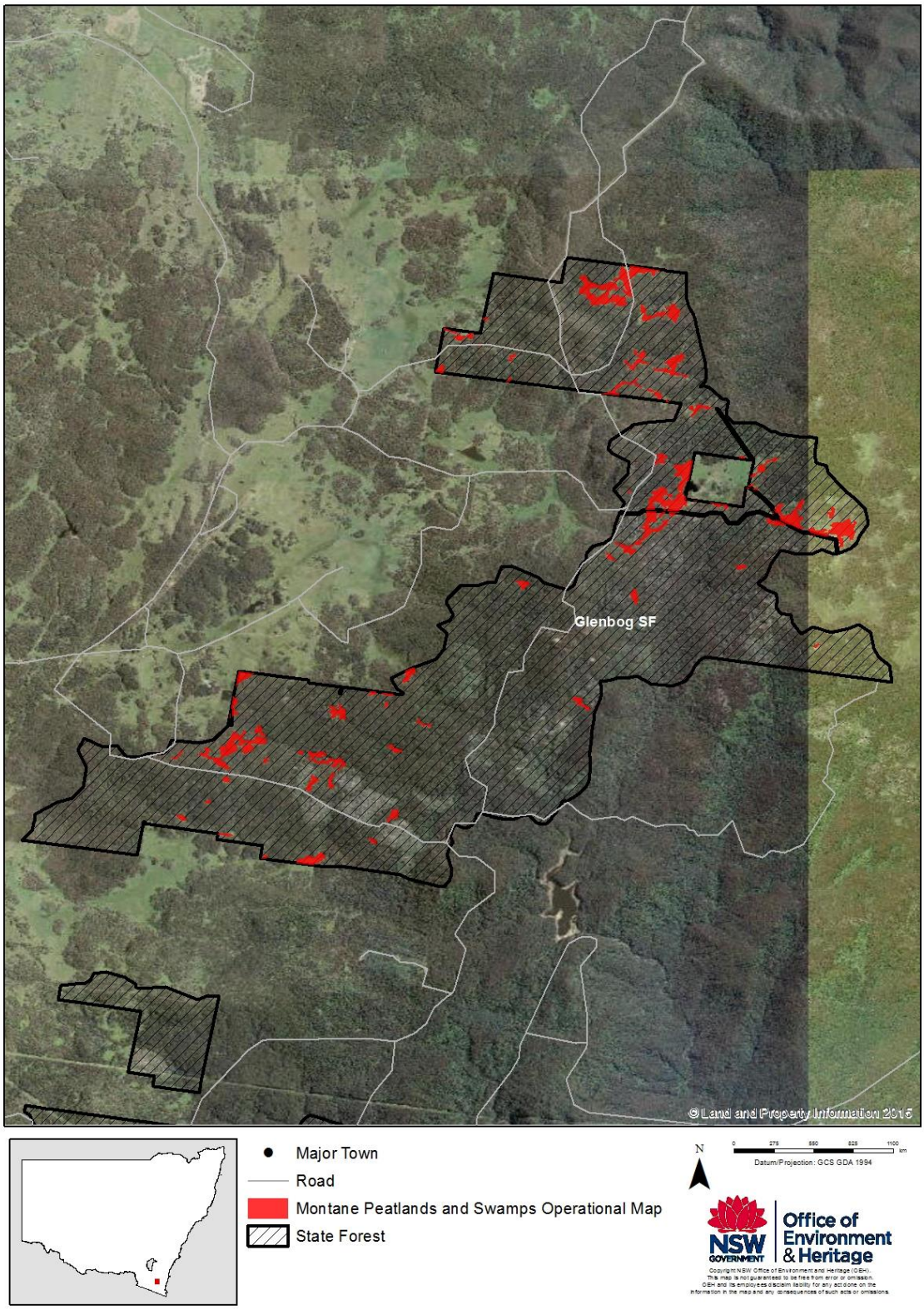
Map 4c: **Spatial accuracy assessment.**



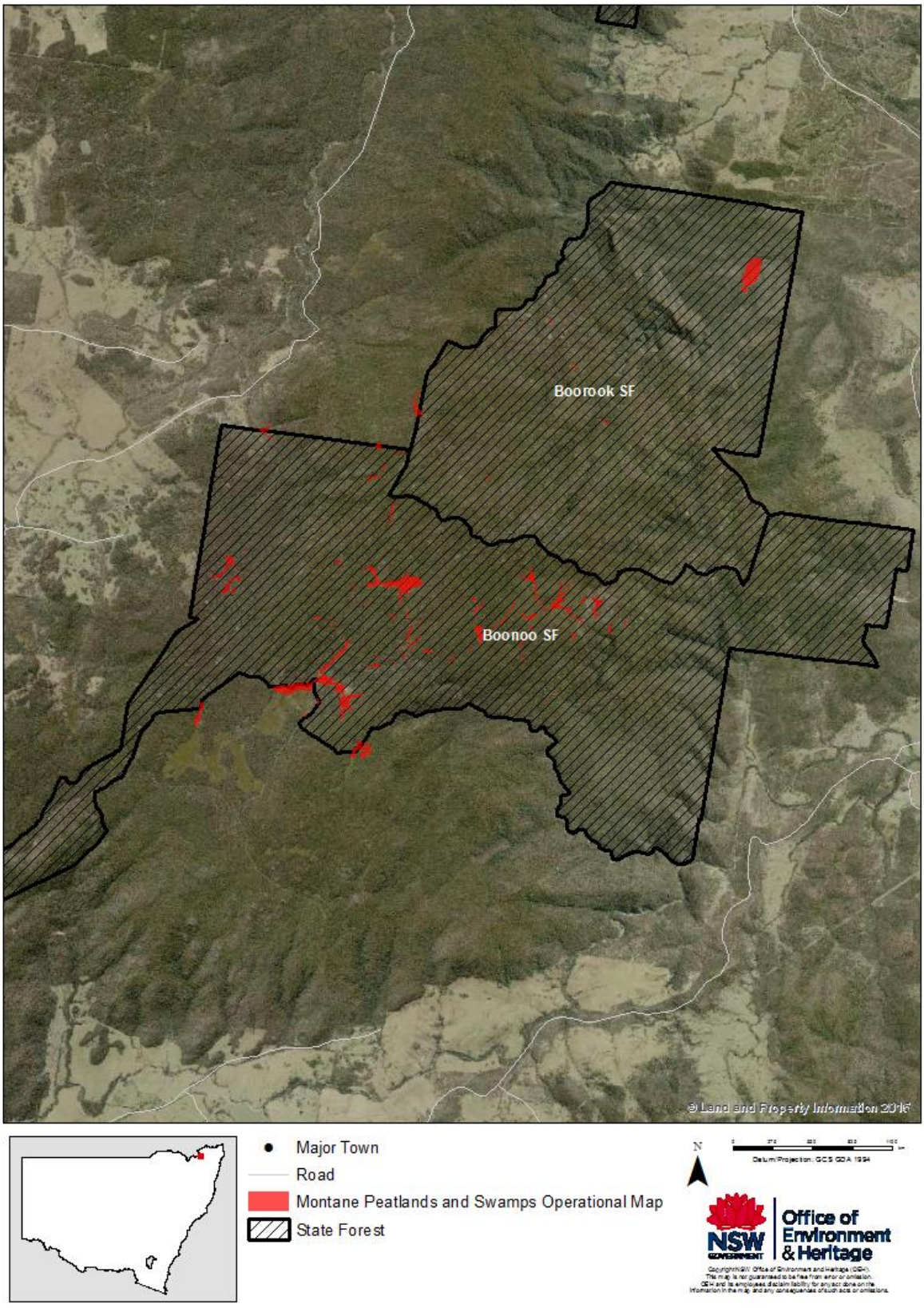
4.3 Operational EEC map

We selected all candidate Montane Peatlands and Swamps from our final API spatial data layer and constrained the mapping to state forest boundaries. Maps 5 and 6 provide examples of the Montane Peatlands and Swamps operational map. Maps 7 and 8 show forests containing mapped occurrences of Montane Peatlands and Swamps across the study area.

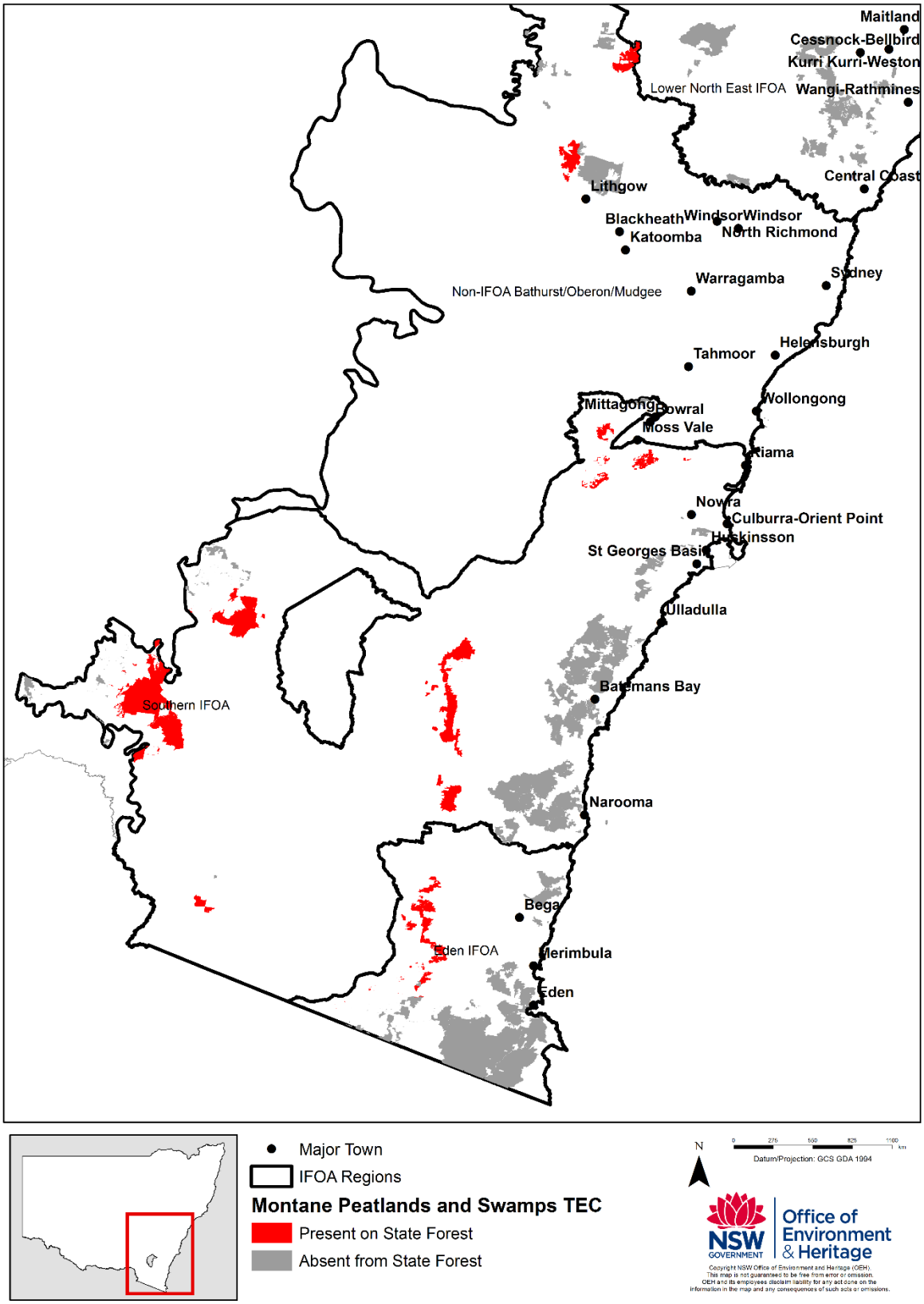
Map 5: **Example of operational map for Glenbog State Forest on the South Coast.**



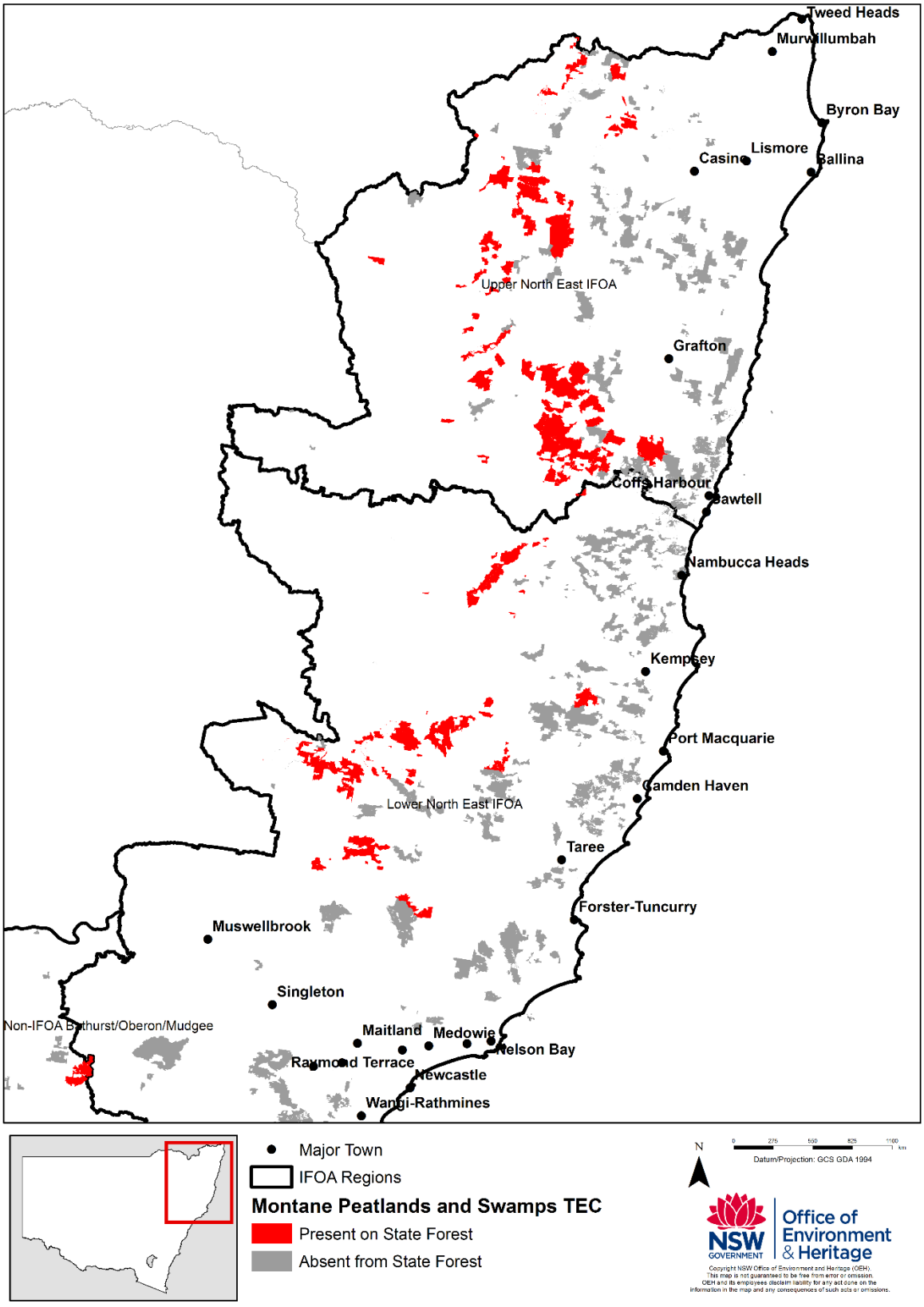
Map 6: **Example of operational map for Boonoo and Boorook State Forests on the North Coast.**



Map 7: **State forests with mapped occurrences of Montane Peatlands and Swamps (South and Central Tablelands)**



Map 8: **State forests with mapped occurrences of Montane Peatlands and Swamps (Northern Tablelands)**



5 Discussion

5.1 Summary

5.1.1 Cited communities and determination species assemblage

The TEC Panel experienced difficulties assessing the floristic composition of Montane Peatlands and Swamps. The final determination species list does not provide a useful means of discriminating between different plant assemblages found on impeded soils, particularly because the TEC encompassed a wide altitudinal and elevational gradient.

We overcame the problem by applying a precautionary approach that agreed to weight the structural and habitat attributes of the assemblage above the compositional values defined by the species list and the cited vegetation communities. The decision acknowledged that the derived maps would contain assemblages that were not relevant to the Montane Peatlands and Swamps TEC. While the inclusion of non-target vegetation may be tolerated for crown tenure forest operations it is unlikely to be the case on other tenures or land uses.

5.1.2 Distribution and habitat descriptors

The project adopted the stated bioregion, vegetation structure and elevation descriptors as the primary attributes used to identify state forests requiring assessment and to map the extent of candidate Montane Peatlands and Swamps TEC.

5.2 TEC Panel review and assessment

5.2.1 Summary of discussions

The results of the community analysis and map products were subject to a review process by the TEC Panel. Table 7 presents the summary of the findings.

Table 7. Summary of issues and Panel review of RFEF, meeting held 14 October 2015.

Determination	TEC Panel Principles	Our Project	TEC Panel Review
Occurs in "….Sydney Basin, South East Corner, South Eastern Highlands and Australian Alps bioregions"	Accept Bioregional Qualifiers	Adopted	Agreed
"..associated with accumulated peaty or organic-mineral sediments on poorly drained flats in the headwaters of streams.."	Assess habitat descriptors and whether these constrain or define the limits of the TEC which otherwise may have a broader distribution	Used to discriminate candidate landforms and vegetation using API. The Panel noted that the patch size of the EEC as it occurs in nature can be small. To address this a smaller minimum mapping threshold is required – 0.1 hectare.	Agreed
It occurs on undulating tablelands and plateaus, above 400-500 m		Assessable state forests were identified as equal to or greater than 400 metres above sea level	Agreed

Determination	TEC Panel Principles	Our Project	TEC Panel Review
elevation, generally in catchments with basic volcanic or fine-grained sedimentary substrates or, occasionally, granite		Excluded Montane Triassic Sandstone Sediments of the Sydney Basin Bioregion (Blue Mountains Swamps, Newnes Plateau Shrub Swamps)	
Small trees may be present as scattered emergents or absent from the community.	Assess vegetation structure descriptors that may constrain or allow a range of structural forms;	Adopted a mapping criteria that identified candidate TEC up to 5-10% eucalypt (tree) cover.	Agreed
Characterised by the list of 86 plant species	Be guided by the species lists presented in the determination	Mapped structural patterns in vegetation cover in suitable habitats as a surrogate for species assemblage. Accepted that map units may include areas which do not conform to the species assemblage. The species list is not useful for discriminating regional patterns in peatland assemblages. Given purpose of the maps, it is not necessary to discriminate the floristic composition of Peatlands and Swamps.	Agreed
Cites 27 existing vegetation communities descriptions included within the definition of the TEC.	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 "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.	Not used.	Agreed

5.3 Final state forest - EEC occurrence matrix

Table 8: Total area of Montane Peatlands and Swamps mapped across all state forests in the study area.

State forest	Area Ha	Number of polygons	Proportion of Total
Eden IFOA	304.7	231	17.0%
Cathcart State Forest	1.6	1	0.1%
Glen Allen State Forest	22.6	15	1.3%
Glenbog State Forest	201.4	160	11.2%
Tantawangalo State Forest	79.1	55	4.4%
Lower North East IFOA	148.3	208	8.3%
Avon River State Forest	1.5	4	0.1%
Barrington Tops State Forest	58.7	69	3.3%
Brassey State Forest	5.0	4	0.3%
Cochrane State Forest	0.3	1	0.0%
Doyles River State Forest	14.2	9	0.8%
Enfield State Forest	14.5	13	0.8%
Enmore State Forest	0.2	1	0.0%
Kippara State Forest	0.8	1	0.0%
Muldiva State Forest	3.5	4	0.2%
Nowendoc State Forest	1.1	1	0.1%
Nundle State Forest	0.5	1	0.0%
Riamukka State Forest	25.7	43	1.4%
Stewarts Brook State Forest	4.6	4	0.3%
Styx River State Forest	4.6	15	0.3%
Tomalla State Forest	0.5	4	0.0%
Tuggolo State Forest	12.6	34	0.7%
Non-IFOA Bathurst/Oberon/Mudgee	58.1	65	3.2%
Ben Bullen State Forest	50.8	63	2.8%
Coricudgy State Forest	7.3	2	0.4%
Southern IFOA	866.3	975	48.3%
Badja State Forest	139.6	100	7.8%
Bago State Forest	340.6	375	19.0%
Belanglo State Forest	2.5	3	0.1%
Bondo State Forest	74.1	150	4.1%
Ingebirah State Forest	51.7	86	2.9%
Maragle State Forest	112.5	90	6.3%
Meryla State Forest	52.3	62	2.9%
Micalong State Forest	50.2	43	2.8%
Tallaganda State Forest	33.1	52	1.8%
Wingello State Forest	3.9	5	0.2%

State forest	Area Ha	Number of polygons	Proportion of Total
Yarrawa State Forest	5.8	9	0.3%
Upper North East IFOA	415.0	522	23.2%
Bald Knob State Forest	1.6	1	0.1%
Beaury State Forest	1.7	7	0.1%
Boonoo State Forest	75.8	87	4.2%
Boorook State Forest	12.0	9	0.7%
Boundary Creek State Forest	1.5	1	0.1%
Brother State Forest	28.4	29	1.6%
Butterleaf State Forest	5.0	13	0.3%
Chaelundi State Forest	7.4	15	0.4%
Clouds Creek State Forest	0.1	1	0.0%
Dalmorton State Forest	5.2	14	0.3%
Ellis State Forest	44.5	19	2.5%
Ewingar State Forest	0.7	2	0.0%
Forest Land State Forest	28.9	44	1.6%
Gibraltar Range State Forest	0.5	1	0.0%
Girard State Forest	98.5	63	5.5%
Glen Elgin State Forest	2.5	3	0.1%
Hyland State Forest	1.2	6	0.1%
Kangaroo River State Forest	3.5	6	0.2%
Koreelah State Forest	0.1	1	0.0%
Malara State Forest	9.6	21	0.5%
Marara State Forest	10.6	21	0.6%
Marengo State Forest	19.9	25	1.1%
Mount Mitchell State Forest	1.2	6	0.1%
Paddys Land State Forest	3.8	9	0.2%
Richmond Range State Forest	0.7	4	0.0%
Spirabo State Forest	0.5	1	0.0%
Torrington State Forest	25.1	62	1.4%
Unumgar State Forest	0.3	1	0.0%
Warra State Forest	16.3	41	0.9%
Willsons Downfall State Forest	7.8	9	0.4%
Grand Total	1792.5	2001	100.0%

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