Department of Planning and Environment

A Revised Classification of Plant Communities of Eastern New South Wales

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Cover photo: Severs Beach, Ben Boyd National Park. John Spencer/DPE

Acknowledgements

We stand on the shoulders of those who came before us. This project was only possible due to the commitment of many people to the collection of systematic floristic survey data over 3 decades, and the curation and management of that valuable data. The work also stands on the strong foundations of systematic plant taxonomy created by the National Herbarium of NSW, and on the many legacy classifications that have preceded this project. The ability to analyse a dataset of over 50,000 plots recording over 7,000 species has only recently become possible. This accumulated dataset represents the cooperative efforts of a great many private individuals, companies and public authorities, too numerous to mention individually. We thank them and acknowledge their contribution. During this project we received contributions to the review of relevant parts of the revised typology from Keith McDougall, Jackie Miles, Greg Steenbeeke, Stephen Bell, Col Bower, John T Hunter, Paul Sheringham, Stephanie Horton, John R Hunter and Megan Powell. Components of the project were conducted in partnership between DPE and the University of New South Wales (UNSW) with funding from the Australian Research Council, grant number LP150100972.

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The assessment of terrestrial biodiversity values under NSW legislation utilises a master typology of native plant assemblages known as ‘plant community types’ (PCTs). The master list of PCTs in eastern NSW, as at November 2018, was an iteratively compiled set of types interpreted from a patchwork of multiple independent sources that vary in scale and methods (DPE 2022a). The absence of an explicit classification protocol for the region resulted in gradual accumulated complexity in the typology, and embedded duplication and redundancy. Subjectivity in interpretation of PCTs hampers their identification and limits their utility for biodiversity assessments and land-use decisions. Recent change to biodiversity legislation in NSW has increased reliance on PCTs in assessment processes and emphasised the need for a schema that enables consistent and objective identification of types by users of the NSW PCT typology.

We developed a new classification protocol and applied a plot-based approach to classify a set of native plant communities for all of eastern NSW, based on analyses of data from approximately 50,900 floristic survey plots held in the Flora surveys module of the BioNet Atlas application. Multivariate techniques were used to identify floristic and environmental patterns, commencing with a mixture modelling approach to partition the dataset into a set of ‘regions of common species probability profile’. We evaluated a suite of contemporary clustering algorithms then adopted k-means clustering to explore floristic patterns at a consistent classification scale within each defined region. Groups identified by k-means clustering were reviewed against multiple factors using a standardised workflow through multiple iterations. The set of final retained groups consisted of 2 subsets: 1,067 groups from 7 coast and tablelands bioregions, and 138 groups from 3 western slopes bioregions.

We identified a set of 13 regional, thematic and local plot-based ‘legacy’ classification projects overlapping our study area, and compiled the plot assignments to legacy classification units of these projects. We used these plot assignments to compare characteristics of our final retained groups against the legacy classification units, and to assess the level of change between the legacy classification units and our final retained groups.

The set of final retained groups are proposed to be adopted into the PCT master list, largely replacing PCTs that were Approved in the eastern NSW bioregions in 2018. The revised classification represents a major advance in the delineation of a comprehensive set of vegetation types for eastern NSW, both in its identification and description of species–environment patterns based on greatly improved coverage of standard floristic survey data, and in its creation of accessible, objective, data-driven definitions and characterisations of types. The revision offers reduced complexity and uncertainty for users, improved access to primary data, and enhanced functionality of PCTs for other applications including mapping. It addresses Recommendation 35 of the Independent Biodiversity Legislation Review Panel (Byron et al. 2014) to improve the PCT classification system to support decision-making, and it applies the recommendations in DPE (2022a).

1. Introduction

1.1 Legislative and administrative context for classification of plant community types

The management and conservation of terrestrial biodiversity in NSW relies in part on a master statewide typology of native plant assemblages, referred to as 'plant community types' (PCTs). In a range of contexts under NSW legislation, including development, offset and incentive scenarios (e.g. see OEH 2019a), metric-based assessment tools are applied to assess and prioritise site biodiversity values including vegetation condition, threatened species habitat and threatened ecological communities (TECs). Successful application of these tools hinges on the ability of assessors to reliably assign the vegetation at a site to one or more PCTs.

The PCT master list is defined in BioNet, the NSW biodiversity data repository administered by the Department of Planning and Environment (DPE). 'Approved' PCTs represent the master set of native vegetation communities that are recognised for NSW. As at November 2018 the BioNet Vegetation Classification applications held over 200 fields of text-based descriptions of PCT composition, structure, distribution, and reference sources. Approved PCTs in the BioNet Vegetation Classification public application on 1 November 2018 are herein referred to as 'Approved PCTs (2018)'. Approved PCTs (2018) are an iteratively accreted compilation of types that have been interpreted from multiple independent sources, ranging from units identified by large regional analyses of floristic survey plot data, to individual expert opinions of distinct types, and various listed TECs (see DPE 2022a).

Although many Approved PCTs (2018) cite the units of past regional (legacy) classification projects as sources, some level of interpretation has generally been applied to the legacy classification units, so that relationships between PCTs and cited classification units are rarely truly equivalent. In some cases a PCT may cite a single legacy classification unit as a source, but the PCT has been interpreted with a broader distribution than the cited classification unit and with modified composition and description information. In other instances, relationships between PCTs and cited classification units range from complex to untraceable. Examples include complex one to many relationships (e.g. a PCT represents an interpreted combination of 5 classification units from one classification project and 2 classification units from another), and untraceable relationships (e.g. a PCT cites a source that is itself a compiled interpretation referencing 'part of' one unit and 'higher rainfall examples' of a different unit). Adding to this complexity, some of the larger cited classification projects were constructed from partially overlapping plot datasets, so individual plots may have contributed to the definitions of classification units in 2 or 3 different classification projects.

Recommendations from an independent review of NSW biodiversity legislation (Byron et al. 2014) included a need to improve the PCT classification. This followed submissions indicating that users experienced difficulties in consistent, objective field recognition of PCTs during assessments, and in mapping PCTs and validating map accuracy. Following the review, new biodiversity legislation in 2016 led to an expanded role for metric-based biodiversity assessment methods and offset provisions in NSW land-use and land management decisions, and further reliance on the PCT classification.

Ongoing pressures for modification and clearing of native vegetation apply across much of NSW, but are most contentious in eastern parts of the state where human population density, agricultural production and mineral extraction pressures are high. Eastern NSW also has a higher density of standard floristic survey plot data available than central and western parts of the state. Related to this, Approved PCTs (2018) from eastern NSW largely reference plot-based classification sources, although with a complex history of interpretation and compilation (DPE 2022a). For these reasons, this project focused on vegetation of eastern NSW – coastal, escarpment, tableland, alpine, and western slopes environments.

1.2 NSW Integrated BioNet Vegetation Data

NSW Integrated BioNet Vegetation Data (IBVD) is a major program within the DPE Remote Sensing and Landscape Science Branch Strategy. This program coordinates the development and management of native vegetation classification data and maps for NSW. The program is recognition of the need to provide consistent statewide vegetation data to support the implementation of NSW legislation, regulations and policies. It moves from a previously fragmented, regionalised and patchy history of investment to a centrally managed program underpinned by scientific standards and methods. IBVD includes:

- the 3-tiered NSW native vegetation classification hierarchy (vegetation formations, vegetation classes and PCTs)
- the State Vegetation Type Map (SVTM) (including extant and 1750 PCT maps)
- threatened species, population and ecological community to PCT association data
- estimates of clearing loss (%) for PCTs
- condition benchmark data
- the BioNet systems that store and deliver data content.

1.3 The NSW vegetation classification schema

Under current NSW legislative contexts, a nested 3-level hierarchy is applied to the classification of native vegetation. The 2 upper levels of this hierarchy, 'vegetation formations' and 'vegetation classes', are drawn from the independently constructed schema of Keith (2004). The 12 vegetation formations recognised for NSW represent major structural and physiognomic groups, while the vegetation classes nested within them group plant assemblages that share related species compositions and are generally united by similar structure and habitat. There are currently 99 vegetation classes recognised across NSW. At the finest level of the hierarchy are plant community types; each PCT is assigned to a single vegetation class, with many PCTs in each class. Each vegetation class is assigned to one vegetation formation, with multiple classes making up each formation.

The upper 2 levels of this vegetation hierarchy are applied in legislative contexts, including in the offset trading groups used by the NSW Biodiversity Offsets Scheme, and in the Bush Fire Environmental Assessment Code for NSW. The focus of the current project is a revision of PCTs at the finest level of the NSW hierarchy, but the revised PCTs will be fitted into the hierarchy of vegetation class and vegetation formation and continue to support these and other applications.

It should be noted that there are various alternative vegetation classification hierarchical schema described by other work in NSW. The Native Vegetation Interim Type Standard (Sivertsen 2009) allows for a 4-level hierarchy, with an additional 'broad floristic types' level intermediate between the PCT and vegetation class levels. Benson (2006) applied a 5-level hierarchy to his 'vegetation classification and assessment' (VCA) framework covering much of the NSW western and central divisions. Continental-scale hierarchies using 6 levels are also applied in NSW and elsewhere across Australia by the Commonwealth Government for environmental reporting and monitoring (ESCAVI 2003). Emerging global classification exercises, including Faber-Langendoen et al. (2016) and Keith et al. (2020), introduce the possibilities of additional upper levels in the hierarchy to position the native vegetation of NSW within an international context.

1.4 Legacy of recent classification efforts

Since the 1990s the collection of standard plot-based floristic data and the application of numerical classification methods have been used in eastern NSW to define vegetation types across a wide range of environments and spatial scales. These have ranged from large regional studies encompassing biogeographic regions or major river catchments, to smaller local projects with study areas defined by local government areas, individual conservation reserves or proposed development sites. Other studies have focused on thematic subsets of native vegetation across large areas including coastal wallum heaths, tableland wetlands, coastal floodplains and treeless alpine vegetation.

Past regional plot-based classification efforts have built a foundation for understanding vegetation patterns across environmental gradients at bioregional scales. Many have applied broadly similar methods, and provide useful points of comparison against which a comprehensive revised eastern NSW classification may be assessed. Past local vegetation studies based on small areas are generally too limited in context to provide useful measures of comparison across our study area, and many hundreds of independent local-scale plot-based classifications and reports exist with varying methods. However, local studies do provide a guide to the classification scale that users are familiar with interpreting and applying at a property level, where biodiversity assessment tools are commonly applied.

Many Approved PCTs (2018) in eastern NSW cite units identified by past vegetation classification projects as sources for that PCT's circumscription and description. Cited sources are dominated by a number of regional plot-based classification projects. We refer to past vegetation classification projects collectively as 'legacy classification projects', and the classification units they identified as 'legacy classification units'. Where the plot assignments to units of these legacy classification projects are available, they allow comparisons to be made with other classifications containing overlapping plot sets.

1.5 Objectives and principles for the current study

The primary objective of the current study was to classify and describe a comprehensive set of native PCTs for eastern NSW at a consistent level (plant association) that is appropriate for use in the context of implementing NSW biodiversity legislation. That is, the types are defined by full-floristic and environmental data (so are likely to be reasonable proxies for broader biodiversity values), and can be consistently differentiated and identified by users in the field based on full-floristic species composition and other features.

Within the constraints of this primary objective, our secondary objective was to minimise disruption to those Approved PCTs (2018) that were based on plot-based legacy classification units. Approved PCTs (2018) have been applied to land-use decisions and mapping projects and embedded in operational and policy applications for a number of years, and users have developed a familiarity with subsets of PCTs relevant to their areas of work. Our approach to this secondary objective began by identifying the plot-based legacy classification projects most frequently cited by Approved PCTs (2018) in eastern NSW, and applying the units of these projects during our clustering and analysis processes. Legacy classification units were also compared against the data standards applied and final groups identified by the current project.

Our approach recognised that vegetation classification is an artificial framework used to describe vegetation patterns along a continuum of environmental, spatial and temporal gradients, and that there are often valid alternative ways to partition plant assemblages along these gradients. The following principles guided our choice of methods (following De Cáceres & Wiser 2012; Faber-Langendoen et al. 2014; Perrin 2015; Biurrun et al. 2016):

- Vegetation classification and description will be based on numerical analysis of systematic full-floristic survey plot data that is stored within the Flora surveys module of the BioNet Atlas application.

- Classification will be based primarily on floristic composition data for all vascular plants, and will also be guided by reference to environmental data.
- Classification will not be constrained to reproduce existing types. It will retain robust groups, some of which are likely to reproduce or expand upon legacy classification units; it may result in removal of duplicate existing types and those that have a weak base of floristic and environmental evidence as distinct types; and it will provide for poorly known communities that await further data for full characterisation or validation.
- Classification will fit within the NSW hierarchy of vegetation formations –> vegetation classes –> PCTs.
- The revised classification will be updatable and expandable.

The final retained groups defined by our classification will be proposed to be adopted into the PCT master list, replacing Approved PCTs (2018) in eastern NSW. Following these principles, our final retained groups will allow summaries of PCT species assemblages, distribution, environments and habitats to be based on member plots, with plot membership defined in the Flora surveys module of the BioNet Atlas application. The descriptions of the revised PCTs, combined with new diagnostic tools, will support transparent, objective and consistent assignment of new standard floristic survey plots to PCTs in eastern NSW.

1.6 Report context

This report is one of a series of 4 describing the context, methods and results, implementation steps and new tools arising from native vegetation classification work in eastern NSW. Report 1 (DPE 2022a) evaluates the set of Approved PCTs in eastern NSW as at 1 November 2018. It identifies strengths and weaknesses of these PCTs and proposes steps for improvements. Report 2 (this report) is a detailed technical document describing the methods applied to the development of a new plot-based classification for eastern NSW and concluding with the identification of 1,067 coast and tablelands groups (ENSW v1.1 groups) and 138 western slopes groups. Report 3 (DPE 2022b) describes the assessment and adoption of the ENSW v1.1 groups into the PCT master list. Report 4 (DPE 2022c) describes a new online identification tool that assists users to identify PCTs in the coast and tablelands bioregions using standard floristic survey plots.

Figure 1 Project reports in this series

2. Study area

The focus of this study is native vegetation of eastern NSW, with a combined study area (Figure 2) covering approximately 346,000 km^2 and comprising 10 of the IBRA v7 bioregions described by DAWE (2021): the Australian Alps, New England Tablelands, NSW North Coast, South East Corner, South Eastern Highlands, South Eastern Queensland, Sydney Basin, Brigalow Belt South, Nandewar and NSW South Western Slopes. The first 7 of these bioregions together represent coastal, escarpment, tableland and alps environments, and are collectively referred to in this document as ‘coast and tablelands bioregions’. We refer to the latter 3 bioregions collectively as ‘western slopes bioregions’.

Note that although we included and classified plot data from the Australian Capital Territory (ACT), the PCT classification does not apply under ACT legislation.

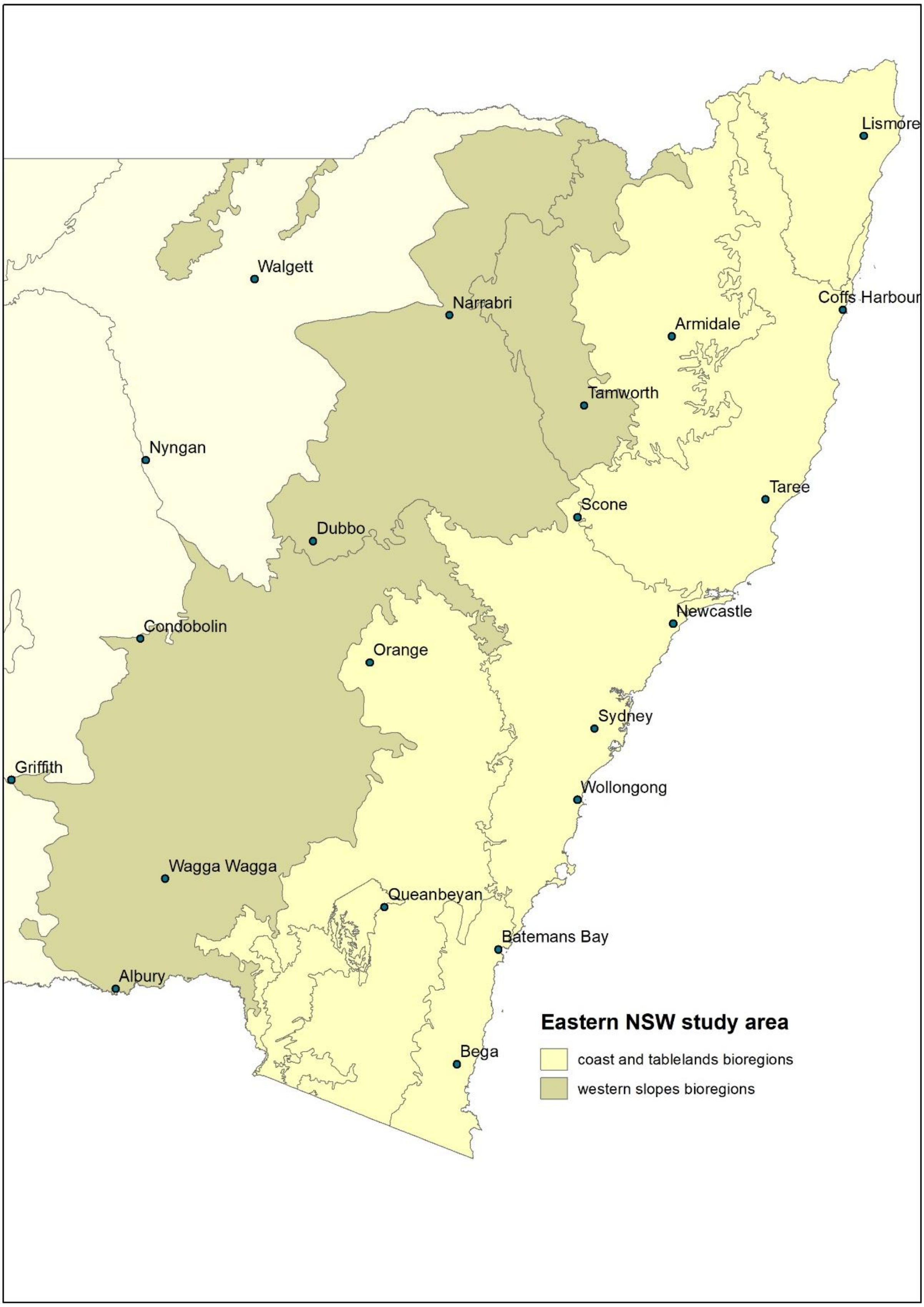

Figure 2 **Eastern NSW study area, comprising 7 'coast and tablelands bioregions' and 3 'western slopes bioregions'**

Locations of a subset of cities and towns are shown for context.

3. Methods – data preparation

3.1 Pre-existing data in the Flora surveys module

We reviewed floristic survey data held in the Flora surveys module of the BioNet Atlas application and identified all samples located within our study area. In addition to pre-existing data in BioNet, we actively sought other floristic survey data that had been collected by various external processes. We undertook an audit of plot data available from environmental impact assessments, biodiversity offset assessments and conservation reserve surveys, and managed the entry of over 4,000 additional samples from these sources to the BioNet Flora surveys module.

The architecture of the Flora surveys module allows for storage of survey data with complex experimental design, including multiple visits to a site location. Survey data is stored in a hierarchical structure in the Flora surveys module: 'replicates' (a single visit to a site) are nested within 'sites' (each site having a particular location), which are nested within 'surveys' (a survey being a set of sites sampled using consistent methods). In this document, we use the word 'plot' to refer to the floristic data collected from a single replicate at a particular site (i.e. a specific combination of replicate number, site number (including location), and survey name).

When exporting data for analysis we included only a single replicate from each site; for those sites with multiple replicates, we selected the replicate with highest native species richness, and lowest exotic species richness or cover.

Details of field survey methods for each of 1,500 separate surveys were retrieved from metadata or obtained from survey reports or data custodians, and cross-checked against the raw floristic data stored in the Flora surveys module of the BioNet Atlas application. Each plot in these surveys was categorised as one of 9 data types (see Appendix A) based on data attributes including completeness of the floristic inventory, size of the sample search area, and species importance scoring method. We then applied a series of filters to determine whether the plot would be included in our classification analysis dataset (Table 1). Consistent with our intention to classify native vegetation, we rejected plots in surveys where metadata indicated a focus on highly modified vegetation, and plots characterised by a high proportion or cover of exotic species. We also rejected plots with a high proportion of plant identifications unresolved beyond genus level, which may result from poor seasonal conditions, disturbance and/or incomplete identification.

Plots that met the standards for inclusion are hereafter referred to as 'analysis plots'. Plots that did not meet the standards for inclusion are hereafter referred to as 'rejected samples'. Table 1 summarises our application of these terms and the sub-categories within them. All analysis plots involved a full-floristic inventory of plant species in a bounded search area, generally 400–1,000 m^2. We differentiated analysis plots as:

- 'standard floristic survey plots' – survey used species importance scores that could reliably be transformed to a 6-point modified Braun-Blanquet cover–abundance (CA) scale, as: 1: present and uncommon; 2: common and up to 5% cover; 3: up to 20% cover; 4: up to 50% cover; 5: up to 75% cover; 6: over 75% cover. Past floristic survey data stored in the Flora surveys module have used more than 20 different species importance schemas, and a transformation to values on this 6-point modified Braun-Blanquet scale (BB CA 1–6) was selected as the point allowing maximum inclusion of these diverse past data
- 'supplementary floristic survey plots' – these included:

  - 'alternative CA plots' – survey used species importance scores that could only loosely be transformed to the chosen BB CA 1–6 scale; for example, surveys that recorded species cover estimates but did not record abundance
  - 'PA plots' – survey simply recorded presence of all species within the plot with no importance scores (i.e. data is presence/absence (PA)), or species importance scores were used that were not transformable to the chosen BB CA 1–6 scale.

For some analyses, standard floristic survey plots and alternative CA plots could be treated as PA plots, but not vice-versa. The transformations applied from original species importance scores to the common BB CA 1–6 scale are shown in Appendix B, including the approximations applied for alternative CA plots.

Table 1 Summary of the terms used to describe the different categories of floristic survey data, and whether the data are included in our classification analysis dataset ('analysis plots') or treated as 'rejected samples'

Inclusion categories and criteria	Data type	Description, and sub-categories
'Analysis plots' • full-floristic bounded area search • generally 400–1,000 m^2 (with some exceptions where they were the only samples available in particular environments)	Type 1a and 2a	**'Standard floristic survey plots'** • field-recorded species importance values are reliably transformable to BB CA 1–6
	Type 1b and 2b	**'Supplementary floristic survey plots'**, includes: • '**alternative CA plots**' – species importance values are only roughly transformable to BB CA 1–6 (e.g. cover-only data) • '**PA plots**' – field-recorded data are only suitable for use in presence/absence form
'Rejected samples'	Type 1x/2x	Plots that would otherwise be categorised as 'standard floristic survey plots' or 'supplementary floristic survey plots' but are situated in highly disturbed environments, sampled in seasons unsuitable for the target vegetation, or dominated by incomplete identifications
	Type 3	Full-floristic samples, but search area is not a fixed size; for example, whole-wetland samples of Monaro lakes and north coast wetlands
	Type 4	Random meander or transect or polygon lists – attempts to characterise the vegetation of a particular mapping polygon/stratification unit/environmental domain or other field-interpreted area
	Type 5	Partial floristics (rapids) – commonly involves either a list of dominant canopy tree species and tall shrubs (for API validation work), or list of dominants in each stratum (U, M, L) plus an attempt to assign a PCT or other pre-determined classification unit

We identified 3 sets of floristic survey plot data that had been collected using bounded areas smaller than our standard size range, and had sampled vegetation from distinctive environments within our study area: treeless alpine vegetation (McDougall & Walsh 2007), temperate natural grasslands of the Liverpool Plains (Allen & Benson 2012), and wallum vegetation of the NSW North Coast (Griffith 2002, Griffith et al. 2003). Despite the smaller bounded areas, we chose to include these plots as analysis plots within our classification analysis dataset.

The comprehensive work of McDougall and Walsh (2007) in treeless vegetation of the Australian Alps used 5 m x 5 m bounded area plots. These plots represent the vegetation of a distinctive environmental envelope of restricted distribution within our study area, and completely dominate the available plot data from this environment, with very few standard 400 m^2 plots available in treeless alpine vegetation.

The 10 m x 10 m plots surveyed in Liverpool Plains grasslands by Allen and Benson (2012) sample small native grassland remnants in a heavily cleared and cropped environment. Native vegetation on the Liverpool Plains primarily survives along narrow public roadsides and linear travelling stock reserves, and the samples collected by Allen and Benson (2012) represent the best available data from these remaining areas of natural grassland.

The north coast wallum data of Griffith (2002) consisted of samples with 2 subplots of either 5 m x 5 m (non-woody vegetation) or 10 m x 10 m (woody vegetation) at each site, and recorded foliage cover classes but not abundance. We evaluated the suitability of these plot data for inclusion in our classification analysis dataset by resampling 40 of the 247 original site locations, across a range of wallum types, using standard plot size and cover and abundance score methods. We tested whether smaller bounded area sizes resulted in a significant difference in species richness using the Wilcoxon signed rank test. The results were consistent with the rationale for smaller bounded area size (Griffith et al. 2003) as we found no significant difference in species richness between Griffith plots and standard floristic survey plots in woody vegetation. We did however find that the standard 400 m^2 plots in non-woody vegetation returned significantly higher species richness than the 5 m x 5 m Griffith plots. Multivariate analysis of the species assemblage data explored the extent to which survey method influenced clustering behaviour, using analyses of paired samples on the revisited plots only and analyses on a larger dataset in wallum. In our analyses (using RELATE and nMDS in Primer 7 (Clarke et al. 2014) and Canonical Analysis of Principal Coordinates (CAP) in Permanova+ for Primer (Anderson et al. 2008)), the clustering behaviour of Griffith et al. (2003) plots showed a strong relationship to that of standard floristic survey plots (using RELATE), and standard floristic survey plots and Griffith et al. (2003) plots mixed through unconstrained and constrained ordinations (nMDS, CAP) in relation to vegetation type rather than strongly separating out by survey method. We concluded that inclusion of the Griffith et al. (2003) plots (in woody and non-woody vegetation) in our classification analysis dataset was unlikely to cause biased clustering.

3.2 New floristic survey effort

Following our initial review of plot data available in the Flora surveys module of the BioNet Atlas application, and an evaluation of legacy classification units cited by Approved PCTs (2018) (see Section 3.5), we identified limitations of existing standard sampling across coast and tablelands bioregions. Three separate analyses were undertaken to guide targeted collection of additional standard floristic survey plot data.

Firstly, the locations of our initial set of analysis plots were intersected with modified biogeographic landscape mapping (Mitchell 2002; ELA 2008) to generate a figure of analysis plot density for each biogeographic landscape unit. We constructed separate maps (OEH 2019b), using the same biogeographic landscape units, that provided an indicative scale of historic and future land-use pressures for 3 classes of development activity: agriculture, urban development, and mining. Our intention was to generate a relative measure of likely ongoing land-use pressures across our study area. Legislative biodiversity assessment protocols are more likely to apply in areas with greater land-use pressure; these areas will require the most robustly defined PCTs for use in decision support tools. Landscape units with high development pressure scores and low density of plots in the initial analysis dataset were identified as ‘priority landscapes’ for new floristic survey effort. We constructed a series of species accumulation curves (Colwell 2019) for each priority landscape, based on existing analysis plot data, to provide an indicative number of new floristic survey plots required to reach the point on the predicted species curve at which the slope equals one.

Secondly, our evaluation of legacy classifications and Approved PCTs (2018) revealed that low numbers of analysis plots were available to support the plot-based classification of rainforest and wetland PCTs across northern coastal bioregions – a legacy of past sampling design in surveys of rainforest and non-woody wetlands in NSW (Floyd 1990; Pressey 1987a, 1987b). For non-woody wetlands, those wetlands on the lower Clarence and lower Macleay floodplains surveyed by Pressey (1987a, 1987b) were sampled where possible when they fell within a priority landscape unit. For rainforests, we undertook a targeted re-survey of the reference locations used by Floyd (1990) to classify and describe rainforest sub-alliances in northern and southern coastal NSW. The survey transect locations used in that study were compared against the distribution of existing standard floristic survey plots, and those sub-alliances with no, or few, standard floristic survey plots proximate to sub-alliance transects were targeted for new survey using standard methods. As original transects were random meanders of varying lengths in response to size of the targeted rainforest patch (resulting in widely varying species numbers), we completed 2 or more plots across each target location in order to sample the variation present.

Thirdly, we identified poorly sampled landscapes under high development pressure that are likely to include TECs listed under NSW and/or Commonwealth legislation. TECs that had been defined using vegetation classification sources that have few or no traceable analysis plots were prioritised, and the relevant landscapes added to the set of areas targeted for new floristic survey effort.

Standard floristic survey methods (Sivertsen 2009) were used in the collection of all new field data. To facilitate field surveys, we consulted with state land management agencies and local governments covering priority landscapes. Finer-scale patterns in development pressures were resolved following local consultation, and private landholders within focus areas were contacted to seek permission for access and survey.

3.3 Accumulated analysis dataset

Our initial analysis dataset contained roughly 48,800 analysis plots, selected from approximately 78,000 plots available in the Flora surveys module from our study area at the time. The data for most of these plots are publicly accessible, while a very small proportion are restricted for various reasons.

Our study proceeded over a number of years, and throughout the project the Flora surveys module continued to accumulate new plot data, both from our own targeted surveys (see Section 3.2) and from other BioNet users. At various points during the classification process we again audited plot data in the Flora surveys module of the BioNet Atlas application and identified any new plots from eastern NSW that met our data standards. These were added to our analysis dataset as large blocks of new plots, through the series of analysis rounds described below.

The density distribution of analysis plots across our study area is uneven, accumulated from both stratified regional survey efforts and targeted local sampling associated with land management or impact assessment processes. Most regional legacy classification projects had applied stratified sampling efforts, and for large parts of our study area (see Figure 3) the resulting data coverages formed the basis for the legacy classifications. We recognised the potential for accumulated sampling biases to impact the derivation of clusters (e.g. Lengyel et al. 2011; Wiser & De Cáceres 2013), but chose to avoid the potential loss of information arising from resampling of the dataset (Rolecek et al. 2007) in order to minimise the potential for disruption to legacy classification units.

Plot data stored in the Flora surveys module were collected across more than 30 years by many different observers. When exporting floristic data for analysis, we applied a standardised taxonomic treatment, which aimed to maximise information retention in the classification analysis dataset within the constraints of taxon name changes and variation in name usage across the dataset. The taxonomic treatment was developed by reviewing species observation records from the classification analysis dataset against current treatments applied by PlantNet and the Australian Plant Name Index (APNI), to identify species names that have undergone taxonomic change since recorded. The treatment lumped subspecies/variety/form to species where appropriate; removed genus-only records and exotic species records; and removed records of non-vascular species (mosses, lichens, bryophytes), which have not been consistently recorded by all observers across the samples in our classification analysis dataset.

3.4 Environmental data

We compiled spatial layers (in raster format) of 54 environmental variables considered to have potential explanatory value as predictors of patterns of vegetation composition, including substrate, climate, topographic and spatial variables. The selected variables and source for each layer are outlined in Appendix C.

The environmental variable rasters were intersected with analysis plot locations to generate a matrix of environmental values for all plots. This matrix was used as a basis for analysing plant assemblages in relation to environmental gradients.

3.5 Classification sources of Approved PCTs (2018)

Our primary objective was to identify a comprehensive set of native PCTs for eastern NSW at a consistent level, and we aimed to achieve this by classifying all available analysis plot data. Within this, where possible we aimed to minimise disruption to Approved PCTs (2018) that were based on plot-based legacy classification units. In order to apply this secondary objective, and measure our success in meeting it, we interrogated the PCT master list held in the BioNet Vegetation Classification applications in November 2018 to identify the plot-based legacy classification projects most frequently cited by PCTs in eastern NSW.

In November 2018, the BioNet Vegetation Classification public application indicated that 1,289 Approved PCTs (2018) were assigned to one or more of the 10 bioregions defining the eastern NSW study area, including 991 PCTs said to occur in one or more of the 7 coast and tablelands bioregions, and an additional 298 PCTs in the 3 western slopes bioregions. We also evaluated Draft-Working PCTs in the NSW North Coast and South Eastern Queensland bioregions, as they represent a significant past investment of classification effort in these regions. Information on 360 Draft-Working PCTs was exported from the BioNet Vegetation Classification edit application in November 2018; these are herein referred to as ‘Draft-Working PCTs (2018)’.

We extracted descriptive data fields for the relevant Approved and Draft-Working PCTs (2018) and identified the primary cited classification project and cited classification unit(s) that formed the basis for circumscription of each PCT. From this, we compiled a list of the most frequently cited plot-based legacy classification projects (Table 2).

Table 2 **Plot-based legacy classification projects frequently cited as sources in the circumscription of Approved or Draft-Working PCTs (2018) in our study area**

Based on information extracted from the BioNet Vegetation Classification applications in November 2018.

Plot-based legacy classification project cited by Approved and/or Draft-Working PCTs (2018)	No. of PCTs that cite this classification project and are restricted to coast and tablelands bioregions	No. of PCTs that cite this classification project and are assigned to both coast and tableland bioregions and western slopes bioregions	No. of PCTs that cite this classification project and are assigned to western slopes bioregions but not coast and tableland bioregions[1]	Are plot assignments to legacy classification units traceable?
North East Comprehensive Regional Assessment (CRA) regions (NPWS 1999)	135	42	0	No[2]
Northern Rivers region (OEH 2012)	228	0	0	Yes
Greater Hunter region (Somerville 2009; Sivertsen et al. 2011)	145	100	1	Yes
Western Blue Mountains (DEC 2006)	16	15	3	Yes
Sydney metropolitan catchment (OEH 2013)[3]	42	0	0	Yes
Southern forests (Gellie 2005)	38	46	2	Yes
South Coast – Illawarra region (Tozer et al. 2010)	180	6	0	Yes
North coast wallum (Griffith 2002; Griffith et al. 2003)	35	0	0	Yes
Australian Alps treeless vegetation (McDougall & Walsh 2007)	7	0	0	Yes
Nandewar bioregion (DEC 2004)	2	78	30	Yes
Brigalow Belt South bioregion (RACAC 2004)	0	49	93	Yes
Rainforests (Floyd 1990)	23	5	3	Yes[4]
Central West (Ismay et al. 2004; and/or Lewer et al. 2003)	0	28	68	Yes
NSW South Western Slopes bioregion (Priday 2006)	0	24	25	No

Plot-based legacy classification project cited by Approved and/or Draft-Working PCTs (2018)	No. of PCTs that cite this classification project and are restricted to coast and tablelands bioregions	No. of PCTs that cite this classification project and are assigned to both coast and tableland bioregions and western slopes bioregions	No. of PCTs that cite this classification project and are assigned to western slopes bioregions but not coast and tableland bioregions[1]	Are plot assignments to legacy classification units traceable?
Reserves of the south west slopes (Gellie & Fanning 2004)	0	26	4	Yes
NSW wheatbelt (Sivertsen & Metcalfe 1995; Sivertsen & Metcalfe 2001; and Metcalfe et al. 2003)	0	3	56	Yes
Guyra area – New England Tablelands (Benson & Ashby 2000)	8	9	1	Yes

[1] The majority of Approved PCTs (2018) in the 3 western slopes bioregions were defined by Benson (2008) and Benson et al. (2010), which in turn cite these other sources, frequently applying qualifying conditions to the cited units.

[2] Although the north east CRA classification by NPWS (1999) assigned field samples to classification units, no record of those assignments could be found so they were effectively untraceable at the time of the current project. However, the more recent Northern Rivers region classification of OEH (2012) covered the same region, used similar classification protocols and overlapping analysis datasets to NPWS (1999) (and also incorporated the wallum classification of Griffith et al. (2003)), and had well-documented and traceable plot assignments. OEH (2012) is cited as a source by a large number of Draft-Working PCTs (2018) for the Northern Rivers region, which were intended to replace Approved PCTs in that region once resources were available for a revision of PCTs in the region.

[3] Note that although the BioNet Vegetation Classification public application cites OEH (2013) V2.0, this project's final release was OEH (2016) V3.0.

[4] Floyd (1990) samples are species lists from random meander transects; these samples were available in the Flora surveys module of the BioNet Atlas application and had traceable assignments; however, due to their non-standard method were rejected from our classification analysis dataset.

From the set of frequently cited legacy classification projects, we chose 7 regional-level and 3 thematic or sub-regional plot-based classification projects through which we would apply our secondary objective, and against which to compare the final retained groups identified by our classification.

These 10 legacy classification projects all used related vegetation classification protocols but differed in data selection rules, choice of classification scale, and classification evaluation processes (Table 3). They include a set of regional-level classifications comprising: the Northern Rivers region work of OEH (2012); the greater Hunter region classification by Somerville (2009) and Sivertsen et al. (2011); the Sydney metropolitan catchment project (OEH 2016); the southern forests classification described by Gellie (2005); the South Coast – Illawarra region vegetation classification by Tozer et al. (2010); and the classifications produced for bioregional assessments of Nandewar (DEC 2004) and Brigalow Belt South (RACAC 2004). They also include a smaller western Blue Mountains classification (DEC 2006), and the 2 thematically-defined projects: McDougall & Walsh (2007) examining treeless vegetation of the Australian Alps; and Griffith (2002) and Griffith et al. (2003) describing coastal wallum types of northern NSW.

We also chose to evaluate the final retained groups identified by our classification against vegetation units identified by Armstrong et al. (2012) for the upper Murrumbidgee catchment. Although this source is not cited by Approved or Draft-Working PCTs (2018), it applied methods and a regional scale similar to many cited sources, has traceable plot assignments, and fills gaps in legacy classification project coverage of tableland and slopes landscapes.

Past local vegetation studies, particularly surveys of conservation reserves, have contributed a significant proportion of currently available standard floristic survey plot data across eastern NSW. To consider the implications of our revised classification at local interpretation scales, we also chose to compare our final classification groups to the units of 2 local plot-based classification projects: the work of Bell and Driscoll (2007) describing vegetation of the Cessnock–Kurri area at a local government area scale, and a classification of vegetation of 4 conservation reserves in the Tenterfield area of the New England Tablelands by Hunter (2000).

We obtained and compiled the final plot assignments to classification units identified by each of these 13 legacy classification projects, which cover much of our eastern NSW study area (Figure 3). For older legacy classification projects, the compilation process included identifying equivalence between site labels used in legacy assignment files and site labels in the Flora surveys module. Compiled plot assignments were then applied during initial clustering processes and referenced during group review phases (see below). Once our classification was complete, we compared our final retained groups against the units of these legacy sources to assess how well final retained groups met our secondary objective.

Note that the western edge of our study area overlaps with the regional classifications of Benson (2008) and Benson et al. (2010), which are referenced sources for Approved PCTs (2018) across much of western NSW. These works involved expert interpretations of the units of multiple other classification projects which themselves varied widely in method and scale. We did not directly trace relationships with these sources in our assessment of legacy classifications, but did so indirectly where there was a stated relationship to any units of our traceable legacy classification projects.

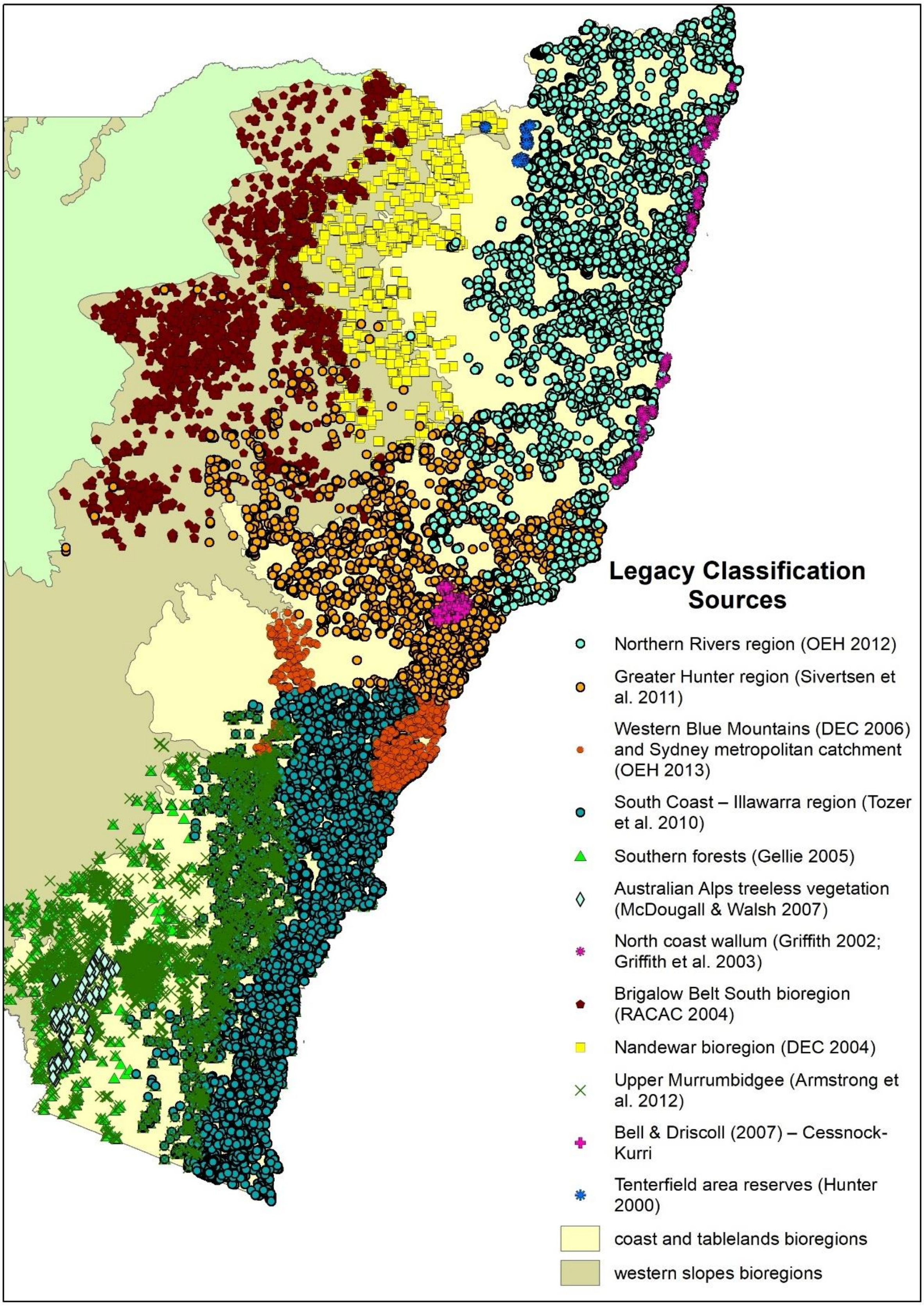

Figure 3 **Indicative study areas of 13 plot-based legacy classification projects cited by PCTs of eastern NSW in 2018**

Study areas are indicated by the locations of floristic survey plots included in our classification analysis dataset that were classified by each legacy classification project.

Table 3 Summary of the classification approaches and plot data used by 13 selected plot-based legacy classification projects from eastern NSW with traceable plot assignments

Selected projects include 8 regional and 2 thematic legacy classifications cited by Approved and/or Draft-Working PCTs (2018), one uncited regional classification, and 2 local level classification projects.

Legacy classification project	General classification approach	No. of plots used by the project	No. of units defined
Northern Rivers region (OEH 2012)	Classification of plot data in A (8,892 plots) + B analyses (4 separate analyses totalling 2,972 plots) including many samples from outside the study area; target group numbers all set by experts; multiple rounds of hierarchical clustering (PATN, β=0) followed by significant input from expert panel	8,892 + 2,972	384
Greater Hunter region (Somerville 2009; Sivertsen et al. 2011)	Analysis of 5,609 plots; group no. expert set; hierarchical clustering (PATN) followed by significant input from expert panel	5,609	254
Sydney metropolitan catchment (OEH 2013)	Analysed 2,202 plots; target group no. interpreted from homogeneity analysis; hierarchical clustering (PATN); groups compared with SCIVI and with broader SydBasin hierarchical clustering	2,202	79
Western Blue Mountains (DEC 2006)	Classified 1,257 plots (including buffer area), homogeneity analysis guided choice of target group number; combined hierarchical and non-hierarchical clustering (PATN)	1,257	57
Southern forests (Gellie 2005)	3,740 plots analysed; target group no. interpreted from homogeneity analysis; hierarchical clustering (PATN), expert review of groups	3,740	206
South Coast – Illawarra region (Tozer et al. 2010) ('SCIVI')	10,805 plots analysed; group no. from homogeneity analysis; combined hierarchical and non-hierarchical clustering (PATN), multiple iterations with additional data, testing of sampling bias	10,805	191
North coast wallum (Griffith 2002; Griffith et al. 2003)	Analysed 247 pairs of subplots; species importance measure foliage cover score only (no abundance); hierarchical agglomerative clustering in PATN	247	42
Australian Alps treeless vegetation (McDougall & Walsh 2007)	Analysed data from 1,222 quadrat plots (NSW, ACT and Vic) using CLUSTER routine in Primer v5; cover values of <5% were amalgamated to value of 1, all values square-root transformed then Bray–Curtis dissimilarities calculated; classified using group average cluster mode; clusters sorted by hand	1,222	34 (NSW) 56 (total)
Brigalow Belt South bioregion (RACAC 2004)	Analysed 3,139 plots; group no. from homogeneity analysis x 2; hierarchical clustering (PATN), plus NN checks and ALOC comparison leading to reallocations	3,139	115

Legacy classification project	General classification approach	No. of plots used by the project	No. of units defined
Nandewar bioregion (DEC 2004)	Analysed 2,854 plots; hierarchical agglomerative process in PATN with ASO-FUSE, plus NN checks and ALOC comparison leading to reallocations	2,854	113
Upper Murrumbidgee (Armstrong et al. 2012)	Analysed 4,106 plots (including 1,089 non-standard); group no. from homogeneity analysis; combined hierarchical and non-hierarchical clustering (PATN), multiple iterations	4,106	117
Cessnock–Kurri area (Bell & Driscoll 2007)	Selected and analysed 284 'good quality' plots; homogeneity analysis plus hierarchical clustering process in PATN, defining vegetation communities at the ~0.6–0.7 level of dissimilarity; NN checks and some reallocations	284	36
Tenterfield area reserves (Hunter 2000)	Analysed 135 plots; combined hierarchical and ordination data exploration; group number from scree plot analysis after removal of 'unnaturally' divergent 15 Mt McKenzie sites	135	14

4. Methods – vegetation classification

4.1 Regional analysis of floristic and environmental patterns

We introduced broad-scale environmental gradients in the earliest stage of our analysis by applying a modelling approach that groups plots by simultaneously modelling their species composition and environmental variables. This was used to provide an initial biogeographically sensitive partition of the analysis dataset. The method is a mixture modelling approach that groups plots into 'regions of common species probability profile' (RCPs) by modelling the plot x species data as a function of the environmental covariate data. The aim of the method is to identify groups of plots that have relative homogeneity in species composition and that can be predicted by the environmental data. The method was initially developed for fish catch data (Foster et al. 2013) and has been adapted to vegetation modelling in NSW (Lyons et al. 2017).

The analysis can be sensitive to very rare or hyper-abundant species, along with plots that have very low species richness (Lyons et al. 2017). We constructed a dataset using presence/absence floristic data from 48,810 plots in our initial analysis dataset (combining standard floristic survey plots and supplementary floristic survey plots, transformed to presence/absence data). We removed species that occurred in fewer than 100 plots, and those with a frequency greater than 14,000, and then removed any plots with a remaining species richness of less than 10. The resulting trimmed plot x species floristic data matrix was 46,496 x 1,714. Plots that were excluded from the RCP clustering process due to low richness (following the removal of the lowest and highest frequency species from the initial analysis dataset) were set aside for inclusion following the initial RCP data partition.

From our set of 54 environmental covariates, we chose a set of 9 variables considered likely to be useful predictors of floristic patterns (following Lyons et al. 2017) at a scale similar to existing biogeographic and physiographic regionalisations of the study area (DAWE 2021;

Pain et al. 2011). The covariates used as inputs to the RCP modelling process were: topographic roughness within a 1 km buffer; elevation; average annual precipitation; summer–winter rainfall ratio; average minimum temperature in the coldest period; Prescott water balance index; annual evapotranspiration; annual evapotranspiration deficit; and annual days with minimum temperature of less than –2°C. These covariate values were extracted for each plot in the trimmed floristic data matrix.

The AIC and BIC information criteria (Akaike and Bayesian information criteria) were used to select the optimal partitioning of the initial floristic and environmental analysis dataset following Lyons et al. (2017). The primary output from the mixture modelling analysis was a set of 9 RCPs to which each plot had a probabilistic membership value. We used the highest membership probability for each plot (i.e. a hard clustering) to partition the data, assigning each plot to an RCP (RCP1, RCP2, … RCP9).

A secondary output was 2 small sets of 'RCP leftover' plots that had not been given an RCP assignment. One was the group of plots that had been set aside during preparation steps due to low richness following removal of very high and very low frequency species. This included plots sampling vegetation of naturally low richness or dominated by species rare in our initial analysis dataset, and plots where the constituent assemblage was only a partial representation of that typically recorded within samples of that environment (i.e. sampling degraded landscapes). The other was a set of plots that had been included in the mixture modelling process but could not be satisfactorily assigned to an RCP; review of these plots indicated that they represented assemblages whose distribution is tied to factors not included in the 9 model input environmental predictor variables (e.g. fine-scale drainage, soil depth or salinity factors).

We assessed these 'RCP leftover' plots for their fit to one of the 9 RCPs, using a combination of k-means clustering and probabilities generated from generalised additive modelling (GAM) using the RCP environmental covariates. Where an unassigned plot's closest RCP centroid was the same as its RCP of highest probability of occurrence, the plot was added to that RCP. Plots that remained unresolved after this process were retained in a residual set that we termed RCP10.

4.2 Development of RCPs

The RCP regionalisation defined the higher order data partitions within which our classification would proceed. Before clustering within each RCP began, we further developed each RCP by (i) allowing for legacy classification units, and (ii) identifying and setting aside a subset of floristic outlier or 'noise' plots.

To maximise the potential for legacy classification units to survive the initial RCP data partition, we reviewed the extent to which individual RCPs retained the full plot membership of legacy classification units from 10 regional and thematic legacy classification projects that were frequently cited by Approved and Draft-Working PCTs (2018) and had traceable plot assignments (see Section 3.5 above). For those legacy units that were split between 2 or more RCPs, we identified the RCP that contained the highest proportion of its plots. We then 'extended' the plot membership of that RCP by adding to it the residual member plots of that legacy classification unit. This resulted in all individual legacy classification units each being fully represented in an RCP. This approach resulted in some duplication of plots across the dataset at this point, with approximately 20% of all plots assigned to 2 or more extended RCPs.

Preliminary testing of clustering behaviour within individual extended RCPs indicated that sets of small groups formed around artificially 'noisy' plots – plots with unusual floristic data resulting from extraneous factors including recent disturbance, probable species misidentifications, low species richness due to relatively high levels of genus-only records, or observer effects. To reduce the influence of this noise on initial clustering results, we identified and set aside a subset of the most extreme outlier plots in each RCP. Pairwise Bray–Curtis dissimilarity scores were calculated across all plots within each extended RCP, and those plots with a minimum pairwise dissimilarity value above the 95th percentile within that RCP were set aside from that RCP.

4.3 Consistent classification scale and removing overlap between RCPs

The above process resulted in 10 RCPs that had been ‘extended’ and ‘cleaned’. We commenced clustering within each of these RCPs.

Following a separate testing phase to compare alternative clustering approaches (see Appendix D), we selected the non-hierarchical centroid-based method applied by the ALOC module of PATN (Belbin 1995) to undertake clustering within each RCP, using the Bray–Curtis association measure. For rounds 1–3 of classification analyses (see below), clustering was undertaken on standard floristic survey plots only, exported from the Flora surveys module with standardised taxonomic treatment and transformed cover–abundance scores. Supplementary floristic survey plots (alternative CA plots and PA plots) were set aside for inclusion in later analysis rounds.

We applied a consistent partition level across all RCPs by using a single allocation radius (Belbin 1995). The choice of partition level followed an evaluation of legacy classifications against alternative k-means clustering solutions produced by a range of allocation radii using both unseeded and seeded clustering. Cluster results that retained a higher proportion of plot membership for the greatest number of legacy classification units were most likely to minimise disruption to the legacy schemas. Based on these comparisons, we selected an allocation radius (Bray–Curtis dissimilarity value) of 0.78 to generate initial clusters within each extended RCP, using the first plot in each RCP as the initial seed.

Our evaluation found that the effect on legacy classification unit retention of seeding the clustering process with any particular legacy classification project’s assignments was generally low, and variable. This is likely due to the many dimensions in which change has occurred between legacy classification analyses and the current project, including increased floristic survey plot coverage; our rejection of some plot data that had been accepted by legacy classification projects; widespread repair/correction of past plot data; and differences in data context, taxonomic treatment, species importance score transformation and choice of clustering algorithm. The process of evaluating seeding effectiveness also highlighted the intractable problem of choosing a single preferred legacy classification project as the source of seeds for each RCP, from up to 5 alternative source projects.

The initial partition step identified varying numbers of clusters or ‘groups’ within each of the 10 extended RCPs. Each group was identified by a unique numeric code consisting of its RCP number and its sequential cluster number within that RCP; for example, R9.136 was group 136 within RCP9. All groups within each RCP were reviewed against legacy classification units, environmental domains, and survey method/observer. Groups that had formed around disturbed plots or observer effects were ‘retired’ and their plots reassigned to other groups based on each plot’s floristic and environmental relationships. Retained groups were given draft names and summary descriptions. During this process a small number of plots were identified as having unresolvable problems and excluded from further analysis.

Following initial group review we recognised that overlap existed between extended RCPs in 2 forms. A proportion of plots (i) had been included in more than one RCP (in order to incorporate all plots defining particular legacy classification units, as described above), or/and (ii) had their closest centroid in a group other than their initially assigned RCP. These were regarded as RCP overlap plots. We implemented a series of steps in the R programming environment to remove this overlap (see Appendix E), resulting in the assignment of each plot to a single RCP representing its closest group centroid across the classification analysis dataset at that time. Moving to the R environment also allowed calculation of values for distances to group centroids (Bray–Curtis dissimilarity) for every plot against all groups in all RCPs. We use the term 'distance to centroid' to refer to these values hereafter.

4.4 Analysis of groups within RCPs

After removal of plot overlap, we commenced a process of comprehensive review of all groups identified within each of the 10 RCPs. Our aim was to decide whether to retain or retire each group, as detailed below. This review was based on analyses of floristic and environmental data for 40,002 standard floristic survey plots.

Within each RCP, each group and all of its individual member plots were reviewed. The review process applied a standardised workflow, with a toolkit of methods including ordinations, group environment analyses and alternative clustering strategies in the PRIMER 7 software package (PRIMER-e 2016) and in the R environment (ordination functions in package 'vegan', comparing groups with multivariate modelling using functions in package 'mvabund' and custom scripts compiled using base R functions).

Within each RCP, groups were initially represented in summary dendrogram form to indicate floristic relationships between groups. Review considered group metrics (species summary, maximum and median radius), relationship to legacy classification units, census-based information (species richness, observer, proportions of native and exotic species, census notes) and environmental data (climatic, topographic and substrate information). Review also considered group spatial distribution in GIS, group floristic data summaries (outputs from Fidel (Bedward 1999) and SIMPER (PRIMER-e 2016)), and a tabulation of the 10 smallest distance to centroid values (Bray–Curtis dissimilarity) for all plots.

Groups were reviewed in the context of related sets of groups, with a subset of environmental variables identified as being most relevant to distinguishing these related groups. In PRIMER 7 software, the BEST function was used to identify the subset of variables with among-sample patterns best matching the relationships between sites in multivariate floristic space. Relationships were examined using group summary box-plots and 2-way scatterplots of individual plots in environmental space. In R, a Wilcoxon signed-rank test was used to identify environmental factors that most clearly discriminated pairwise comparisons among floristically related groups, and 2-way scatter on these significant variables was examined to review environmental relationships. Environmental outlier plots in each group were identified based on standard outlier measures for environmental data (1.5 x the interquartile range above and below quartiles for relevant variables). Outlier plots were considered for reassignment to alternative groups indicated by floristic relationships (based on distance to centroid values) where the reassignment was within the environmental range of the alternative group.

For each group, a decision was made to either retain the group or retire the group. Groups with a combination of high floristic and environmental homogeneity, high fidelity to legacy classification unit/s, low floristic overlap metrics (see below), and/or coherent environmental relationships were retained. Groups with a combination of high floristic overlap metrics, weak species separation, signs of observer effects, signs that disturbance or sample density had influenced cluster formation, implausible ecological relationships, and/or high environmental heterogeneity were retired.

Where a group was retired, its member plots were individually examined for potential reassignment to other (retained) groups based on each plot's floristic and environmental relationships. Individual plots whose group membership could not be resolved were treated as unassigned plots, and were reviewed again in subsequent analysis rounds following addition of new plot data (see Section 4.7).

Retained groups that were defined by fewer than 5 plots but occupied distinct environmental space were distinguished as ‘placeholder’ groups.

The standardised workflow applied to the review of groups was developed to be a repeatable process applied consistently across all groups and between RCPs; however, some indicators of group cohesion/validity have no available objective measures, and these required an element of judgement. An example is groups consisting of plots dominated by a single observer, in some cases with consistently lower species richness than nearby plots by other observers, clustering together despite sampling widely different environments.

4.5 Plot membership rules

For retained groups, plot membership was defined by applying a standard distance-based measure. Individual plots were categorised as ‘Primary’ members of a group where their distance to centroid was less than or equal to a threshold value of 0.695. This value represented the 95th percentile of distances for all groups (across all RCPs) with 20 or more plots (the group size at which plot radius becomes independent of group size).

Plots exceeding the group membership threshold were assigned to one of 3 categories. Plots were categorised as ‘Secondary’ members of a group if the plot had plausible floristic and environmental relationships to the group but its distance to centroid was above our threshold and its census data suggested low species richness, atypical cover–abundance scores or potential disturbance effects. Alternatively, a plot was categorised as unresolved if choices between groups were ambiguous or no satisfactory choices were available. Finally, a small subset of plots was excluded from the classification analysis dataset where census data was found to have an irredeemable problem not detected earlier, such as an incomplete species list, likely erroneous species identifications, implausible cover–abundance scores or unresolvable location error.

4.6 Treatment of coastal non-woody wetland vegetation

We modified our classification methods for the treatment of coastal non-woody wetland vegetation. These assemblages are characterised by low native species richness (median 7 species) and a high degree of temporal and spatial heterogeneity, and occupy environments that are frequently impacted by high levels of anthropogenic disturbance (e.g. Pressey & Griffith 1992; Keith & Scott 2005). Legacy classification projects that provide the basis for existing PCTs do not include a consistent overarching structure against which individual units have been defined. Unlike wetlands dominated by woody vegetation, type definition of coastal non-woody wetlands (e.g. OEH 2012) currently relies on very low numbers of plots (including non-standard plots) to define assemblages widely distributed along parts of coastal NSW.

We adopted a higher order classification hierarchy for coastal non-woody wetland plots prior to clustering, to structure our initial interpretation of patterns. Three geomorphological units can be broadly recognised across wetland studies in coastal NSW and Queensland (e.g. Kingsford et al. 2004; Pressey & Griffith 1992; Environmental Protection Agency 2005 and Claus et al. 2011): estuarine wetlands, floodplain wetlands, and freshwater coastal swamps and lagoons fed by rainfall/runoff (including depressions and swales of dunal areas). Clustering results were examined to assess the extent to which groups represented assemblages occurring across one or more of these higher order classes. We retained groups that were exclusive to one class and proceeded to resolve these groups following our standard processes. Groups were dismembered if they spanned multiple classes or represented implausible ecological relationships. Groups were partitioned to represent unique classes with plot membership of each new group evaluated against alternative groups within the same class.

4.7 Subsequent rounds of plot addition, assignment and review

As our classification process progressed, large numbers of additional standard floristic survey plots were accumulating in the Flora surveys module of BioNet Atlas, both from our own ongoing floristic survey effort and from survey work undertaken by others across our study area. Over the course of our classification work, more than 4,000 additional plots entered into the Flora surveys module were assessed as suitable for addition to our classification analysis dataset.

During early analysis rounds, we also identified subsets of plot data that behaved oddly in clustering, and investigated possible causes. Data quality problems, ranging from incorrect survey-level metadata to individual plot location, species name and cover–abundance score data entry errors, were identified through reference to original field datasheets, project reports and botanists involved in the original field survey. Where appropriate, data were permanently corrected in the Flora surveys module of the BioNet Atlas application, and the ‘repaired’ data re-exported to be replaced in the accumulated analysis dataset for subsequent rounds. In total, over 700 plots were repaired and replaced across our analysis rounds.

To incorporate into our accumulated analysis dataset the additional standard floristic survey plots, repaired plots, and also the subset of supplementary floristic survey plots that had been set aside from initial clustering, we undertook the process of group review and individual plot categorisation described above in a series of successive analysis rounds. Each round involved detailed review of all groups, and categorisation of all plots in the accumulated analysis dataset as Primary or Secondary members of a group or as unresolved or excluded plots, using our standard workflow and membership rules. This was followed by a final set of group review processes, as described under Section 4.8. At the conclusion of each round, the summary set of all retained groups across all RCPs was revised, and the set of revised Primary member plots was used to recalculate group centroids and update distance to centroid values for all plots. The next round of analysis commenced from this set of group centroids.

Analysis rounds 2–5 each involved the addition of a significant block of new plot data to the classification analysis dataset, so we made provision for the formation of new groups from these additional data (see Appendix F). All plot distance to centroid values were recalculated against groups defined by Primary member plots at the completion of the previous round, and new groups were defined as described in Appendix F. While all groups and plots were reviewed in each round, those with a higher proportion of new and/or noisy plots were most closely scrutinised.

Supplementary floristic survey plots (alternative CA plots and PA plots) were introduced to the classification analysis dataset in round 4. Alternative CA plots were transformed to closest approximation on the BB CA 1–6 scale (see Appendix B), then assessed in the same way as standard floristic survey plots; however, their primary or secondary categorisations were distinguished as ‘B-Primary’ or ‘B-Secondary’.

PA plots were evaluated using 2 sets of centroid comparisons: centroids defined by cover–abundance (CA) data, and centroids defined by presence/absence (PA) data. We increased our threshold distance to centroid value for primary plot membership of a group to 0.713 for PA plots in the PA analysis, following recalculation of the median radius for all groups with more than 20 member plots using the presence/absence version of the data matrix. PA plots closest to the same group in both the CA and PA analyses, and within each relevant threshold (≤0.695 CA and ≤0.713 PA), were categorised as primary members of that group if they also fitted within the target group’s environmental envelope. PA plots that were not closest to the same group in both the CA and PA analyses, or exceeded threshold for one or more values, were left unresolved at the end of this round. The primary or secondary categorisations for PA plots were distinguished as ‘P-Primary’ or ‘P-Secondary’.

The plot data added in each analysis round comprised:

- round 1: the initial set of 40,002 standard floristic survey plots
- round 2: approximately 2,300 new standard floristic survey plots (including plots targeting poorly sampled landscapes) and 3,400 standard floristic survey plots that had been withheld as potential 'noise' in earlier steps
- round 3: approximately 800 new standard floristic survey plots
- round 4: approximately 3,300 supplementary floristic survey plots comprising approximately 1,000 alternative CA plots and approximately 2,300 PA plots
- round 5: approximately 1,050 new standard floristic survey plots.

4.8 Evaluating groups at the end of each review round

At the end of each analysis round, the set of revised Primary member plots was used to update group definitions and distance to centroid values for all plots. Each round was then completed by applying a final set of group review processes relating to group overlap, and group accuracy and reliability.

For each retained group we calculated group overlap as the proportion of plots within the group that were below our ≤0.695 distance to centroid threshold for that group, and for all other groups. For each group, results were tabulated as the 10 groups with the highest overlap proportion (including the subject group itself), in decreasing order.

Calculation of group accuracy and reliability involved a bootstrap resampling process and is described in Appendix G.

All groups with overlap to one or more other groups of ≥0.7 and reliability of ≤0.7 were evaluated against a set of indicators designed to maintain consistency in classification scale. Where there was no evidence of environmental separation between the overlapping groups on any significant environmental variable or on substrate (mapped or inferred), and no separation between these groups in perennial and larger biomass species, then the lower reliability group was dismembered and its plots reassigned based on individual floristic and environmental relationships. Where a group with high floristic overlap and relatively low reliability was separable from its related sister group on environmental factors, or was characterised by one or more perennial high biomass species at frequency of 0.7 or more but less than 0.3 frequency in the sister group, the groups were retained as separate entities. We applied the same review process to groups with 5 or fewer plots if 50% or more of the plots had a distance to centroid of ≤0.695 to another group.

Placeholder groups were also reviewed at the end of each round. Groups were dissolved where the round identified better fits that hadn't been considered previously. Where new plots joined a placeholder group as Primary member plots and group membership rose above 5 plots, placeholder status was removed.

4.9 Group environmental domains and outliers

Group review processes in each round included examination of member plots in individual groups, or small sets of related groups, against environmental factors. On completion of round 4, we also applied a broad and consistent approach to identify environmental outlier plots within all groups at that point. All groups were evaluated against environmental covariates to identify those variables most strongly related to within-RCP group variation. The evaluation process is described in detail in Appendix H. Elevation, average annual precipitation, annual mean temperature and seasonal radiation were selected as the variables most useful in explaining within-RCP group variations, using pairwise comparisons between groups. These 4 variables were used to review consistency of environmental definition of each group and to identify potential environmental outliers. We calculated thresholds for all groups and each covariate to identify outliers. We defined outliers as 3 x (median-q1) below the first quartile and 3 x (median+q3) above the third quartile, to allow for highly skewed distributions. Plots identified as outliers against upper and lower thresholds for each covariate were re-evaluated to identify candidate groups of better environmental fit using the available choices from the clustering outputs.

4.10 Expert review of groups

On completion of round 4, various sets of groups were also evaluated by a number of external ecologists familiar with the vegetation of particular regions. Areas of expert interest included the north coast; northern tablelands and northwest slopes; central tablelands and central western slopes; Hunter valley and central coast; and southern tablelands, alps and south coast. Each expert reviewed group floristic data summaries (outputs from Fidel (Bedward 1999)), group spatial distribution in GIS, and draft summary descriptions for each group.

The review aimed to compare our draft groups against current understandings of plant community patterns from experienced field botanists and vegetation ecologists. Focuses for evaluation and feedback included draft groups suggesting new vegetation types (not previously recognised within a region), draft groups that may have reflected disturbance or seasonal conditions, and identification of possible misclassified plots arising from known sampling or data integrity issues. Expert review did not involve direct reassignment of individual plots between groups; review results were integrated within our standard classification protocols applied to subsequent analysis rounds.

5. Methods – treatment of final retained groups

5.1 Coast and tablelands groups and western slopes groups

Following completion of our final analysis round, the distributions of all final retained groups were compared against the bioregions defining our study area. All groups with one or more plots located within the coast and tablelands bioregions were categorised as 'coast and tablelands groups'. Those groups consisting entirely of plots located in western slopes bioregions were categorised as 'western slopes groups'.

Each final retained group was identified by a unique numeric label, indicating the RCP within which the group had been identified, and that group's sequential group number from initial clustering within the RCP; for example, R3.19 was group 19 within RCP3. Each final retained group was also given a brief descriptive name of generally less than 50 characters. For groups very strongly related to a legacy classification unit, the legacy name was used. Otherwise each name consisted of a combination of regional or location identifier, topographic or substrate descriptor, frequent species in the tallest stratum, and vegetation structure; for example, R3.1 is named Far North Escarpment Blackbutt Grassy Forest.

5.2 Placeholders

We aimed for a plot membership of 5 or more samples for each group, to provide discriminatory power between types for identification and distribution mapping processes.

Final retained groups with fewer than 5 member plots were generally given ‘placeholder’ status. This threshold was lowered for groups restricted to narrow environmental ranges, if we considered fewer plots were needed to circumscribe the floristic and environmental variation present. Placeholder status was also applied to groups defined by larger numbers of plots if they had been sampled by a single observer within a unique environmental domain where no other plot data were available to confirm patterns independently.

5.3 Evaluating final retained groups

The plot memberships of all final retained groups were summarised, and all groups assessed using our measures of group overlap, accuracy and reliability (see Section 4.8 and Appendix G.

5.4 Comparing final retained groups with legacy classification units

Final retained groups were compared against the units of 13 plot-based legacy classification projects (see Section 3.5 above) on several performance measures. These classification projects included the most comprehensive previously available regional plot-based classifications for eastern NSW. Our revised classification offers a replacement for these sources with a single set of types that represent an improvement on various measures, while allowing for the continuation of existing legacy classification units where appropriate. We compiled figures for each legacy classification project to assess the degree to which its input floristic data met the inclusion standards applied by the current project, and compared the performance of its identified classification units against measures of group performance for the current project. For each legacy classification project we compiled the following data:

- a tally of the number of classification units and numbers of plots assigned to those units. We calculated the mean number of plots assigned to units across the project
- a tally of the number of classification units with fewer than 5 plots (assigned by the legacy classification project and categorised as analysis plots by the current study), and that figure as a proportion of the total number of units
- a tally of the number of plots/samples assigned by the legacy classification project that were rejected by the current study (did not meet our criteria for inclusion), and the number of units defined by >25% rejected samples
- a measure of the density of plots across the project’s study area that were classified by the project, and the number of additional analysis plots available to the current project in the legacy project’s study area (i.e. a measure of new plots collected since the legacy classification project was produced).

The effectiveness of final retained groups in meeting our secondary aim (to minimise disruption to legacy-based Approved PCTs (2018)) was assessed by tracing shared plot memberships between legacy classification units and our final retained groups. For each legacy classification project, tracing of plots was used to categorise the strength of relationships between legacy classification units and final retained groups of the current study, based on 4 relationship strength classes defined as in Table 4.

Outcomes against these classes are influenced by the size of the legacy classification unit (number of member plots); for example, a legacy classification unit defined by 2 member plots is more likely to be entirely included within a final retained group than a unit defined by 20 member plots. For purposes of comparison, we differentiated between local or thematic studies (which tend to have relatively few plots sampling small areas) and regional-level studies, which have thousands of plots over broad areas.

Table 4 Classes used to summarise strength of relationships between units of legacy classification projects and the final retained groups of the current project

Relationship strength class	Definition
Very strong	>70% of the member plots of a legacy classification unit are within a single final retained group
Strong	>70% of the member plots of a legacy classification unit are within 2 final retained groups
Moderate	>70% of the member plots of a legacy classification unit are within 3 final retained groups
Weak	More than 3 final retained groups collectively account for >70% of the legacy classification unit's member plots

The 13 selected legacy classification projects varied widely in their treatments of vegetation patterns, particularly in the classification scale or level of subdivision of floristic patterns that each project chose to recognise and describe from the samples that were available at the time of the project. To investigate differences in classification scale across the selected legacy projects, we generated comparative measures of the internal floristic variation present within the units of each of the 7 large regional legacy classification projects. Within-group variance (cluster variance sensu Wiser & De Cáceres 2013) versus group size was compared across these 7 legacy classification projects.

We also generated within-group variance versus group size figures for all final retained groups in each of our 9 RCPs, as an indication of the relative classification scale of the final retained groups in each RCP. Group variance was calculated using Primary member plots. For each RCP, variance calculations were compared against the same calculations for units of the regional legacy classification project that shared the highest number of plots with that RCP.

5.5 Assigning final retained groups to vegetation class and formation

To fit the final retained groups into the NSW vegetation classification hierarchy, each group had to be allocated to a single 'vegetation class'. Each vegetation class fits within a 'vegetation formation' at the upper level of the hierarchy.

All final retained groups were assessed against the 99 vegetation classes and 12 vegetation formations defined by Keith (2004). This assessment compared attributes of each final retained group against the qualitative descriptions of classes and formations, and maps of their distributions, in Keith (2004), following a sequential process:

1. Identify the most plausible vegetation formation using the dominant or most frequent structural characteristics of the group.
2. Of those vegetation classes within the chosen vegetation formation, discount vegetation classes that are by definition (Keith 2004) outside the current project's study area.
3. Identify the class assignments of the most strongly related legacy classification units.
4. Evaluate classes for fit, by comparing elevation, rainfall and substrate characteristics, and distribution of the group (using member plot locations), against descriptions and maps of the candidate classes (using Keith (2004) and Keith & Simpson (2008).
5. Resolve the final class choice by comparing floristic composition of the final retained group with the indicative species of the candidate classes (Keith 2004).

6. Results

6.1 Floristic survey plot data

In total, our review of floristic survey data held in the Flora surveys module of the BioNet Atlas application considered approximately 87,300 samples located within our study area, from 1,500 surveys.

Our RCP analysis commenced with an initial analysis dataset of roughly 48,800 plots, consisting of approximately 44,000 standard floristic survey plots and 4,800 PA plots. Through various analysis rounds, approximately 4,000 plots were added to the accumulated analysis dataset, while roughly 2,000 of the initial dataset were excluded over the course of analysis for various reasons. At the conclusion of the project, across the study area the average density of analysis plots assigned to a final retained group was roughly one plot per 7.4 km^2 of study area, and one plot per 3.9 km^2 of extant native vegetation cover (based on OEH (2017) mapping).

Figure 4(a) below indicates those parts of the study area that have had greatest increases in the numbers of available analysis plots (orange–red areas) compared with the numbers of plots that were available to legacy classification projects cited by Approved and Draft-Working PCTs (2018). Improvements in quantity and coverage of standard floristic survey plot data allow for improved understanding and description of vegetation patterns.

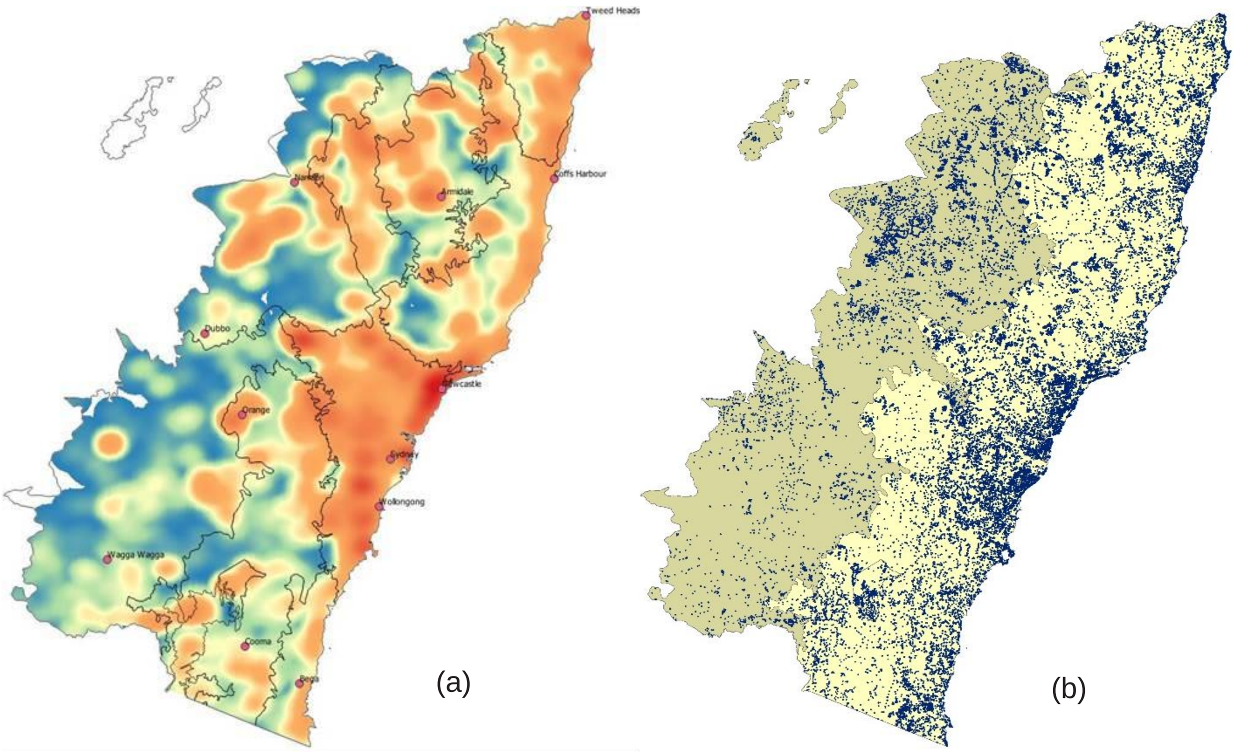

Figure 4 Distribution of analysis plots across the study area at completion of the project

(a) Heat map showing areas where new analysis plots were available to this project that were not available to legacy classification projects cited by Approved and Draft-Working PCTs (2018). This included new samples from gap-filling surveys by the current project, plots added to BioNet through our audit of data from other projects, and plots added to BioNet by other users. Heat map is based on a 25 km radius, with colour scale ranging from blue= low numbers of new plots, to red= highest densities of new plots.
(b) Distribution of all analysis plots assigned to final retained groups. Each plot location is represented by a dot. Background study area map follows Figure 2.

Plots added to the classification analysis dataset during the project included those collected by other projects and added to BioNet independently, plots from other projects identified and added by our data audit, and plots collected by the new gap-filling floristic survey undertaken for this project. The gap-filling floristic survey effort resulted in the addition of approximately 2,000 standard floristic survey plots, sampling 35 priority landscapes. The new data addressed some of the unevenness in past survey effort, particularly on private tenures in the local government areas of Tweed, Ballina, Byron, Lismore, Richmond Valley, Kyogle, Clarence Valley, Port Macquarie–Hastings and Kempsey on the north coast; Armidale Regional, Walcha and Uralla on the New England tablelands; Blayney, Orange, Oberon and Bathurst Regional on the central tablelands; Snowy–Monaro Regional, Upper Lachlan Shire and Goulburn–Mulwaree on the southern tablelands; and littoral environments along the coastlines of the Shoalhaven, Eurobodalla and Bega Valley shires.

Targeted rainforest sampling addressed 24 rainforest sub-alliances of Floyd (1990), by revisiting 252 reference locations cited by Floyd (1990) and collecting 524 standard floristic survey plots. Greater survey effort was applied to the Subtropical, Cool Temperate and Littoral alliances where data suitable for inclusion in our classification analysis dataset was most deficient. A small number of sub-alliances situated in remote locations remain unsampled by standard floristic survey plots.

Despite an emphasis on gap-filling sampling programs by many past regional-scale legacy classification projects (e.g. RACAC 2004; Tozer et al. 2010; OEH 2012; Armstrong et al. 2012), and by the current project, the distribution of samples across our very large study area remains relatively uneven (Figure 4(b) and Table 5). This is primarily due to 2 contributing factors. Firstly, the amount of extant native vegetation varies widely across the study area, with relatively small proportions remaining within tablelands and western slopes bioregions. Secondly, ongoing independent survey effort continues to be focused in regions of high development pressure (Sydney, Central Coast and Hunter regions), and in conservation reserves and production forests. Sampling density also remains low in rugged, inaccessible tracts of the eastern escarpment.

Table 5 Density of assigned analysis plots per km^2, based on bioregion total area and on extant native vegetation cover per bioregion

Based on State Vegetation Type Map extant native vegetation coverage from OEH (2017).

IBRA bioregion	Plots/km^2 of total bioregion area	Plots/km^2 of extant native vegetation
Australian Alps	0.237	0.243
Brigalow Belt South	0.082	0.172
Nandewar	0.117	0.261
New England Tablelands	0.152	0.257
NSW North Coast	0.17	0.219
NSW South Western Slopes	0.029	0.115
South East Corner	0.276	0.329
South Eastern Highlands	0.101	0.193
South Eastern Queensland	0.2	0.307
Sydney Basin	0.378	0.515

At the conclusion of the project our classification analysis dataset consisted of 50,963 analysis plots. Over 700 of these plots had been subject to some form of ‘repair’ or correction of their data in BioNet during the project, most commonly involving correcting the recorded survey cover score method, plot location details (including datum), or plot bounded area size.

6.2 RCPs as floristic-environmental regions of eastern NSW

Our initial analysis dataset consisted of 48,810 plots (of which 43,875 were standard floristic survey plots transformed to presence/absence data). Of these, 42,393 plots passed through the RCP model process and were assigned to an RCP. The remainder consisted of 2,316 plots excluded due to low richness following removal of very high and very low frequency species, and 4,101 plots that were excluded by the model as it failed to find species–environment relationships using our chosen covariates.

Based on the AIC and BIC information criteria (Lyons et al. 2017), the RCP analysis identified 9 regions as the optimal partitioning of the initial floristic and environmental analysis dataset. The 9 RCP regions represent a biogeographical partitioning of the data and study area at a scale broadly analogous to IBRA bioregions, but without the use of traditional geographically interconnected boundaries. Figure 5 provides a spatial representation of the 9 regions across the study area, showing the highest probability RCP within a 2 km grid. Appendix I provides a floristic summary for each of the 9 RCPs, listing the 10 most frequently occurring species in each stratum based on presence/absence floristic data from plots assigned to each RCP. Appendix J summarises the environmental characteristics of each RCP from the 8 covariates applied in the RCP modelling process.

Of the 43,875 standard floristic survey plots in our initial analysis dataset, 38,360 passed through the RCP model process and were assigned to an RCP. Through our process of extending RCPs (based on legacy classification units and a combination of k-means clustering and GAM) we assigned a total of 3,512 of the ‘RCP leftover’ standard floristic survey plots to one of the 9 RCPs, and the remaining 2,003 standard floristic survey plots were retained as a residual set that we labelled as RCP10 for convenience.

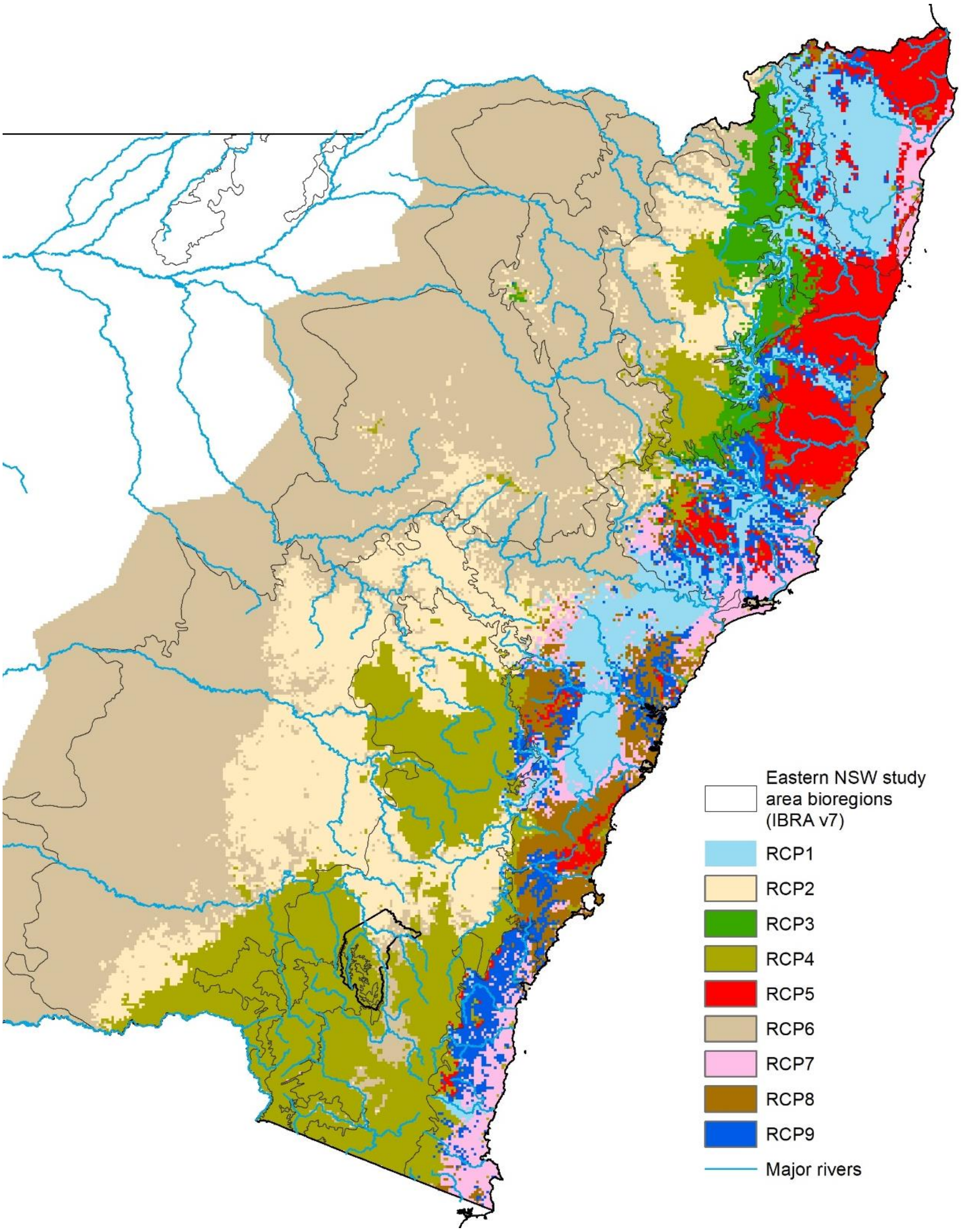

Figure 5 Spatial representation of RCPs 1–9 across the study area based on initial analysis dataset, showing highest probability RCP within a 2 km grid

6.3 Clustering within RCPs

Initial clustering of standard floristic survey plots within each of the 10 RCPs yielded between 43 and 296 clusters per RCP, with RCP3 containing the least number of groups and RCP10 the greatest (Table 6). Initial data exploration identified a small number of plots with unresolvable problems, which were excluded from further analysis. Following overlap removal, and the setting aside of floristic outlier or 'noise' plots, analysis round 1 began with 40,002 standard floristic survey plots, each having a single assignment to its closest group, and a total of 1,530 initial groups. Through the course of subsequent analysis rounds, 7,552 additional standard floristic survey plots were added, along with 1,039 alternative CA plots and 2,289 PA plots. A total of 715 plots out of the accumulated analysis dataset were found during various rounds to have data problems that required data 'repair' in BioNet; revised data from these plots was exported and replaced in the master analysis matrix.

Table 6 Summary of plots assigned and groups identified within RCPs at commencement and conclusion of the cluster analysis process

RCP	Number of standard floristic survey plots at commencement of round 1	No. of groups at start of analysis	No. of Primary + Secondary member plots (incl. standard + supplementary floristic survey plots) at conclusion of analysis	Number of final retained groups (non-placeholders +placeholders)	
				Coast and tablelands	Western slopes
RCP1 Coast and Hinterland Grassy Forests	3,731	116	4,437	78 +30	Nil
RCP2 Tablelands and Slopes Dry Sclerophyll Forests	4,609	205	5,322	84 + 17	44 + 6
RCP3 Eastern New England Moist Grassy Forests	1,525	43	1,511	23 + 2	Nil
RCP4 Tablelands Grassy Forests	5,013	172	6,553	118 + 9	2 + 0
RCP5 Rainforests and Layered Wet Sclerophyll Forests	3,308	103	5,028	113 + 59	1 + 0
RCP6 Western Slopes Grassy Woodlands	7,143	193	8,419	67 + 9	55 + 21
RCP7 Coast and Hinterland Dry Sclerophyll Forests	4,028	141	4,110	101 + 15	Nil
RCP8 Coast and Hinterland Heaths and Heathy Forests	3,985	121	5,113	108 + 12	Nil
RCP9 Coast and Hinterland Moist Grassy Forests	4,143	140	5,316	114 + 37	1 + 0
RCP10 mixed habitat specialist groups	2,517	296	1,104	35 + 36	1 + 7
Totals	**40,002**	**1,530**	**46,913**	**841 + 226**	**104 + 34**

At the conclusion of the analyses, our accumulated analysis dataset of 50,963 plots consisted of:

- 39,602 Primary member plots (including 773 B-Primary and 981 P-Primary assignments)
- 7,311 Secondary member plots (including 177 B-Secondary and 982 P-Secondary assignments)
- 349 unresolved plots
- 3,701 excluded plots (including 95 excluded due to apparent location errors).

6.4 Group environmental domains and outliers

Three environmental factors – annual mean temperature, average annual precipitation, and elevation – were consistently reliable for discriminating among groups within RCPs and are easily interpretable. Of 736 groups with 15 or more member plots at the end of analysis round 4, some 105 groups had no environmental outliers for any of these 3 factors using our criteria, and 643 groups had <20% of member plots as outliers. Groups with higher proportions of environmental outliers were generally those for which occurrence is more strongly related to other environmental factors not included in our data (e.g. salinity, flood frequency), or environmental factors for which data is not available at fine-scale resolution and accuracy (e.g. topographic position, exposure).

6.5 Summary of final retained groups

Table 6 above shows the number of plots included in each of the 10 RCPs, and the number of initial clusters generated from the application of our chosen allocation radius (0.78) using the k-means clustering strategy implemented by the ALOC module of PATN (Belbin 1995). This table also summarises the final number of retained groups within each RCP at the conclusion of our analyses. Final retained groups were all defined by plot membership, with each plot assigned to a single group.

We identified a total of 1,205 final retained groups across our eastern NSW study area. Of these, 1,067 groups included one or more plots located in the 7 coast and tablelands bioregions and were categorised as 'coast and tablelands groups'. These groups are proposed to be adopted into the PCT master list in a first stage, addressing the coast and tableland bioregions. This stage of PCT additions is referred to as 'eastern NSW PCT classification v1.1', with the groups referred to as 'ENSW v1.1 groups'. Adoption of these groups into the PCT master list is described in DPE (2022b). Groups of this category are present in all RCPs. Some 35,324 plots defined the Primary membership of ENSW v1.1 groups. These were supplemented by 5,881 plots with Secondary membership, considered useful in defining group distributions and environmental relationships. The set of 1,067 ENSW v1.1 groups included 226 groups designated as placeholders, in most cases on the basis that they were defined by 5 or fewer member plots.

An additional 138 groups (including 34 placeholders) from RCPs 2, 4, 5, 6, 9 and 10 showed a distribution restricted to the 3 western slopes bioregions only, and were categorised as 'western slopes groups'. These groups were defined by 4,278 Primary member plots, supplemented by 1,430 Secondary member plots. The western slopes groups potentially extend west of the current study area so their definitions could be improved in future iterations of classification work by including additional samples from the bioregions of central and western NSW. The western slopes groups are proposed to be adopted into the PCT master list in a second stage, likely eastern NSW PCT classification v1.2, which will address all 10 eastern NSW bioregions.

At the end of our analyses, 4,050 of the plots in our accumulated analysis dataset remained unassigned for various reasons, including limitations of the census data, apparent plot location errors and difficulties in resolving plausible floristic and environmental relationships.

6.6 Evaluation of final retained groups

The performance of all 1,205 final retained groups against independent evaluation measures is summarised by RCP in Figure 6 and Figure 7.

Group overlap is a measure of the proportion of plots in a group that are also strongly floristically related to one or more other groups. Low floristic overlap indicates floristically distinctive groups that are relatively reliably discriminated from other groups using floristic data. Figure 6 illustrates the variation in levels of group overlap between RCPs. Note that placeholder groups are treated as a separate category because they are defined by very low numbers of Primary member plots, which can influence group overlap calculations. Overall, the level of floristic overlap between final retained groups is low, with 70% of all groups recording group overlap values to all other groups of less than 0.7. RCP5 (Rainforests and Layered Wet Sclerophyll Forests) and RCP8 (Coast and Hinterland Heaths and Heathy Forests) have the largest numbers of groups with high levels of floristic overlap, while a subset of distinctive assemblages of alpine, wetland and rock outcrop habitats (particularly in RCP10) have the lowest group overlap values.

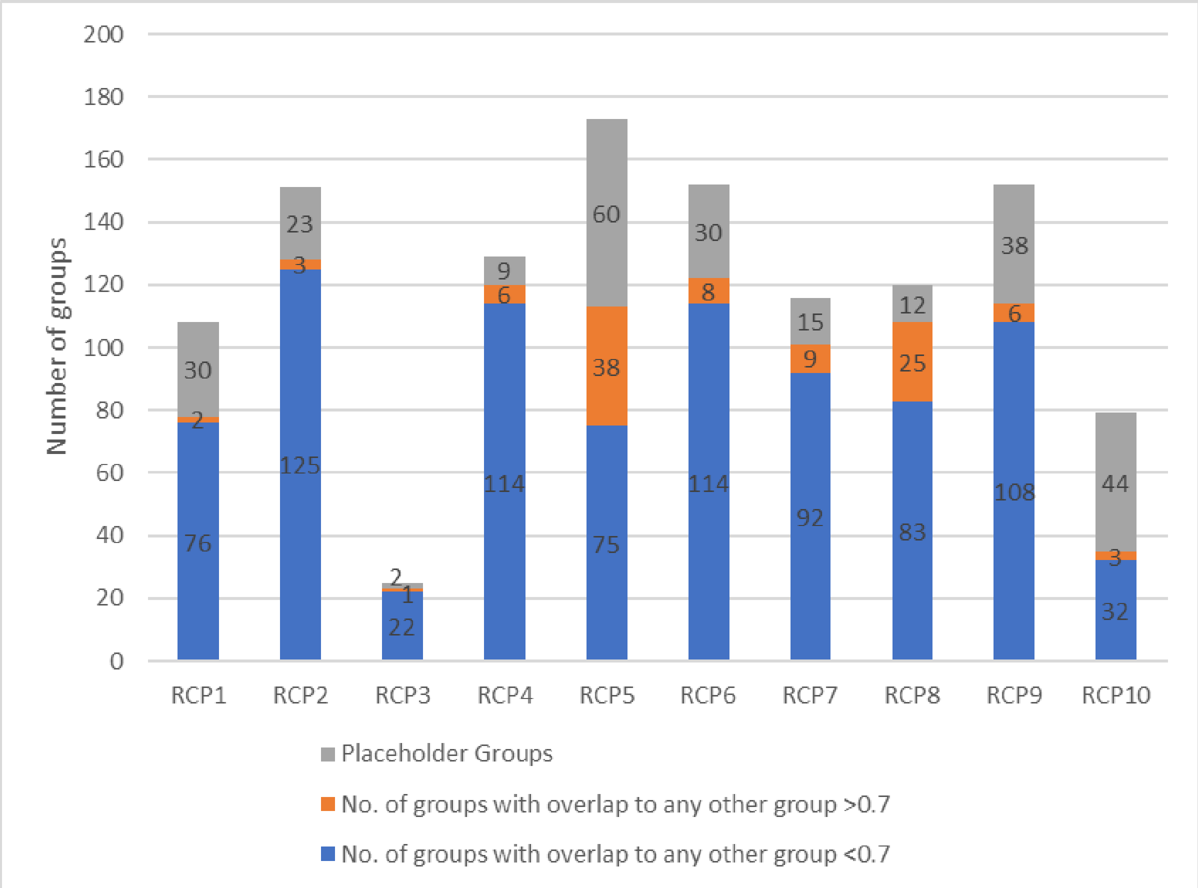

Figure 6 **Comparison of group overlap patterns across RCPs**

Of 714 final retained groups with at least 15 Primary member plots, 573 groups (80%) have both high accuracy and high reliability (both ≥0.7), indicating groups that are relatively robust or stable to the addition of new standard floristic survey plot data. Patterns of group stability and robustness vary between RCPs (Figure 7). Groups representing vegetation subject to widespread degradation may tend to have reduced accuracy and/or reliability. For example, RCPs 1, 3, 4 and 6 include many groups that represent open grassy forests and woodlands of moderate to high fertility substrates on areas of low topographic relief, which have been widely cleared and disturbed. Remnants are commonly subject to degradation pressures that favour a limited subset of species, which may blur floristic distinctions between groups. The compositional attributes of groups defined in these environments may also be more sensitive to prevailing climatic conditions at the time of survey. Separation of these groups, and assignment of new plots, particularly from disturbed remnants, requires a greater reliance on environmental predictor data. Groups occurring in environments with long, diffuse environmental gradients (as in some tableland and western slopes landscapes of RCP3, 4 and 6) might also be expected to have reduced accuracy and reliability compared with groups restricted to combinations of environmental conditions that are distinctive at fine scales (as with many groups in RCP10).

For comparison, patterns in the accuracy and reliability of legacy classification units from 4 of the compared legacy classification projects are illustrated in Figure 7. These 4 projects differed in the density and coverage of available plot data, in their inclusion of non-standard plots, and in their approach to classification scale and therefore the level of internal floristic heterogeneity or variation that was accepted within their final units (see Figure 9). The general patterns of accuracy and reliability for final retained groups of the current project (Figure 7) compare favourably with the patterns in these 4 legacy classification projects.

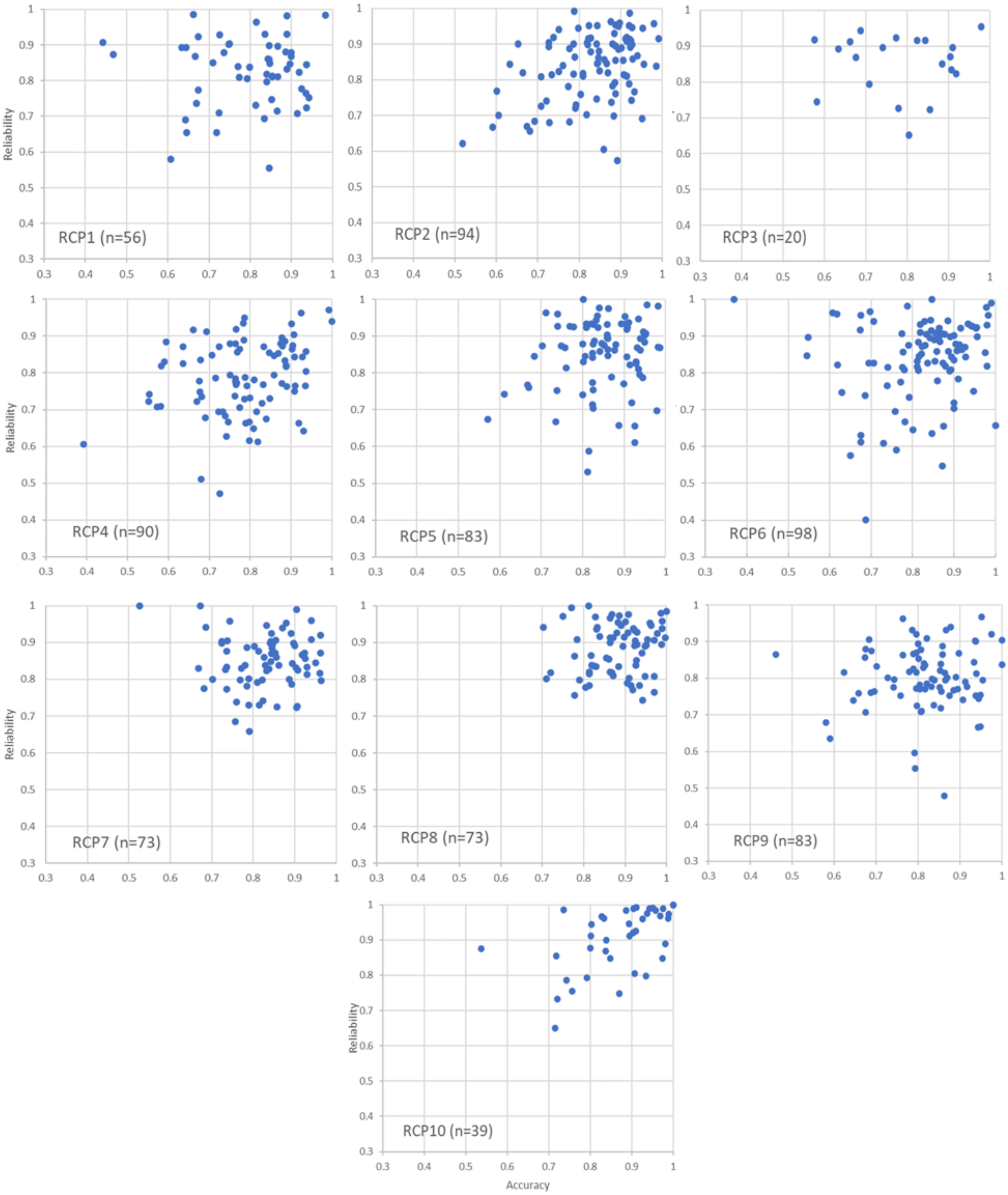

Figure 7 Group accuracy and reliability by RCP

Each point represents the calculated accuracy and reliability of a final retained group with ≥15 Primary member plots, following the method described in Appendix G.

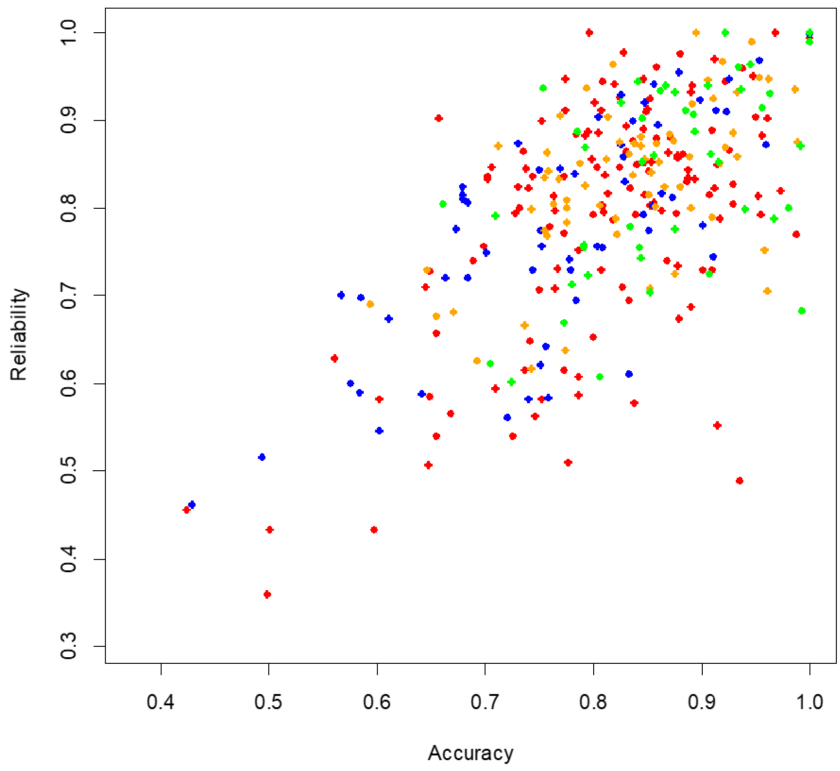

Figure 8 **Comparison of legacy classification unit accuracy and reliability across 4 legacy classification projects**

Each point represents the calculated accuracy and reliability of a legacy unit with ≥15 member plots, following the method described in Appendix G. Red points represent South Coast – Illawarra region units defined by Tozer et al. (2010); blue are Brigalow Belt South bioregion units of RACAC (2004); orange are southern forests units of Gellie (2005); and green are Upper Murrumbidgee catchment units of Armstrong et al. (2012). Calculations were based on plots shared between the current project and each legacy classification project.

6.7 Comparison against legacy classification units

We identified 13 traceable plot-based legacy classification projects covering parts of our study area (Table 3), and compiled the plot assignments to classification units of these projects in order to track and report on relationships between our final retained groups and the classification units identified by each project (see Section 4.5 above). Roughly 28,820 (57%) of the 50,963 analysis plots in our classification analysis dataset had been classified in one or more of these 13 legacy classification projects.

The study areas (Figure 3) and data contexts of the legacy classification projects overlap each other to varying degrees, and many plots that fall within areas of overlap have been classified by multiple projects. Compilation of legacy member plot assignments indicated that some plots had been assigned to as many as 4 alternative legacy classification units.

Table 7 and Table 8 summarise the patterns of relationship strength between units of legacy classification projects and the final retained groups of the current project, using 4 classes of relationship strength (see Table 4). Note that Table 7 and Table 8 deal with large regional-level studies, and local-level or thematic studies, respectively. The 8 regional classification projects in Table 7 all described many units defined by at least 15 analysis plots, and for these projects the relationship strength figures presented are based only on these larger units, to provide a consistent measure of comparison across similarly sized groups. The 5 local-level or thematic legacy classification projects in Table 8 were dominated by units defined by low numbers of analysis plots, and relationship strength figures are shown for all units regardless of size.

Table 7 Overview of strength of relationships between the units of legacy classification projects and the set of final retained groups identified by this project – regional-level legacy classification projects

This table presents the subset of regional-level legacy classification projects, for which the relationship strength figures are based only on units defined by 15 or more analysis plots.

Legacy classification project	No. of plot-based units (with plots shared by our analysis dataset)	Average no. of analysis plots defining each unit	No. of groups defined by ≥15 analysis plots	% of all groups of ≥15 analysis plots by relationship strength class				No. (%) of units whose member plots included >25% rejected samples
				Very strong	Strong	Moderate	Weak	
Northern Rivers region (OEH 2012)	264	15	81	30%	42%	21%	7%	117 (31%)
Greater Hunter region (Sivertsen et al. (2011)	261	20	97	28%	35%	15%	22%	29 (11%)
Sydney metropolitan catchment (OEH 2016)	78	28	42	41%	41%	13%	5%	3 (2%)
South Coast – Illawarra region (Tozer et al. 2010)	185	43	139	21%	39%	26%	14%	15 (8%)
Southern forests (Gellie 2005)	163	13	70	19%	36%	27%	19%	23 (13%)
Brigalow Belt South bioregion (RACAC 2004)	109	22	60	33%	27%	20%	20%	17 (15%)
Nandewar bioregion (DEC 2004)	108	20	71	24%	35%	18%	23%	24 (22%)
Upper Murrumbidgee catchment (Armstrong et al. 2012)	66	37	43	36%	43%	17%	5%	19 (13%)

Across the compared legacy classification projects, the degree of correspondence between legacy classification units and final retained groups of the current study was broadly related to the extent and specificity of the legacy classification project. Agreement was generally high for classifications that were local to subregional in their extent or had a thematic focus. The north coast wallum vegetation study (Griffith et al. 2003), the Cessnock–Kurri study (Bell & Driscoll 2007), the Tenterfield area reserves study (Hunter 2000) and the Australian Alps treeless vegetation study (McDougall & Walsh 2007) all had at least 85% of their classification units very strongly or strongly related to final retained groups of the current study. The subregional classification of western Blue Mountains vegetation (DEC 2006) had slightly lower agreement, with 79% of its classification units very strongly or strongly related to our final retained groups.

Table 8 Overview of strength of relationships between the units of legacy classification projects and the set of final retained groups identified by this project – local-level or thematic legacy classification projects

This table presents the subset of local-level and thematic legacy classification projects, for which the relationship strength figures are based on all units with one or more analysis plot.

Legacy classification project	No. of plot-based units (with plots shared by our analysis dataset)	Average no. of analysis plots defining each unit	No. of groups defined by ≥15 analysis plots	% of all groups of ≥1 analysis plot by relationship strength class				No. (%) of units whose member plots included >25% rejected samples
				Very strong	Strong	Moderate	Weak	
North coast wallum (Griffith et al. 2003)	42	6	3	81%	19%	0%	0%	0 (0%)
Australian Alps treeless vegetation (McDougall & Walsh 2007)	32	10	7	69%	16%	16%	0%	0 (0%)
Western Blue Mountains (DEC 2006)	52	7	4	42%	37%	15%	6%	0 (0%)
Cessnock–Kurri area (Bell & Driscoll 2007)	35	8	4	82%	12%	6%	0%	0 (0%)
Tenterfield area reserves (Hunter 2000)	14	10	4	85%	8%	8%	0%	0 (0%)

Amongst the regional-level classifications, the strongest agreement between well-defined legacy classification units and final retained groups of the current study was achieved with units of the Sydney metropolitan catchment classification (OEH 2016) and the upper Murrumbidgee catchment classification (Armstrong et al. 2012). These projects are relatively recent and based on relatively high densities of standard floristic survey plots. The larger units of the Northern Rivers study (OEH 2012) had slightly lower levels of agreement with the final retained groups of the current study, followed by units of the greater Hunter (Sivertsen et al. 2011), Brigalow Belt South (RACAC 2004), South Coast – Illawarra (Tozer et al. 2010) and Nandewar classifications (DEC 2004). Lowest levels of agreement were found with units of the southern forests classification (Gellie 2005).

In general, classification units from older studies have less strong relationships to our final retained groups than those completed more recently, likely reflecting the impact of improved coverage of standard floristic survey data over time.

There are several factors to be considered in these comparisons. One source of differences between legacy classification units and final retained groups from the current study is that not all of the plots assigned to legacy classification units were used in our set of analysis plots, for various reasons including past survey data that had been lost and was untraceable, plots that did not meet our data standards (rejected samples), and plots excluded during classification. For example, the Northern Rivers classification (OEH 2012) included 11,864 plots of which 8,109 were within its study area; of these, 2,226 plots were categorised as rejected samples by the current study due to non-standard methods including random meander lists and canopy-only lists, duplicated plots, and highly disturbed samples.

Another factor influencing cross-classification comparisons is that legacy classification projects varied widely in the scale of classification they chose to recognise, and therefore in the sizes of groups defined. Table 9 indicates the number of units identified by each legacy classification project that were defined by fewer than 5 standard floristic survey plots. In the Northern Rivers classification (OEH 2012) for example, 176 of 384 groups were defined by fewer than 5 plots, and 140 of these by 3 or less. This compares with 10 of 185 groups in the South Coast – Illawarra classification of Tozer et al. (2010) defined by fewer than 5 plots.

Relationships between final retained groups of the current project and legacy classification units are also affected by widespread improvements in quantity and coverage of standard floristic survey plots. The current project had significantly more data available to identify and describe vegetation patterns across many of the study areas of legacy classification projects than were available at the time the projects themselves were completed. Table 9 summarises the increases in availability of standard floristic survey plots across each legacy classification project study area since each project was completed. In some areas the current project had access to more than double the number of standard floristic survey plots than were assigned by legacy classification projects. For example, the current study included 3,494 plots from the Flora surveys module of the BioNet Atlas application that were within the study area of the Northern Rivers classification (OEH 2012) but were not classified by that work. In total, the previously unclassified plots from that study area (including plots included in the Northern Rivers analysis but not assigned to a classification unit by OEH (2012)) contributed to 308 final retained groups in the current study, including 64 groups defined entirely by previously unclassified plots.

Table 9 Overview of legacy classification projects – increases in plot data availability for each study area and its consequences for final retained groups identified by this project

Legacy classification project	Number of units described	Density of standard plots classified by each legacy project within its study area (plots/ 1,000 ha)	No. of units with <5 standard floristic survey plots (and % of total no. of units)	No. of plots assigned by legacy project that are rejected samples by current project	Approximate no. of new standard floristic survey plots in legacy study area since legacy project published (and % increase)	Approximate no. of final retained groups in legacy study area that are defined entirely by plots that were not classified by legacy project
Northern Rivers region (OEH 2012)	384	1.13	176 (46%)	797	3,494 (61%)	64
Greater Hunter (Sivertsen et al. 2011)	254	1.51	39 (15%)	540	5,394 (109%)	21
Western Blue Mountains (DEC 2006)	57	2.81	6 (11%)	28	162 (37%)	0
Sydney metropolitan catchment (OEH 2016)	78	10.01	4 (5%)	61	590 (27%)	0

Legacy classification project	Number of units described	Density of standard plots classified by each legacy project within its study area (plots/ 1,000 ha)	No. of units with <5 standard floristic survey plots (and % of total no. of units)	No. of plots assigned by legacy project that are rejected samples by current project	Approximate no. of new standard floristic survey plots in legacy study area since legacy project published (and % increase)	Approximate no. of final retained groups in legacy study area that are defined entirely by plots that were not classified by legacy project
Southern forests (Gellie 2005)	206	0.44	53 (26%)	368	5,030 (185%)	35
South Coast – Illawarra (Tozer et al. 2010)	190	2.04	15 (8%)	460	4,559 (54%)	23
North coast wallum (Griffith et al. 2003)	42	NA*	27 (64%)	40(duplicated)	NA*	NA
Australian Alps treeless vegetation (McDougall & Walsh 2007)	34 (NSW+ACT)	NA*	5 (15%)	1	NA*	NA
Nandewar bioregion (DEC 2004)	113	1.11	6 (5%)	418	2,451 (106%)	0
Brigalow Belt South bioregion (RACAC 2004)	115	0.45	8 (7%)	420	4,138 (163%)	6
Upper Murrumbidgee (Armstrong et al. 2012)	75	0.69	12 (16%)	382	763 (80%)	0
Cessnock-Kurri area (Bell & Driscoll 2007)	36	4.03	14 (39%)	0	108 (38%)	0
Tenterfield area reserves (Hunter 2000)	14	25.18	6 (43%)	2	20 (15%)	0

* Precise study area boundaries were not set by these thematically defined projects so plot density cannot be reliably calculated.

We examined the relative levels of subdivision of vegetation patterns (or classification scale) that were applied by 8 regional-level and 2 local-level legacy classification projects from Table 9 above, by calculating within-group variance (cluster variance sensu Wiser and De Cáceres 2013) for all classification units described by these past projects. Figure 9 illustrates patterns of within-group variance against group size for each of these legacy classification projects, with the results for the South Coast – Illawarra vegetation classification of Tozer et al. (2010) ('SCIVI') shown against each of the other legacy projects for comparison. Compared with SCIVI units, the general patterns of variance accepted in units of other regional-level legacy classifications varied from slightly higher or similar (9(e) BBS, 9(f) Nandewar), to much lower in the units of the Northern Rivers classification (9(a)), many of which were defined by 3 or fewer plots. The local-level classification of Bell & Driscoll (2007, 9(h)) shows particularly low levels of cluster variance, with this study producing tightly defined units from plots collected by a single observer across a small and relatively environmentally homogenous area. In contrast, the local units of Hunter (2000) from a set of 4 nature reserves on the northern tablelands display a much wider range of cluster variance.

We also generated within-group variance versus group size figures for all final retained groups in each of our RCPs, as an indication of the relative classification scale of the final retained groups in each RCP. Group variance was calculated using all Primary member plots. Figure 10 illustrates patterns of within-group variance against group size for final retained groups within each of the 10 RCPs. Each RCP figure also includes, for comparison, results of the same variance calculations for units of the regional-level legacy classification project that shared the greatest number of plots with that RCP.

Patterns of within-group variance in final retained groups of the current project are generally consistent across all RCPs, with the upper quartile of group variances lowest in RCP10. For all RCPs, this indicator is lower for the groups of the current project than it is for the compared regional-scale legacy classification with greatest amount of shared plot data.

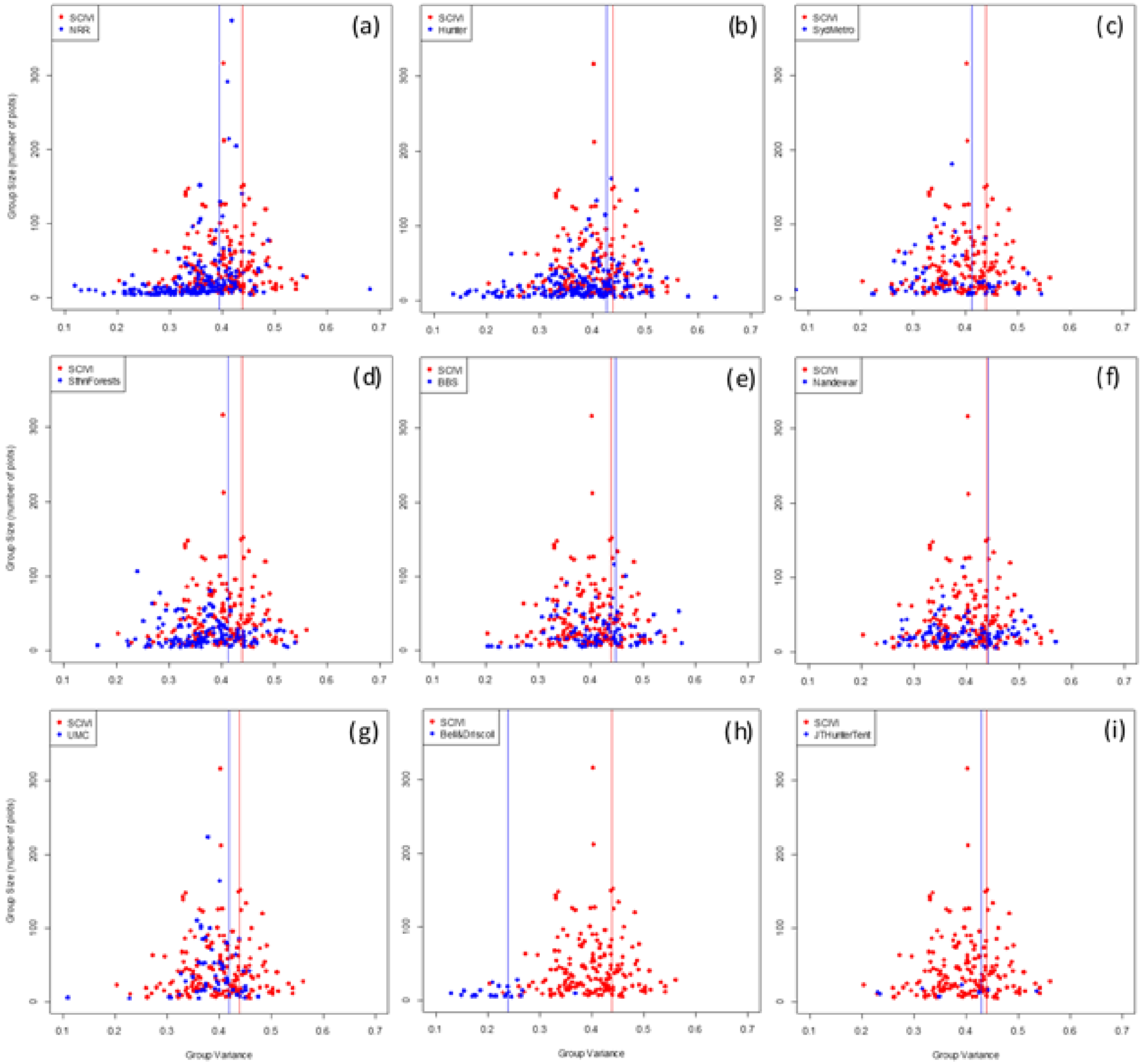

Figure 9 **Within-group variance (cluster variance sensu Wiser and De Cáceres 2013) plotted against group size (number of member plots), for each of 8 regional-level and 2 local-level legacy classification projects**

All subfigures include the data points for the South Coast – Illawarra classification of Tozer et al. (2010), shown in red as 'SCIVI', as a common point of comparison. Vertical lines mark the upper quartile of group variances for each source. Legacy classification projects compared are: (a) NRR = Northern Rivers region classification (OEH 2012); (b) Hunter = greater Hunter region (Sivertsen et al. 2011); (c) SydMetro = Sydney metropolitan catchment (OEH 2016); (d) SthnForests = southern forests (Gellie 2005); (e) BBS = Brigalow Belt South bioregion (RACAC 2004); (f) Nandewar = Nandewar bioregion (DEC 2004); (g) UMC = upper Murrumbidgee classification (Armstrong et al. 2012); (h) Bell&Driscoll = Cessnock–Kurri area (Bell & Driscoll 2007); (i) JTHunterTent = Tenterfield area reserves (Hunter 2000).

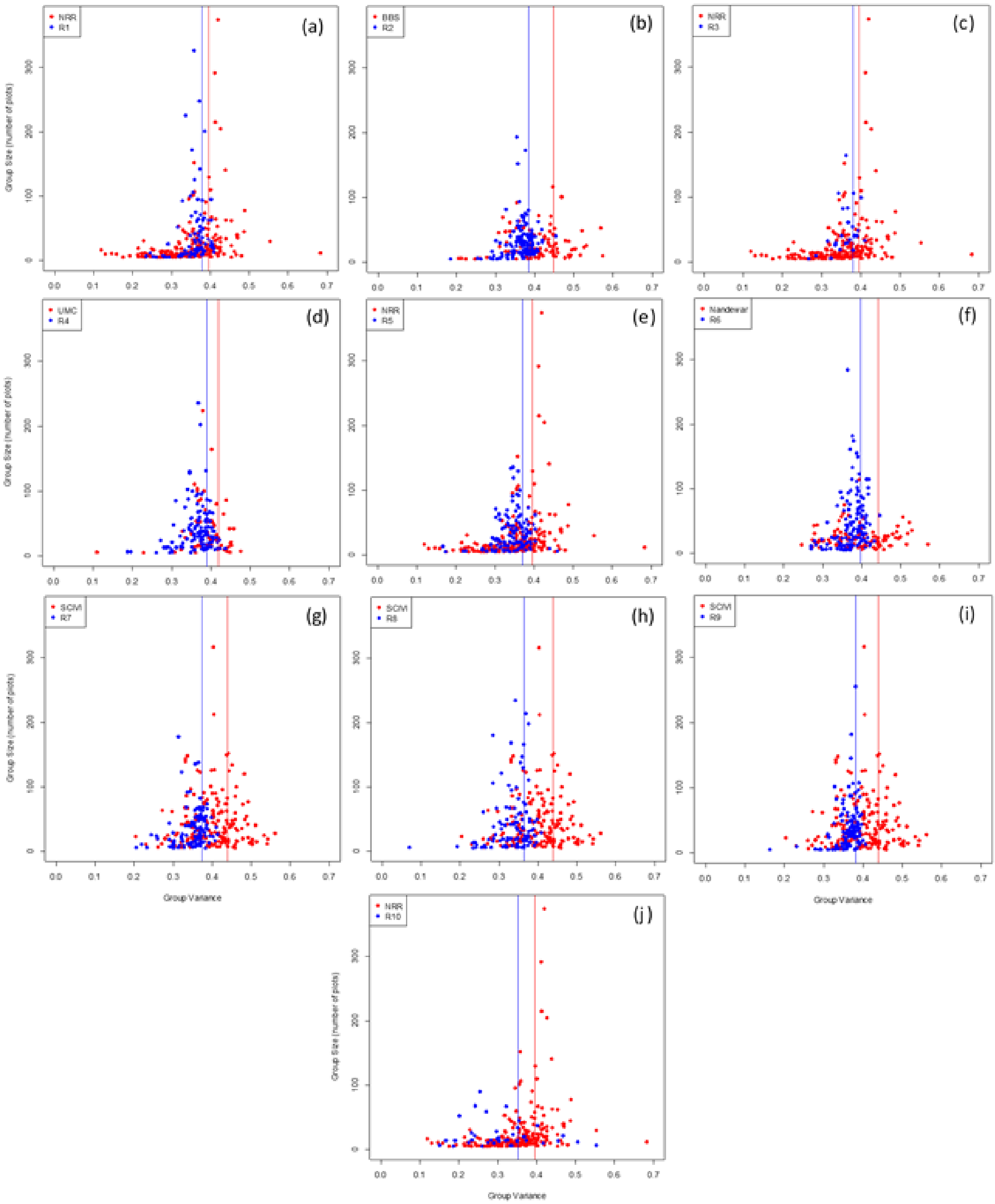

Figure 10 **Within-group variance (cluster variance sensu Wiser and De Cáceres 2013) plotted against group size (number of Primary member plots) for final retained groups in each of 10 RCPs (blue points)**

For each RCP, the regional-level legacy classification project that shared the highest number of plots with that RCP was identified, and the same variance vs group size calculations were plotted for the units of that legacy project (red points). Vertical lines mark the upper quartile of group variances for each source. Legacy classification projects compared are: (a), (c), (e), (j) NRR = Northern Rivers region (OEH 2012); (b) BBS = Brigalow Belt South bioregion (RACAC 2004); (d) UMC = upper Murrumbidgee classification (Armstrong et al. 2012); (f) Nand = Nandewar bioregion (DEC 2004); and (g), (h), (i) SCIVI = South Coast – Illawarra classification (Tozer et al. 2010).

6.8 Relationships between final retained groups and vegetation classes and formations

Each of the 1,205 final retained groups was assigned to one of the 99 vegetation classes defined by Keith (2004), and thereby to a vegetation formation within the NSW vegetation classification hierarchy. Note that although the assignment process sought to maximise consistency across all interpretations, there was an unavoidable element of subjectivity in allocations as current vegetation classes and formations are defined by qualitative descriptions.

Table 10 summarises the allocations of final retained groups to vegetation formations by RCP. A more detailed breakdown of the number of groups across vegetation classes and formations is provided in Appendix K. The broad character of each RCP is indicated by the vegetation formations its groups are assigned to. For example, RCP5 is dominated by groups assigned to Rainforests and Wet Sclerophyll Forests formations, RCP2 includes a range of Dry Sclerophyll Forests and Heathlands, and RCP6 contains a diverse set of groups in Grasslands, Grassy Woodlands, Dry Sclerophyll Forests and wetland formations spanning from the western slopes to drier parts of the tablelands and upper Hunter valley.

Table 10 Summary of the number of final retained groups assigned to each vegetation formation, by RCP

Vegetation formation	No. of final retained groups in each RCP										Total
	1	2	3	4	5	6	7	8	9	10	
Rainforests	2			1	99	12			15	4	**133**
Wet Sclerophyll Forests (Shrubby sub-formation)	4			11	43		5		33		**96**
Wet Sclerophyll Forests (Grassy sub-formation)	8		7	22	7	1	6	1	39		**91**
Grassy Woodlands	17	4	1	30		45	1		6		**104**
Grasslands	1			2		12	2		1	4	**22**
Dry Sclerophyll Forests (Shrub/grass sub-formation)	44	24	9	11		38	9		10	1	**146**
Dry Sclerophyll Forests (Shrubby sub-formation)	11	100	5	16	3	15	63	51	10	1	**275**
Heathlands	10	17	1	2	2	2	9	36	7	7	**93**
Alpine Complex				16							**16**
Freshwater Wetlands	2	4	2	15		2	6	27	2	34	**94**
Forested Wetlands	9	1		3	18	10	15	5	29	14	**104**
Saline Wetlands					1					12	**13**
Semi-arid Woodlands (Grassy sub-formation)						6					**6**
Semi-arid Woodlands (Shrubby sub-formation)		1				6				1	**8**
Arid Shrublands (Chenopod sub-formation)						3				1	**4**
Totals	**108**	**151**	**25**	**129**	**173**	**152**	**116**	**120**	**152**	**79**	**1,205**

7. Discussion

7.1 Eastern NSW regional vegetation patterns

Past vegetation classification across eastern NSW has developed as a patchwork of separate and overlapping projects. One of the obstacles to undertaking a broader classification of the size undertaken by the current project has been the combination of the very large size of the classification analysis dataset involved, and computation limitations of available clustering software. We were fortunate to have access to significant computing resources for initial partitioning of our very large dataset into regions of common species probability profile or RCPs, based on a combination of species composition and environmental variables. This initial RCP subdivision provided a sound basis from which to undertake more tractable further exploration of finer floristic patterns.

We consider the spatial representation of the RCPs, based on primary floristic survey plot data (see Figure 5), to provide a potentially useful adjunct to the existing bioregionalisation (IBRA v7, DAWE 2021) and upper level vegetation classification hierarchy (vegetation formations and classes of Keith (2004)) currently applied in NSW biodiversity assessment protocols.

It is common practice for a vegetation classification exercise to provide detailed summary information for each of the separate units or types identified, in the form of large appendices of vegetation unit descriptions, distribution maps, and tables of species composition and environmental summary data. However, the size of the current project makes this simply not practicable; it would be likely to run over 2,000 pages. Instead, detailed data for all **final retained groups from coast and tableland bioregions** are accessible online through 2 BioNet applications. The coast and tablelands groups are entered into BioNet applications under the 'authority' Eastern NSW PCT Classification (see DPE 2022b). The BioNet Vegetation Classification public application provides summary information on the floristic, environmental and distribution characteristics of each PCT. The Flora surveys module of the BioNet Atlas application provides access to the member plots for each PCT, and the underlying floristic survey plot data. The western slopes groups are proposed to be made accessible through BioNet applications in a second stage.

Here, we provide a broad overview of vegetation patterns across our study area, structured around the floristic-environment regions identified by the RCP analysis. This discussion describes some of the higher order vegetation patterns evident in our classification analysis dataset within each of the 9 RCPs identified, and within the 'remainder' subset labelled RCP10 for convenience. The PCT ID numbers presented in the tables below correspond to those entered into the BioNet applications for coast and tablelands groups (see DPE 2022b). Western slopes groups will not be given an approved PCT ID under eastern NSW PCT classification v1.1, and their group names remain draft until finalised and approved in the PCT master list.

7.1.1 RCP1: Coast and Hinterland Grassy Forests

RCP1 encompasses eucalypt-dominated dry grassy and shrub-grass forests and woodlands on moderately fertile to fertile soils across NSW coastal and hinterland regions. Lowland environments are characteristic, and plots assigned to groups within RCP1 have a median elevation of 125 m above sea level (asl) (range 1–1,061 m) together with a warm and moderately moist climate. Plots in the RCP have a median modelled mean annual rainfall of 910 mm (578–2,227 mm) and median annual mean temperature of 16.6°C (9.7–19.5°C). Frosts are infrequent, with a median frequency of less than one day per year. Undulating coastal rain shadow ranges, valleys and adjoining foothills are typical, but the RCP also includes deeply dissected gorges of the central and northern ranges, which share similar climatic conditions, moderately fertile lithologies and grassy forest assemblages. Example localities include the Bega, Moruya, Araluen and Illawarra valleys and plains of the south coast, the Cumberland Plain and central and lower Hunter valley within the Sydney Basin bioregion, and the hinterland valleys of the north coast including the Manning, Hastings, Macleay and upper and lower Clarence rivers. Examples of the dissected gorges within RCP1 include the catchments of the Burragorang and Wollondilly rivers in the southern Sydney Basin, the northern gorges including the upper reaches of the Macleay River in Oxley Wild Rivers National Park and the upper Clarence in Guy Fawkes River National Park.

RCP1 is characterised by forests and woodlands with a tall to very tall eucalypt canopy and a sparse to mid dense shrub layer with a grassy and herbaceous ground cover. Eucalypts comprising the tree canopy are frequently drawn from the ironbark, red gum, spotted gum, box and stringybark groups. Species of *Angophora* are also common together with tree species from the genera *Allocasuarina* and *Acacia*. The shrub layer varies from sparse to mid dense and includes a mix of soft and hard leaved species. Examples of the most common and widespread species include *Bursaria spinosa* and *Breynia oblongifolia*, while *Alphitonia excelsa* is characteristic of the subtropical northern latitudes. The ground layer is a consistent compositional attribute of RCP1, with an assemblage of grasses, small forbs, ferns and twiners. Grasses *Microlaena stipoides*, *Themeda australis*, *Aristida* spp., *Cymbopogon refractus*, *Panicum* spp., *Entolasia* spp. and *Imperata cylindrica* are among the most frequent and abundantly recorded. Other very frequently recorded species include forbs *Lobelia purpurascens, Desmodium* spp. and *Dichondra repens*, graminoids *Dianella* spp., *Lomandra* spp., and small twiners including *Glycine* spp.

There are 108 final retained groups within RCP1, with 30 (27%) of these groups given placeholder status owing to low numbers of member plots. Table 11 highlights some of the widely distributed groups found within RCP1. Over two-thirds of groups we recognised with a High or Very High 'classification confidence level' (see DPE 2022b) have been assigned to the Dry Sclerophyll Forests (Shrub/grass sub-formation) (44%) or Grassy Woodlands (19%) vegetation formations, illustrating the compositional and environmental relationship between these formations. However, all final retained groups within the Grassy Woodlands formation are assigned to a single vegetation class, Coastal Valley Grassy Woodlands, which spans a wide latitudinal gradient between the Bega valley on the far south coast and upper Clarence valley in the Northern Rivers region. Groups within the Dry Sclerophyll Forests (Shrub/grass sub-formation) are mostly assigned to 4 vegetation classes: Clarence Dry Sclerophyll Forests, Hunter-Macleay Dry Sclerophyll Forests, Northern Gorge Dry Sclerophyll Forests and Central Gorge Dry Sclerophyll Forests, reflecting topographic and regional variations in forest species assemblages.

The remainder of final retained groups in RCP1 are assigned to other vegetation formations; however, they are influenced by coastal environments and exhibit the grassy and herbaceous assemblage. Grassy forests associated with river flats and riparian areas within rain shadow coastal valleys and plains are assigned to the Forested Wetlands formation. RCP1 also includes a small set of semi sheltered grassy forests found in hinterland ranges or gorges that are assigned to Northern Hinterland Wet Sclerophyll Forests vegetation class as they frequently include a sparse cover of mesophyll shrubs.

The western analogue of RCP1 is RCP6, which is widespread across the western slopes of NSW. The Hunter valley is one of only a few areas where groups from RCP1 and RCP6 overlap environmentally and spatially. Our analysis suggests that groups typical of RCP1 grade into those of RCP6 where mean annual rainfall falls below 700 mm in the central and upper Hunter valley, where groups east of Singleton are characterised by coastal species, and those to the west increasingly include flora of the western slopes. Closer to the coast RCP1 grades into RCP9 with increasing rainfall or shelter and into RCP7 as soil fertility decreases.

Table 11 Some examples of final retained groups within RCP1 Coast and Hinterland Grassy Forests

Bioregion	Final retained group	PCT ID (ENSW v1.1)	PCT name	Vegetation class
South East Corner	R1.6	3332	Southeast Lowland Grassy Woodland	Coastal Valley Grassy Woodlands
	R1.17b	3313	Araluen Scarp Grassy Forest	Coastal Valley Grassy Woodlands
Sydney Basin	R1.12	3330	South Coast Lowland Woollybutt Grassy Forest	Coastal Valley Grassy Woodlands
	R1.45	3320	Cumberland Shale Plains Woodland	Coastal Valley Grassy Woodlands
	R1.62	3321	Cumberland Shale-Sandstone Ironbark Forest	Coastal Valley Grassy Woodlands
	R1.80	4025	Cumberland Red Gum Riverflat Forest	Coastal Floodplain Wetlands
	R1.1	3448	Castlereagh Ironbark Forest	Cumberland Dry Sclerophyll Forests
	R1.49	3444	Lower Hunter Spotted Gum-Ironbark Forest	Hunter-Macleay Dry Sclerophyll Forests
	R1.53	3433	Hunter Coast Foothills Spotted Gum-Ironbark Grassy Forest	Hunter-Macleay Dry Sclerophyll Forests
	R1.110	3315	Central Hunter Ironbark-Spotted Gum Forest	Coastal Valley Grassy Woodlands
	R1.20	3482	Burragorang Gorges Ironbark Grassy Forest	Central Gorge Dry Sclerophyll Forests
	R1.28	3483	Central Gorges Box-Red Gum Grassy Forest	Central Gorge Dry Sclerophyll Forests
NSW North Coast	R1.75	3446	Lower North Foothills Ironbark-Box-Gum Grassy Forest	Hunter-Macleay Dry Sclerophyll Forests
	R1.9.107c	3329	Northern Hinterland Valleys Red Gum Grassy Forest	Coastal Valley Grassy Woodlands
	R1.22	3322	Far North Ranges Red Gum Grassy Forest	Coastal Valley Grassy Woodlands
	R1.44	3420	Clarence Lowland Ironbark-Spotted Gum Grassy Forest	Clarence Dry Sclerophyll Forests
	R1.77	3461	Macleay Gorges Stringybark-Red Gum Grassy Forest	Northern Gorge Dry Sclerophyll Forests
	R1.114	3464	Northern Gorges Grey Gum-Tallowwood Grassy Forest	Northern Gorge Dry Sclerophyll Forests

Bioregion	Final retained group	PCT ID (ENSW v1.1)	PCT name	Vegetation class
	R1.99	3465	Northern Gorges Red Gum Grassy Forest	Northern Gorge Dry Sclerophyll Forests
	R1.16	4078	Northern Gorges River Oak Forest	Eastern Riverine Forests
Trans bioregional	R1.61	3409	Southern Headland Grassland	Maritime Grasslands

7.1.2 RCP2: Tablelands and Slopes Dry Sclerophyll Forests

Dry shrubby eucalypt–callitris forests and woodlands dominate most of RCP2. The RCP covers extensive areas of the western slopes of NSW and extends east across rugged ranges of the northern and southern tablelands. It is one of 2 RCPs with a high median annual water deficit, suggesting that soils are characteristically dry. Its plots have a median elevation of 570 m asl and moderate mean annual rainfall with a median value of 700 mm (446–1,282 mm). In the north west the RCP occupies sandy, high-quartz Jurassic sandstones in a wide band between the Pilliga district south to Dubbo. It rises in altitude on the isolated exposed trachyte peaks of the Warrumbungles and Mount Kaputar, and onto shallow rocky soils along the Nandewar ranges and western New England plateau. In the western Hunter valley it includes the dry Triassic sandstones of the Goulburn River and northern Wollemi plateaux. In the central west of NSW it occurs on quartz rich soils of the hills and ranges between Mudgee and Orange and follows the length of Herveys Range near Cowra. High ranges of the southern tablelands included in RCP2 run north from the Monaro tablelands to the southern highlands and gorges of the Abercrombie River. It is also extensive on exposed ranges of the south west slopes, from the western side of Kosciuszko National Park near Tumut, north toward the dry ranges of the southern tablelands west of Goulburn.

RCP2 is characterised by mid high to tall shrubby forests and woodlands, occasionally shrublands or heaths. The tree canopy frequently includes species from both the *Eucalyptus* and *Callitris* genera, a feature that separates the flora of this RCP from other dry sclerophyll forests that experience wetter climates along the coast and hinterland ranges. *Callitris endlicheri* is common, with *Callitris glaucophylla* also recorded but less frequently. Among the eucalypts, ironbarks, stringybarks and red gum species are most frequent. The latter mainly includes those species associated with poorer soils including *Eucalyptus dwyeri*, *E. prava* and *E. dealbata*. Some eucalypts are common but restricted to parts of RCP2 including *Corymbia trachyphloia* in the Pilliga and Goulburn River districts and *Eucalyptus rossii* in the southern and central tablelands. Mallee species or stunted multi-stemmed forms of widespread species may occur on very dry and rocky sites. A sparse to mid dense mid stratum is characterised by hard leaved shrub species such as *Hibbertia obtusifolia*, *Brachyloma daphnoides*, *Calytrix tetragona* or *Leucopogon muticus*. Ground cover species are indicative of relatively low fertility and shallow soils, and are a mix of graminoids, small forbs and hardy grasses and small ferns. *Lomandra filiformis, Lomandra multiflora* subsp. *multiflora*, *Cheilanthes sieberi* subsp. *sieberi*, *Pomax umbellata*, *Dianella revoluta*, *Goodenia hederacea*, *Lepidosperma laterale*, *Aristida ramosa* and *Rytidosperma pallidum* are examples of frequently occurring ground cover species.

We identified 151 final retained groups within this region, 22 (14%) of which were assigned placeholder status. There are 101 groups that occur in coast and tablelands bioregions, with an additional 50 groups restricted to the western slopes bioregions. Table 12 gives examples of widely distributed groups and others that are assigned to vegetation classes with restricted distributions. Over 80% of groups in RCP2 are included within the Dry Sclerophyll

Forests vegetation formation, with most allocated to vegetation classes within the Shrubby sub-formation. The Western Slopes Dry Sclerophyll Forests and Northern Tableland Dry Sclerophyll Forests vegetation classes overwhelmingly include the highest number of final retained groups, together encompassing over 50% of all groups within the RCP. Both classes are within the Dry Sclerophyll Forests (Shrubby sub-formation). The number of final retained groups assigned to the Southern Tableland Dry Sclerophyll Forests vegetation class is low, but they are extensively distributed between Mudgee and the Monaro tablelands. The forest assemblages on sandstone in the far north west near Yetman are assigned to a vegetation class with a restricted distribution, the Yetman Dry Sclerophyll Forests. Final retained groups assigned to the Dry Sclerophyll Forests (Shrub/grass sub-formation) fall within the Upper Riverina Dry Sclerophyll Forests, North-west Slopes Dry Sclerophyll Forests, Pilliga Outwash Dry Sclerophyll Forests or Central Gorge Dry Sclerophyll Forests vegetation classes.

Treeless vegetation forming heathlands and scrubs is also found within RCP2, on dry, exposed sites with rocky and shallow soils. On the southern tablelands, *Allocasuarina nana* forms a dense heath of low species richness compared to heathlands of coast and hinterland environments. These are included in the Southern Montane Heaths vegetation class. On the northern tablelands, the widespread granite tors, together with silica rich volcanic outcrops, support shrublands and scrubs that include *Allocasuarina rigida*, *Leptospermum novae-anglica* and *Kunzea obovata*. These are typical of the Northern Montane Heaths vegetation class. Other examples of shrublands in RCP2 are found among the sandstone pagodas of the western Blue Mountains and are included within the Sydney Montane Heaths vegetation class.

RCP2 includes some groups that are restricted to poorly drained or periodically waterlogged soils. These are typically dominated by woody shrubs with an open canopy of eucalypts and a ground cover of sedges and graminoids, and are assigned to the Montane Bogs and Fens vegetation class.

RCP6 adjoins RCP2 on soils of higher fertility in similarly low rainfall environments. RCP2 is replaced by RCP4 on moderately fertile soils on the elevated northern and southern tablelands.

Table 12 Some examples of final retained groups within RCP2 Tablelands and Slopes Dry Sclerophyll Forests

Bioregion	Final retained group	PCT ID (ENSW v1.1)	PCT name	Vegetation class
Brigalow Belt South	R2.159	n/a	(draft) Yetman Sandstone Black Pine-Red Gum-Ironbark Shrub Forest	Yetman Dry Sclerophyll Forests
	R2.56	n/a	(draft) Warialda Sandstone Rusty Gum-Black Pine Shrub Forest	Yetman Dry Sclerophyll Forests
	R2.173	n/a	(draft) Pilliga Red Ironbark-Bloodwood Shrub Forest	Western Slopes Dry Sclerophyll Forests
	R2.24	n/a	(draft) Pilliga Flats Red Gum Shrub-Grass Forest	Pilliga Outwash Dry Sclerophyll Forests
	R2.183	n/a	(draft) Pilliga Sandplain Shrubland	Western Slopes Dry Sclerophyll Forests

Bioregion	Final retained group	PCT ID (ENSW v1.1)	PCT name	Vegetation class
	R2.49	n/a	(draft) Pilliga South White Pine- Narrow-leaved Ironbark Forest	Western Slopes Dry Sclerophyll Forests
	R2.81	n/a	(draft) Coonabarabran Sandstone Bloodwood-Black Pine Shrub Forest	Western Slopes Dry Sclerophyll Forests
	R2.48	n/a	(draft) Dubbo East Narrow-leaved Ironbark-Pine Shrub Grass Forest	Western Slopes Dry Sclerophyll Forests
	R2.89	n/a	(draft) Goonoo Sandstone Blue-leaved Ironbark-Pine Forest	Western Slopes Dry Sclerophyll Forests
	R2.153	3753	Dunedoo Sandstone Ironbark-Pine Forest	Western Slopes Dry Sclerophyll Forests
New England Tablelands and Nandewar	R2.21	3702	Northwest New England Ranges Caleys Ironbark Woodland	Northern Tableland Dry Sclerophyll Forests
	R2.37	3706	Northwest New England Laterite McKies Stringybark Forest	Northern Tableland Dry Sclerophyll Forests
	R2.46	3710	Western New England Hills Orange Gum-Ironbark Forest	Northern Tableland Dry Sclerophyll Forests
	R2.22	3716	Northwest New England Tumbledown Gum-Ironbark Exposed Forest	Northern Tableland Dry Sclerophyll Forests
	R2.123	3854	New England Rockplate Shrubland	Northern Montane Heaths
	R2.187a	3933	New England Orange Gum Boggy Woodland	Montane Bogs and Fens
Sydney Basin	R2.186	3780	Goulburn River Ironbark-Bloodwood Heathy Forest	Western Slopes Dry Sclerophyll Forests
	R2.197	3786	Western Hunter Scribbly Gum-Pine Woodland	Western Slopes Dry Sclerophyll Forests
	R2.156	3769	Upper Hunter Sandstone Stringybark-Ironbark Forest	Western Slopes Dry Sclerophyll Forests
NSW South Western Slopes	R2.118	n/a	(draft) Herveys Range Stringybark -Pine Heath-Woodland	Western Slopes Dry Sclerophyll Forests
	R2.101	3534	Central West Stony Hills Stringybark-Box Forest	Upper Riverina Dry Sclerophyll Forests
	R2.108	n/a	(draft) Southwest Foothills Red Box-Stringybark Forest	Upper Riverina Dry Sclerophyll Forests
	R2.150	3543	Southwest Rockplate Shrub Woodland	Upper Riverina Dry Sclerophyll Forests

Bioregion	Final retained group	PCT ID (ENSW v1.1)	PCT name	Vegetation class
South Eastern Highlands	R2.191	3739	Monaro Hills Brittle Gum Exposed Forest	Southern Tableland Dry Sclerophyll Forests
	R2.129	3747	Southern Tableland Western Hills Scribbly Gum Forest	Southern Tableland Dry Sclerophyll Forests
	R2.204	3876	Kybeyan Montane Heath	Southern Montane Heaths

7.1.3 RCP3: Eastern New England Moist Grassy Forests

RCP3 covers the narrowest geographic range of all the RCPs identified for eastern NSW, and its highest probabilities of occurrence are restricted to a narrow north–south zone along wetter parts of the eastern New England Tablelands and adjacent elevated ranges of the northern escarpment. This RCP is dominated by moist, cool forests in a region that experiences high mean annual rainfall (median 1,040 mm per annum) and a cool climate (median average minimum winter temperatures 2°C), at elevations averaging over 1,000 m asl. Final retained groups in RCP3 dominate northern tableland areas east of the New England Highway through Tenterfield, Glen Innes, Guyra and Armidale, while further east they are sampled from high escarpment ranges including Washpool, Chaelundi and the Carrai plateau. To the south they occur along the moist escarpment rim to the east and south of Walcha, and on high flanks of the Barrington plateau.

Some 25 groups were resolved within RCP3, with largest numbers in the Northern Tableland Wet Sclerophyll Forests vegetation class and in 2 dry sclerophyll forest classes, New England Dry Sclerophyll Forests and Northern Escarpment Dry Sclerophyll Forests. Although categorised as dry forests these 2 vegetation classes are at the moist end of the rainfall gradient for the Dry Sclerophyll Forests vegetation formation. These 2 classes both occur where mean annual rainfall is moderate to high but substrates are relatively infertile granitic soils. RCP3 also includes small numbers of groups in the Montane Bogs and Fens and the Northern Montane Heaths classes, restricted to small patches of very shallow and either damp or dry soils.

The tall to very tall moist forests of RCP3 tend to have a sclerophyll shrub mid stratum and ground covers rich in grasses, forbs and ferns. Tree canopies are dominated by eucalypts, with *Eucalyptus campanulata* common across many RCP3 groups. Other canopy species are variable but are typically stringybarks (e.g. *E. caliginosa*, *E. cameronii*, *E. obliqua*), peppermints (e.g. *E. radiata*) or gums (e.g. *E. brunnea*, *E. saligna*) of cool moist climates. The most frequently recorded smaller tree species in RCP3 are *Allocasuarina* spp. and *Banksia integrifolia*. The shrub stratum varies from very sparse to moderately dense, and common taxa include scattered tall *Acacia* spp., *Leucopogon lanceolatus* and sprawling *Rubus parvifolius* in moderately fertile situations, and low sclerophyllous species including *Lomatia silaifolia*, *Monotoca scoparia*, *Bossiaea neo-anglica* and *Melichrus urceolatus* on higher-quartz substrates. Ground cover species commonly include grasses *Poa sieberiana, Imperata cylindrica, Themeda triandra* and *Microlaena stipoides* and a diversity of forbs including twiners *Desmodium varians, Hardenbergia violacea* and *Glycine clandestina*, and small *Viola betonicifolia, Lobelia purpurascens* and *Poranthera microphylla*. Large tufted *Lomandra longifolia* and *Dianella caerulea* are also commonly recorded, while in some situations ferns are dominant, including *Pteridium esculentum* or less commonly *Calochlaena dubia*.

To the east of RCP3, escarpment slopes drop away into deep gorges, and average temperatures increase as elevation falls. Here RCP3 is replaced by a complex mosaic of

RCP1 on drier exposed slopes and RCP9 and RCP5 on sheltered, moist aspects. On western edges of the RCP3 region, in cool but drier tableland environments away from the high rainfall escarpment rim, RCP3 is replaced by areas of RCP4 where soil fertility is moderate to high, and by RCP2 on lower fertility substrates.

Table 13 Some examples of final retained groups within RCP3 Eastern New England Moist Grassy Forests

Bioregion	Final retained group	PCT ID	PCT name	Vegetation class
New England Tablelands	R3.2	3286	Northern Escarpment Blackbutt Cool Moist Forest	Northern Tableland Wet Sclerophyll Forests
	R3.19	3287	Northern Escarpment Messmate Cool Wet Forest	Northern Tableland Wet Sclerophyll Forests
	R3.1	3278	Far North Escarpment Blackbutt Grassy Forest	Northern Tableland Wet Sclerophyll Forests
	R3.36	3679	Northeast New England Ranges Blackbutt Dry Forest	Northern Escarpment Dry Sclerophyll Forests
	R3.39	3501	Eastern New England Ranges Blackbutt Forest	New England Dry Sclerophyll Forests
	R3.6	3507	Tenterfield Plateau Stringybark Sheltered Forest	New England Dry Sclerophyll Forests
NSW North Coast	R3.14	3672	Carrai-Werrikimbe Blackbutt Dry Shrub Forest	Northern Escarpment Dry Sclerophyll Forests
	R3.20B	3277	Carrai Moist Grassy Forest	Northern Tableland Wet Sclerophyll Forests

7.1.4 RCP4: Tablelands Grassy Forests

The RCP4 region is dominated by grassy woodland and shrub-grass forest assemblages of cool to cold climates on relatively fertile parts of the elevated tablelands and ranges of eastern NSW. It includes tableland, montane, sub-alpine and alpine environments and is characterised by the coolest climate of any RCP, with plots assigned to groups in this RCP having median values for average minimum winter temperature of 0.2°C and 22 days per annum of frosts below –2°C. Median elevation across all RCP4 plots is 980 m asl (range 200–2,200 m) and the median of mean annual rainfall is 960 mm (510–2,700 mm), some falling as snow on the highest elevations.

In the south, RCP4 covers the Australian Alps and large parts of the South Eastern Highlands bioregions, and extends both west and east into higher parts of the NSW South Western Slopes and South East Corner bioregions. In the north it dominates extensive areas on high, cool, fertile plateaus around Walcha and Armidale on the New England Tablelands bioregion, and smaller areas on Barrington Tops in the NSW North Coast bioregion and westwards along high parts of the Liverpool Range and on Mount Kaputar in the Brigalow Belt South and Nandewar bioregions.

Some 129 final retained groups were identified in RCP4, including 9 with placeholder status. Some 127 groups have distributions that include coast and tablelands bioregions, and 2 are restricted to high parts of Mount Kaputar, which falls within western slopes bioregions. RCP4 includes the majority of groups in the Tableland Clay Grassy Woodlands, Southern Tableland Grassy Woodlands and Subalpine Woodlands vegetation classes, and a smaller number of groups in the New England Grassy Woodlands class. A number of tableland wet and dry forest classes are also predominantly within RCP4, including Montane Wet Sclerophyll Forests, Southern Tableland Wet Sclerophyll Forests, Southern Tableland Dry Sclerophyll Forests, and Southern Hinterland Dry Sclerophyll Forests. The RCP also includes smaller numbers of groups in the Upper Riverina Dry Sclerophyll Forests, Northern Tableland Wet Sclerophyll Forests and South East Dry Sclerophyll Forests vegetation classes.

RCP4 also includes a subset of final retained groups that are associated with restricted habitats of high elevations including montane riparian areas, wetlands, lakes and alpine peaks. This RCP contains all groups in the 4 Alpine Complex vegetation classes and 45% of all groups in the Montane Bogs and Fens class. Other notable components are Eastern Riverine Forests, Northern Montane Heaths, Temperate Montane Grasslands, a group in the Montane Lakes vegetation class and a group assigned to the Cool Temperate Rainforests class.

Forest and woodland groups in RCP4 are dominated by eucalypts, ranging in height from tall to extremely tall, with a wide variety of species recorded as dominant. Typical species across this region include mountain and ribbon gums (*Eucalyptus dalrympleana*, *E. viminalis*), snow gums (*E. pauciflora*), rough barked trees from peppermint and stringybark groups (*E. radiata, E. dives, E. macrorhyncha*), monkey gum (*E. cypellocarpa*) and brown barrel (*E. fastigata*). When present, the mid stratum is variable in cover from sparse to mid dense. *Acacia* species are common, with *Acacia melanoxylon* frequently present as an understorey tree in higher rainfall zones and *Acacia dealbata* common in the lower shrub layer. Other frequent shrub species include *Leucopogon lanceolatus*, *Hibbertia obtusifolia*, *Rubus parvifolius*, *Bursaria spinosa*, *Coprosma quadrifida* and *Cassinia* spp. The ground cover commonly has a grassy character, and ferns, graminoids, twiners and other forbs are common. Snow grasses (*Poa* spp.) are characteristic, together with *Lomandra longifolia*, *Microlaena stipoides, Pteridium esculentum, Hydrocotyle laxiflora, Gonocarpus tetragynus, Glycine clandestina, Dichondra repens* and *Acaena novae-zelandiae*.

Treeless assemblages in RCP4 occur in alpine zones, on poorly drained areas, and as grasslands on tableland plateaus and valleys with frequent frosts. These fall into the Alpine Complex, Freshwater Wetlands, and Grasslands vegetation formations respectively. Small areas of these distinctive habitats are scattered across the South Eastern Highlands and New England Tablelands bioregions. The characteristic plant assemblages of these areas have links with similar habitats south into the Victorian high country (e.g. McDougall & Walsh 2007).

The species assemblages found across RCP4 are indicative of soils of moderate to high fertility, and include clay-influenced material derived from lithologies including basalts, granitoids, fine-grained sediments and alluvium. Substrates with higher quartz composition found within the same broad climatic domain are associated with RCP2, characterised by a relatively dense, diverse sclerophyll shrub layer and relatively depauperate and hardy grass and forb components. On the New England Tablelands, RCP4 grades into RCP3 to the east with increasing rainfall, while to the west in drier environments it adjoins areas of RCP6.

Table 14 Some examples of final retained groups within RCP4 Tablelands Grassy Forests

Bioregion	Final retained group	PCT ID	PCT name	Vegetation class
Australian Alps	R4.158	3381	Kosciuszko Alpine Sally Woodland	Subalpine Woodlands
	R4.36	3306	Kosciuszko Alpine Ash High Wet Forest	Montane Wet Sclerophyll Forests
	R4.10.58	3882	Alpine Windswept Feldmark	Alpine Fjaeldmarks
	R4.137	3885	Alpine Snowpatch Herbfield	Alpine Herbfields
	R4.157	3879	Kosciuszko High Plateau Grassy Open Heath	Alpine Heaths
	R4.136	3890	Kosciuszko Alpine Wet Heath	Alpine Bogs and Fens
	R4.10.9a	3049	Kosciuszko Cool Temperate Rainforest	Cool Temperate Rainforests
South East Corner	R4.17	3194	Southeast Escarpment Flats Swamp Gum Forest	South Coast Wet Sclerophyll Forests
	R4.10	3212	Far South Escarpment Damp Flats Forest	Southern Escarpment Wet Sclerophyll Forests
NSW South Western Slopes	R4.115	3542	Southwest Ranges Stringybark-Box Sheltered Forest	Upper Riverina Dry Sclerophyll Forests
South Eastern Highlands	R4.33	3413	Monaro Kangaroo Grass Woodland-Grassland Complex	Temperate Montane Grasslands
	R4.141	3338	Goulburn Tableland Frost Hollow Grassy Woodland	Tableland Clay Grassy Woodlands
	R4.144W	3295	Crookwell-Taralga Basalt Grassy Forest	Southern Tableland Wet Sclerophyll Forests
	R4.144E	3302	Southern Highlands Shale-Basalt Dry Forest	Southern Tableland Wet Sclerophyll Forests
	R4.38	3735	Central Tableland Peppermint Shrub-Grass Forest	Southern Tableland Dry Sclerophyll Forests
	R4.63	3384	Mount Canobolas Grassy Forest	Subalpine Woodlands
	R4.49	3510	Capertee Slopes Stringybark-Box Forest	Upper Riverina Dry Sclerophyll Forests
NSW North Coast	R4.41	3927	Barrington Subalpine Swamp Meadow	Montane Bogs and Fens
New England Tablelands	R4.164	3345	New England Snow Gum-Black Sally Woodland	Tableland Clay Grassy Woodlands
	R4.105	3281	Guyra Granitoids Gum-Messmate Forest	Northern Tableland Wet Sclerophyll Forests

Bioregion	Final retained group	PCT ID	PCT name	Vegetation class
	R4.64	3339	Guyra Basalt Snow Gum Woodland	Tableland Clay Grassy Woodlands
	R4.10.28	3936	Ebor Basalt Wet Heath	Montane Bogs and Fens
Nandewar	R4.106	n/a	(draft) Mount Kaputar Montane Gum Forest	Tableland Clay Grassy Woodlands
Brigalow Belt South	R4.121	3282	Liverpool Range Apple Gully Forest	Northern Tableland Wet Sclerophyll Forests
Trans bioregional	R4.170	3981	Tableland Semi-permanent Shallow Wetlands	Montane Lakes

7.1.5 RCP5: Rainforests and Layered Wet Sclerophyll Forests

RCP5 represents rainforest and layered wet sclerophyll forest vegetation of eastern NSW, primarily found within coast and hinterland environments. It is characterised by high rainfall or locally sheltered and moist environments, generally in combination with relatively warm to mild temperatures, and often on substrates of moderate to high fertility. RCP5 is the wettest of the RCPs with a median mean annual rainfall of 1,350 mm (690–2,640 mm), and is dominated by samples from low to mid elevations (median 190 m asl). It is most extensive across large parts of the NSW North Coast and South Eastern Queensland bioregions, from the coast and lowlands to the high escarpment rim. It is less common in the Sydney Basin bioregion, where largest areas are found along coastal escarpments of the Watagan ranges and the Illawarra, and incised gorges of the greater Blue Mountains including Wollemi National Park. In the South East Corner bioregion, it is increasingly constrained to narrow gullies and to sheltered slopes at higher elevations. In southern and western parts of its range, it is commonly associated (together with RCP9) with landscapes of high topographic relief where it prefers sheltered slopes that are protected from drying westerly winds and so have lower risk of fire. It tends to occur on clay rich soils that together with low annual water deficit ensure reliably elevated soil moisture levels. Common lithologies include basalts, shales and related fine-grained sediments, silty alluviums and relatively fertile granitoids.

The warm and wet climate of RCP5 supports the most luxuriant, species rich and structurally complex plant assemblages of NSW. There are 173 final retained groups within this RCP (including 59 with placeholder status), dominated by the Rainforests vegetation formation including the mainland classes Subtropical Rainforests, Northern Warm Temperate rainforests, Southern Warm Temperate Rainforests, Littoral Rainforests, Dry Rainforests, and some Cool Temperate Rainforests. RCP5 also includes many groups in the Wet Sclerophyll Forests vegetation formation, particularly the Shrubby sub-formation, including North Coast Wet Sclerophyll Forests, Northern Escarpment Wet Sclerophyll Forests and Northern Hinterland Wet Sclerophyll Forests vegetation classes. Other notable components are groups in the Forested Wetlands vegetation formation (Eastern Riverine Forests, Coastal Swamp Forests and Coastal Floodplain Wetlands classes) and a far north coast group with rainforest elements in the Mangrove Swamps vegetation class.

The closed forests of RCP5 vary in height from mid high in windswept littoral zones to extremely tall in subtropical and warm temperate classes. In many rainforest classes the canopy layer contributes a characteristically high proportion of total species richness, with high diversity of trees, palms, woody vines and epiphytes in the upper stratum. The most common mesophyll tree genera across plots assigned to groups in RCP5 include *Acmena, Guioa, Cryptocarya, Doryphora, Schizomeria* and *Diploglottis*. Sclerophyll dominant canopies in RCP5 form very tall to extremely tall forests, and species are mainly from the blue gum, blackbutt, mahogany and tallowwood eucalypt groups, together with brush box and turpentine. RCP5 forests commonly have diverse and complex multi-stratum understoreys that may include palms (*Archontophoenix cunninghamiana, Livistona australis*), small trees (e.g. *Allocasuarina torulosa, Acacia melanoxylon, Elaeocarpus reticulatus*), large and small mesophyll shrubs (*Synoum glandulosum, Pittosporum multiflorum, Eupomatia laurina, Wilkiea huegeliana, Breynia oblongifolia*), tree ferns (*Cyathea australis*), climbers (*Cissus hypoglauca, Pandorea pandorana* subsp. *pandorana, Cissus antarctica*) and epiphytes. Their ground cover layers are characterised by a diversity of ferns, graminoids and scrambling vines (e.g. *Blechnum cartilagineum, Blechnum neohollandicum, Gymnostachys anceps, Lomandra longifolia, Smilax australis, Gynochthodes jasminoides, Geitonoplesium cymosum*).

The relatively high proportion of RCP5 groups with placeholder status reflects a combination of high plant diversity in these environments and relatively sparse coverage of analysis plots. A subset of these groups are restricted to fertile north coast lowlands and hinterlands where they have been heavily cleared and few remnants remain for sampling. Others are restricted to small areas of distinctive habitat that are relatively inaccessible for survey due to tenure or rugged terrain, so await more thorough sampling and description.

With its widespread but scattered and patchy distribution, areas of the RCP5 region adjoin many of the other RCP regions across our study area. In coastal valleys and hinterland gorges, areas of RCP5 on moist sheltered slopes and deep gullies may grade into RCP9 on slightly more exposed aspects, or RCP1 on gentle valley floors. In sandstone-dominated environments of the central coast, Blue Mountains and Illawarra escarpment, plateaus supporting a mosaic of RCP7 and RCP8 give way to narrow strips of RCP5 along sheltered gorges and talus slopes. On the high rainfall eastern rim of the New England Tablelands, tall moist eucalypt forests of RCP3 are replaced by rich shrubby wet sclerophyll forests and rainforests of RCP5 on sheltered escarpment slopes.

Table 15 Some examples of final retained groups within RCP5 Rainforests and Layered Wet Sclerophyll Forests

Bioregion	Final retained group	PCT ID	PCT name	Vegetation class
South Eastern Queensland	R5.14	3003	Border Ranges Black Booyong Subtropical Rainforest	Subtropical Rainforests
	R5.46b	3080	Killarney Dry Rainforest	Dry Rainforests
	R5.11.84a	3064	Far North Hoop Pine Dry Rainforest	Dry Rainforests
	R5.102	3988	Far North Mesophyll Paperbark Swamp Forest	Coastal Swamp Forests
	R5.27	4034	Far North Swamp Oak-Tuckeroo Swamp Fringe Forest	Coastal Floodplain Wetlands
	R5.43	4090	Far North Estuarine Mangrove-Swamp Oak Forest	Mangrove Swamps
	R5.88	3035	Northern Ranges Coachwood Warm Temperate Rainforest	Northern Warm Temperate Rainforests

Bioregion	Final retained group	PCT ID	PCT name	Vegetation class
New England Tablelands	R5.10.197	3053	Northern Escarpment Sassafras Rainforest	Cool Temperate Rainforests
NSW North Coast	R5.2	3166	Northern Escarpment Brush Box-Tallowwood-Maple Wet Forest	North Coast Wet Sclerophyll Forests
	R5.30	3205	Northern Escarpment New England Blackbutt-Tallowwood Wet Forest	Northern Escarpment Wet Sclerophyll Forests
	R5.62	3206	Northern Escarpment Corkwood-Brush Box Wet Forest	Northern Escarpment Wet Sclerophyll Forests
	R5.77	3033	Northern Escarpment Sassafras-Prickly Ash Rainforest	Northern Warm Temperate Rainforests
	R5.20	3167	Northern Hinterland Blackbutt-Forest Oak Wet Forest	Northern Hinterland Wet Sclerophyll Forests
	R5.38	3169	Northern Hinterland Tallowwood-Brush Box Wet Forest	North Coast Wet Sclerophyll Forests
	R5.7	3174	Northern Turpentine-Brush Box Wet Forest	North Coast Wet Sclerophyll Forests
	R5.8a	3020	Northern Hinterland River Oak Sheltered Forest	Eastern Riverine Forests
	R5.57	4005	Northern Paperbark Banksia Littoral Forest	Coastal Swamp Forests
	R5.15	4048	Northern Swamp Oak-Paperbark Forest	Coastal Floodplain Wetlands
	R5.33s	4114	Lower North Sands Littoral Rainforest	Littoral Rainforests
	R5.11.103	3001	Lismore Basalt Subtropical Rainforest	Subtropical Rainforests
	R5.11.3	3026	Comboyne Plateau Warm Temperate Rainforest	Northern Warm Temperate Rainforests
Sydney Basin	R5.79	3076	Hunter Valley Whalebone Dry Rainforest	Dry Rainforests
	R5.73	3150	Hunter Coast Ranges Turpentine Wet Forest	North Coast Wet Sclerophyll Forests
	R5.84	3025	Central Coast Gallery Rainforest	Northern Warm Temperate Rainforests
	R5.93	3038	Sydney Coastal Coachwood Gallery Rainforest	Northern Warm Temperate Rainforests
	R5.58	3047	Sydney Montane Basalt Rainforest	Southern Warm Temperate Rainforests

Bioregion	Final retained group	PCT ID	PCT name	Vegetation class
	R5.24a	4106	Illawarra Escarpment Cool Temperate Rainforest	Cool Temperate Rainforests
	R5.71	3077	Illawarra Complex Dry Rainforest	Dry Rainforests
	R5.85	3013	Illawarra Lowland Subtropical Rainforest	Subtropical Rainforests
	R5.59a	4146	Illawarra Sands Littoral Rainforest	Littoral Rainforests
	R5.81	3187	Shoalhaven Hinterland Peppermint Wet Gully Forest	South Coast Wet Sclerophyll Forests
South East Corner	R5.10	3046	Southeast Warm Temperate Rainforest	Southern Warm Temperate Rainforests
	R5.10.9	3054	Southeast Cool Temperate Rainforest	Cool Temperate Rainforests
	R5.63b	4113	Far Southeast Littoral Rainforest	Littoral Rainforests

7.1.6 RCP6: Western Slopes Grassy Woodlands

RCP6 is the largest of the RCP regions, covering extensive areas of the 3 western slopes bioregions of Nandewar, Brigalow Belt South and NSW South Western Slopes. RCP6 includes higher elevations on the isolated volcanic peaks of the Warrumbungle range and high slopes of Mount Kaputar, and extends eastwards onto drier western parts of the New England Tablelands bioregion, the upper Hunter, and low rainfall zones of the South Eastern Highlands bioregion including the Murrumbateman and Monaro subregions. Elevation of plots assigned to groups in RCP6 ranges from 40–1,240 m asl, with a median of 425 m asl. The region is characterised by environments with relatively high annual water deficit, with mean annual rainfall relatively low across most of RCP6 (median 670 mm per annum, range 400–1,200 mm). Much of the RCP experiences warm to hot summers, but at higher elevation margins it includes areas with dry mild summers and cool winters.

Some 152 final retained groups are within RCP6, of which 76 occur in coast and tablelands bioregions. Plots from RCP6 define groups across the widest variety of vegetation formations and classes of any RCP, with representatives of 36 vegetation classes across 10 formations. The RCP is dominated by relatively warm and dry environments of the western slopes, but also extends eastwards onto western parts of tablelands and Hunter valley, and west to the margins of central NSW environments. Groups in RCP6 dominate a number of western vegetation classes in the Grassy Woodlands formation (Western Slopes Grassy Woodlands, Floodplain Transition Woodlands, New England Grassy Woodlands and a subset of Tableland Clay Grassy Woodlands) and the Dry Sclerophyll Forests formation (particularly North-west Slopes Dry Sclerophyll Woodlands, Pilliga Outwash Dry Sclerophyll Forests and a subset of Northern Tableland Dry Sclerophyll Forests and Upper Riverina Dry Sclerophyll Forests). RCP6 contains all groups in the Western Vine Thickets class of rainforests, all groups in Western Slopes Grasslands, and a subset of groups in Temperate Montane Grasslands. It also includes inland vegetation types that are at their eastern limit along our study area’s western margin, including groups in the Semi-arid Woodlands and Arid Shrublands vegetation formations, and in the classes Riverine Plain Grasslands, Semi-arid Floodplain Grasslands and Inland Riverine Forests.

The assemblages of this region are united by a flora characteristic of relatively low rainfall environments with moderately fertile to fertile soils. Mid high to very tall open forests, woodlands and grasslands are the most frequent structural forms across RCP6. Eucalypts may dominate the tree canopy, form mixed stands with *Callitris* spp., or be absent altogether where *Callitris* or *Acacia* are the primary canopy genera. Tree cover is variable, from closed to widely spaced to absent. Eucalypts are typically box species (*Eucalyptus albens, E. melliodora, E. microcarpa, E. conica* and *E. populnea*), red gums (*E. blakelyi, E. dealbata, E. camaldulensis, E. chloroclada*) and ironbarks (*E. crebra, E. melanophloia* and *E. sideroxylon*), and *Angophora floribunda* is also common. *Callitris glaucophylla* is a common associate tree, either as canopy dominant or component of the mid stratum, and in parts of the western slopes such as on transitional floodplains it forms dense stands and eucalypts may be absent. A mid stratum may be mid dense to sparse or absent, with the most common shrub species across all plots in RCP6 including *Notelaea microcarpa, Olearia elliptica* subsp. *elliptica, Pimelea neo-anglica*, *Dodonaea viscosa, Cassinia quinquefaria, Acacia deanei* and *Acacia implexa*. As mean annual rainfall declines westward onto the plains there is increasing cover and diversity of chenopods, with *Maireana microphylla* the most commonly recorded. The ground cover is characterised by a mid dense to dense cover of grasses, forbs and twiners. The most common taxa across RCP6 plots are *Aristida* spp., *Austrostipa scabra, Cymbopogon refractus, Microlaena stipoides, Cheilanthes sieberi* subsp. *sieberi*, *Desmodium varians, Dichondra repens, Glycine tabacina, Desmodium brachypodum* and *Oxalis perennans*.

RCP6 includes a subset of groups in the Western Vine Thickets vegetation class of the Rainforests formation. These groups may include a sclerophyll component in the tree layer but are distinguished by the presence of many small tree, shrub and ground cover species related to rainforest flora of the wetter regions of RCP5 and RCP9, including *Geijera parviflora, Alectryon oleifolius, Alstonia constricta* and *Elaeodendron australe* and vines in genera including *Jasminum, Marsdenia, Parsonsia* and *Tylophora*.

Grasslands are also a feature of this region and are associated with rich clay soils, often on basaltic or alluvial substrates, in low-rainfall zones including the Liverpool Plains, Monaro, Moree and south west plains. They may form the primary native vegetation cover across areas of open plains or tablelands or form a mosaic with grassy woodlands. Dominant species may include *Themeda triandra, Poa sieberiana, Bothriochloa macra* in the Temperate Montane Grasslands vegetation class, and *Austrostipa aristiglumis, Chloris truncata, Enteropogon acicularis* in the Western Slopes Grasslands class.

Riverine and floodplain groups within RCP6 are split between the Forested Wetlands and Grassy Woodlands vegetation formations. Ribbons of *Casuarina cunninghamiana* forests with a grassy ground cover are widespread along the major river systems of higher tablelands and slopes areas and represent the Eastern Riverine Forests vegetation class. In contrast groups in the Inland Riverine Forests class, which are characterised by *Eucalyptus camaldulensis*, are restricted to lower, drier parts of western slopes bioregions, except in the Hunter valley where stands reach an eastern limit near Singleton.

RCP6 is commonly replaced by RCP2 in areas of rocky and infertile soils across the western slopes and tablelands. RCP6 grades into RCP1 in areas such as the upper Hunter valley and the Capertee where temperatures are warm and elevation low but mean annual rainfall increases, with the probability of RCP1 rising strongly where rainfall is above 700 mm per annum. Cooler temperatures and increasing rainfall introduce RCP4, particularly where soil fertility remains moderate to high.

Table 16 Some examples of final retained groups within RCP6 Western Slopes Grassy Woodlands

Bioregion	Final retained group	PCT ID	PCT name	Vegetation class
Nandewar	R6.80	4151	Northwest White Pine-Silver-leaved Ironbark Forest	North-west Slopes Dry Sclerophyll Woodlands
	R6.9	3515	Nandewar Serpentinite Red Stringybark Woodland	North-west Slopes Dry Sclerophyll Woodlands
	R6.145	n/a	(draft) Melville Range Ironbark-Pine Woodland	Western Slopes Dry Sclerophyll Forests
Nandewar and Brigalow Belt South	R6.82	4149	Northwest Red Gum-Apple-White Pine Grassy Woodland	North-west Slopes Dry Sclerophyll Woodlands
	R6.10.125	n/a	(draft) Northwest Basalt Box-Plains Grass Woodland	Western Slopes Grassy Woodlands
	R6.11	n/a	(draft) North West Slopes Volcanics White Pine-Ironbark Shrub Grass Forest	Western Slopes Dry Sclerophyll Forests
	R6.26	n/a	(draft) Nandewar Paperbark-Native Olive-Apple Viney Flats Forest	Eastern Riverine Forests
Nandewar and Brigalow Belt South and New England Tablelands	R6.17	3396	Northwest Flats Box-Blakelys Red Gum Forest	Western Slopes Grassy Woodlands
	R6.86p	4076	Northwest Ranges River Oak Forest	Eastern Riverine Forests
Brigalow Belt South	R6.100	n/a	(draft) Terry Hie Hie Ooline-Pilliga Box Forest-Thicket	Western Vine Thickets
	R6.39	n/a	(draft) Northwest Grassland and Sparse Woodland on Alluvial Plains and Basalt	Western Slopes Grasslands
	R6.126	n/a	(draft) Kaputar-Warrumbungles White Box Shrubby Woodlands	North-west Slopes Dry Sclerophyll Woodlands
	R6.65	n/a	(draft) Pilliga Apple White Cypress-Red Gum Forest	Western Slopes Grassy Woodlands
	R6.162p	n/a	(draft) Western Pilliga Pine-Box Woodland	Pilliga Outwash Dry Sclerophyll Forests
	R6.104	n/a	(draft) Wee Waa Moree Brigalow-Wilga-Belah Chenopod Forest	Brigalow Clay Plain Woodlands

Bioregion	Final retained group	PCT ID	PCT name	Vegetation class
	R6.37	n/a	(draft) Northwest Clay Plain Bluegrass-Panic-Cup Grass Grassland	Semi-arid Floodplain Grasslands
	R6.106	n/a	(draft) Northwest Clay Plain Plains Grass-Nardoo Moist Grassland	Western Slopes Grasslands
Sydney Basin	R6.13	3532	Western Hunter Ironbark-Box Forest	North-west Slopes Dry Sclerophyll Woodlands
	R6.178	3403	Western Hunter Creekflat Apple Grassy Forest	Western Slopes Grassy Woodlands
	R6.84	4104	Central Hunter Weeping Myall Forest	Riverine Plain Woodlands
NSW North Coast	R6.168	3119	Upper Hunter White Box Vine Thicket	Western Vine Thickets
NSW South Western Slopes	R6.93	n/a	(draft) Southwest Plains Grey Box Grassy Woodland	Floodplain Transition Woodlands
	R6.118	n/a	(draft) Lower Slopes and Plains Grassy Open Floodplain Woodland	Inland Floodplain Woodlands
	R6.41	n/a	(draft) Southwest Plains Chenopod Grassland	Western Slopes Grasslands
	R6.153	n/a	(draft) Central West Stony Hills White Cypress-Dwyers Red Gum Woodland	Inland Rocky Hill Woodlands
	R6.87	n/a	(draft) Central West Hills White Box-Pine Woodland	Western Slopes Grassy Woodlands
	R6.177	n/a	(draft) Southwest Slopes Box-Blakelys Red Gum Grassy Woodland	Western Slopes Grassy Woodlands
South Eastern Highlands	R6.91	3414	Monaro Snowgrass-Kangaroo Grass Grassland	Temperate Montane Grasslands
Trans bioregional	R6.10.236	n/a	(draft) Lower Western Slopes River Red Gum Floodplain Forest	Inland Riverine Forests

7.1.7 RCP7: Coast and Hinterland Dry Sclerophyll Forests

The dry shrubby and shrub grass eucalypt forests of RCP7 are widespread on soils of low to intermediate fertility across the coastal lowlands and hinterland ranges of the South East Corner and Sydney Basin bioregions. In the NSW North Coast bioregion the RCP forms only a narrow band tracing the mineral rich Holocene sand plains of the coastal zone and isolated sandstone bedrock near Kempsey. In the South Eastern Queensland bioregion, RCP7 also follows the sand plains along the coastline but extends into coastal lowlands and ranges underlain by the Jurassic sandstones in the lower Clarence valley. It covers the isolated rhyolite peaks of the Mount Warning Caldera and Focal Peak areas near the Queensland border. Small areas of RCP7 occupy the granite plateau edge along the northern escarpment in the New England Tablelands bioregion. The RCP is influenced by a coastal climate with a moderate to high median mean annual rainfall of 1,125 mm (650–2,640 mm) and moderate to warm annual mean temperatures with median of 16.4°C (9.0–19.8°C). The topographic characteristics of the RCP are variable. The median elevation is 87 m asl (0–1,300 m asl). It follows a range of aspects and topographic positions including sheltered slopes, enriched sandy soils on exposed crests on plateaus and ranges, and sand plains and sandy creek flats on coastal lowlands.

The plant assemblages within RCP7 are dominated by tall to very tall eucalypt forests with sparse to mid dense sclerophyll shrubs and a ground cover of grasses, ferns, graminoids and small twiners. The tree canopy very frequently comprises one or more species from the stringybark, angophora, mahogany, ironbark, peppermint and bloodwood groups. The wide latitudinal range of the region also encompasses species including *Eucalyptus sieberi* and *Syncarpia glomulifera*. A small tree layer is very frequently present with *Allocasuarina* and taller *Acacia* species common, sometimes with *Elaeocarpus reticulatus*. On impeded soils along coastal creek flats a distinct sub canopy layer of *Melaleuca* spp. and *Leptospermum* spp. is very frequently present below a taller cover of *Eucalyptus robusta* or *Eucalyptus botryoides*. Frequently occurring shrub species include *Acacia longifolia, Acacia ulicifolia, Banksia spinulosa, Dodonaea triquetra, Leucopogon lanceolatus* and *Persoonia* spp. The ground layer is a sparse to mid dense cover of grasses including *Entolasia* spp., *Imperata cylindrica, Microlaena stipoides, Themeda triandra* with graminoids *Lomandra* spp., *Dianella* spp., *Patersonia* spp., and *Lepidosperma* spp. The fern *Pteridium esculentum* is very frequently present with forbs that include *Lobelia purpurascens* and *Viola hederacea*. Frequently recorded small twiners and vines include *Cassytha* spp., *Glycine* spp., *Billardiera scandens, Pandorea pandorana* subsp. *pandorana* and *Kennedia rubicunda*.

We identified 116 final retained groups within RCP7, 15 (13%) of which were assigned placeholder status. Most groups in RCP7 are assigned to the Dry Sclerophyll Forests vegetation formation and fall mainly in the Shrubby sub-formation. Smaller proportions of groups fall in the Forested Wetlands and Wet Sclerophyll Forests formations. The dry sclerophyll forest groups are assigned to 11 different vegetation classes, a reflection of the wide distribution of RCP7 assemblages across both latitudinal gradients and geological types. The primary classes include the North Coast Dry Sclerophyll Forests, South East Dry Sclerophyll Forests, Sydney Coastal Dry Sclerophyll Forests and Sydney Hinterland Dry Sclerophyll Forests as well as the sand plain environments dominated by the South Coast Sands Dry Sclerophyll Forests and Coastal Dune Dry Sclerophyll Forests. There are 2 Forested Wetlands classes represented in RCP7: Coastal Swamp Forests and Coastal Floodplain Wetlands. Almost half of all final retained groups in the Coastal Swamp Forests vegetation class across eastern NSW are within RCP7 as they are characterised by a diverse and high cover of sclerophyll shrubs found on intermittently waterlogged sandy substrates.

A smaller number of groups in RCP7 fit within the Wet Sclerophyll Forests vegetation formation and these largely align with classes found on the south coast including the Southern Lowlands Wet Sclerophyll Forests and South Coast Wet Sclerophyll Forests. These southern wet sclerophyll forests have a much higher proportion of sclerophyll shrubs than their northern counterparts. Also within RCP7 are a handful of treeless assemblages associated with headlands and lowland swamps. These include many of the dry shrub species that are common to groups defined within RCP7. They are assigned to various vegetation classes within the Heathlands or Freshwater Wetlands formations.

RCP7 is replaced by RCP8 on exposed and rocky sandstone environments or highly podsolised marine sands. RCP9 adjoins along the south coast escarpment and within deep gullies of the coastal hills. On soils of higher fertility in the undulating coastal valleys and plains it is replaced by RCP1.

Table 17 Some examples of final retained groups within RCP7 Coast and Hinterland Dry Sclerophyll Forests

Bioregion	Final retained group	PCT ID	PCT name	Vegetation class
South East Corner	R7.13	3196	Southeast Hinterland Intermediate Shrub Forest	South Coast Wet Sclerophyll Forests
	R7.10.62	3871	Far Southeast Mountain Skeletal Rockplate Scrub	Southern Montane Heaths
	R7.132	3275	South Coast Spotted Gum Cycad Dry Forest	Southern Lowland Wet Sclerophyll forests
	R7.48	3661	South Coast Hinterland Yertchuk Forest	South East Dry Sclerophyll Forests
Sydney Basin	R7.118	3273	South Coast Lowland Shrub-Grass Forest	Southern Lowland Wet Sclerophyll forests
	R7.107	4009	Shoalhaven Lowland Flats Wet Swamp Forest	Coastal Swamp Forests
	R7.38	3638	South Coast Sands Bangalay Forest	South Coast Sands Dry Sclerophyll Forests
	R7.31	3614	Southern Highlands Sandstone Peppermint Forest	Sydney Hinterland Dry Sclerophyll Forests
	R7.47	3667	Southern Highlands Enriched Sandstone Forest	South East Dry Sclerophyll Forests
	R7.94	3475	Burragorang Escarpment Ironbark Forest	Central Gorge Dry Sclerophyll Forests
	R7.1	3692	Upper Blue Mountains Moist Forest	Sydney Montane Dry Sclerophyll Forests
	R7.69	3599	Blue Mountains Peppermint Shrub Forest	Sydney Hinterland Dry Sclerophyll Forests
	R7.52	3239	Hunter Range Sheltered Grey Gum Forest	Northern Hinterland Wet Sclerophyll Forests
	R7.89	3591	Southern Sydney Sheltered Forest	Sydney Coastal Dry Sclerophyll Forests
	R7.42	3259	Sydney Coastal Shale-Sandstone Forest	Northern Hinterland Wet Sclerophyll Forests
	R7.123	3594	Sydney Coastal Sandstone Foreshores Forest	Sydney Coastal Dry Sclerophyll Forests
	R7.19	3176	Sydney Enriched Sandstone Moist Forest	North Coast Wet Sclerophyll Forests
	R7.110	3437	Hunter Coast Lowland Spotted Gum Dry Forest	Hunter-Macleay Dry Sclerophyll Forests
	R7.111	3443	Lower Hunter Spotted Gum Scrubby Transition Forest	Hunter-Macleay Dry Sclerophyll Forests

Bioregion	Final retained group	PCT ID	PCT name	Vegetation class
NSW North Coast	R7.87	3544	Coastal Sands Apple-Blackbutt Forest	Coastal Dune Dry Sclerophyll Forests
	R7.66	3435	Hunter Coast Lowland Flats Damp Forest	Hunter-Macleay Dry Sclerophyll Forests
	R7.102	3573	Northern Lowland Scribbly Gum-Bloodwood Forest	North Coast Dry Sclerophyll Forests
	R7.10.107b	3552	Northern Sands Blackbutt-Stringybark Forest	Coastal Dune Dry Sclerophyll Forests
South Eastern Queensland	R7.65	3574	Northern Lowland Sandstones Dry Open Forest	North Coast Dry Sclerophyll Forests
	R7.99a	4002	Northern Lowland Orange Gum Dry Swamp Forest	Coastal Swamp Forests
	R7.115	3563	Clarence Sandstone Blackbutt-Bloodwood Forest	North Coast Dry Sclerophyll Forests
	R7.58c	3548	Far North Sands Scribbly Gum Heathy Forest	Coastal Dune Dry Sclerophyll Forests
	R7.139	3850	Tweed Caldera Outcrops Grassy Scrub	Northern Montane Heaths
	R7.109	3575	Urbenville Plug Peaks Shrub Woodland	North Coast Dry Sclerophyll Forests
New England Tablelands	R7.61	3683	Timbarra Granite Blackbutt Forest	Northern Escarpment Dry Sclerophyll Forests

7.1.8 RCP8: Coast and Hinterland Heaths and Heathy Forests

RCP8 is almost exclusively dominated by sandstone ranges and plateaus of the Sydney and Clarence–Morton basins and coastal sand plains. These substrates weather to the most impoverished soils of the coastal bioregions, the high silica content associated with quartz rich sandstone, coarse grained granites and Pleistocene dunes. The plant assemblages found within the RCP are characterised by genera from the families Proteaceae and Fabaceae, including *Banksia, Grevillea, Hakea, Isopogon*, *Persoonia* and *Acacia*. The climate of the region has a strong coastal influence with median mean annual rainfall around 1,170 mm (690–2,470 mm) and median annual mean temperature 16.3°C (9.1–19.8°C). Elevation median across all plots in RCP8 is 144 m asl but extends from near sea level to 1,280 m at high points on the hinterland ranges. The Triassic sandstone plateaus of the Sydney Basin represent the most extensive parts of RCP8 including the Morton, Woronora, Hornsby, Blue Mountains and Wollemi plateaux, Hunter Range and lowland foothills of the central coast and Shoalhaven. The lower Clarence valley includes RCP8 where Jurassic sandstones are exposed along the Coast Range in Yuraygir National Park and surrounding hinterland hills and ranges between Glenreagh and the Grafton district. Coastal sand plains, or wallum country, is a feature of RCP8 on the north coast between Port Stephens and the Tweed coast. There are also several disjunct occurrences of RCP8 on the elevated granite plateau at Gibraltar Range and on the shallow rocky rhyolite soils of the Koonyum Range in the Byron Bay hinterland. On the south coast, RCP8 is restricted to the sandy tertiary alluviums found on the lowlands of the Eden area and the surrounding rocky rhyolite peaks. An outlier of RCP8 extends along the south east escarpment cliffs and ranges.

The structure of the vegetation within this RCP varies between mid high to tall eucalypt forests and woodlands with a mid dense understorey of heath shrubs to treeless heathlands. Where present the tree canopy is dominated by eucalypts, and frequently includes species from the bloodwood, angophora, scribbly gum, stringybark, peppermint and ash groups. Localised multi-stemmed mallee trees may occasionally dominate. Taller non eucalypt species include *Allocasuarina* spp. and *Banksia serrata*, or *Banksia aemula* on sand plains. Examples of frequent shrub species are *Leptospermum trinervium, Banksia spinulosa, Persoonia levis, Lambertia formosa, Isopogon anemonifolius* and *Hakea dactyloides*. The composition of the ground cover varies in response to soil drainage characteristics. Free draining sands or shallow rocky soils are characterised by hardy grasses and graminoids including *Entolasia stricta, Lomandra obliqua, Patersonia sericea, Lomandra glauca* and *Lepidosperma laterale*. Impeded soils on both sand swales and plateau swamps include an abundant cover of restioid and cyperoid species including *Lepyrodia scariosa, Leptocarpus tenax, Empodisma minus, Lepidosperma limicola* and *Gymnoschoenus sphaerocephalus*.

We identified 120 final retained groups within RCP8 and all are located within coast and tableland bioregions. Twelve of these groups (10%) are assigned placeholder status. Table 18 highlights examples of the widely distributed groups and others that are assigned to vegetation classes with restricted distributions. The groups are assigned to 3 main vegetation formations: Dry Sclerophyll Forests (Shrubby sub-formation), Heathlands, and Freshwater Wetlands. Almost half of all groups in the RCP are assigned to one of 8 vegetation classes in the Dry Sclerophyll Forests formation. These are dominated by classes representing major environmental gradients across the sandstone plateaus in the Sydney Basin including the Sydney Coastal Dry Sclerophyll Forests, Sydney Montane Dry Sclerophyll Forests and Sydney Hinterland Dry Sclerophyll Forests. They encompass many of the exposed sandstone ridgetop forests and woodlands across the Sydney area. A vegetation class with a restricted distribution in the Sydney Basin is the Sydney Sand Flats Dry Sclerophyll Forests, found on weathered sand deposits between western Sydney and the lower Hunter valley. Other vegetation classes in the Dry Sclerophyll Forests formation, including the North Coast Dry Sclerophyll Forests, Northern Escarpment Dry Sclerophyll Forests and South East Dry Sclerophyll Forests, are less tightly constrained to sandstone environments and RCP8 represents a comparatively small proportion of groups assigned to them.

Groups assigned to the Heathlands vegetation class are dry heaths characterised by dense low-growing shrubs and heaths found on exposed rocky sandstone soils or deeply weathered coastal dunes. The dry heaths of the Sydney Basin fall within 3 vegetation classes: Sydney Coastal Heaths, Sydney Montane Heaths and Coastal Headland Heaths following the broad environmental gradients of the dry sclerophyll forests; however, on the north coast most of the groups within the Heathlands vegetation formation are assigned to a single class, the Wallum Sand Heaths. Some groups in this class also occur in the Sydney Basin bioregion, but are less extensive there. Further south, RCP8 includes all groups assigned to the outlying South Coast Heaths vegetation class.

RCP8 includes a pool of 27 groups that are assigned to the Freshwater Wetlands formation, but only to vegetation classes that include a high cover of sclerophyll shrubs. The Coastal Heath Swamps class is the most extensive and complex as it includes a large proportion of the sandstone plateau swamp heath vegetation and the swamps found within coastal sand swales along the central and north coasts. While most of the sandstone swamps are found within the Sydney Basin, there are floristically related assemblages found on the Kangaroo Creek sandstones of the Kremnos plateau west of Coffs Harbour. A small number of the sandstone swamp heaths occur on cool, high elevation plateaus and fit within the Montane Bogs and Fens vegetation class.

RCP8 lithologies and climate envelopes overlap substantially with those occupied by RCP7. Where they occur together, RCP8 is generally constrained to areas of relatively shallow, rocky or well drained sandy and infertile soils.

Table 18 Some examples of final retained groups within RCP8 Coast and Hinterland Heaths and Heathy Forests

Bioregion	Final retained group	PCT ID	PCT name	Vegetation class
South East Corner	R8.7	3816	Far Southeast Coastal Lowland Heath	South Coast Heaths
	R8.8	3817	Mount Nadgee Heath	South Coast Heaths
Sydney Basin	R8.10	3588	Shoalhaven Foothills Bloodwood Heathy Forest	Sydney Coastal Dry Sclerophyll Forests
	R8.1a	3917	Shoalhaven Lowland Heath	Coastal Heath Swamps
	R8.47	3668	Southern Highlands Scribbly Gum Forest	South East Dry Sclerophyll Forests
	R8.29	3919	Southern Highlands Wet Swamp Heath	Coastal Heath Swamps
	R8.33	3814	Woronora Plateau Heath-Mallee	Sydney Coastal Heaths
	R8.113	3924	Sydney Coastal Upland Swamp Heath	Coastal Heath Swamps
	R8.55	3593	Sydney Coastal Sandstone Bloodwood Shrub Forest	Sydney Coastal Dry Sclerophyll Forests
	R8.40	3807	Northern Sydney Heath-Mallee	Sydney Coastal Heaths
	R8.9	3622	Sydney Hinterland Yellow Bloodwood Woodland	Sydney Hinterland Dry Sclerophyll Forests
	R8.63	3629	Castlereagh Scribbly Gum Woodland	Sydney Sand Flats Dry Sclerophyll Forests
	R8.34	3694	Upper Blue Mountains Ridgetop Woodland	Sydney Montane Dry Sclerophyll Forests
	R8.2	3929	Blue Mountains Swamp Heath	Coastal Heath Swamps
	R8.21	3611	Nattai Plateau Bloodwood-Peppermint Forest	Sydney Hinterland Dry Sclerophyll Forests
	R8.10.70	3859	Genowlan Point Heath	Sydney Montane Heaths
	R8.52	3945	Newnes Plateau Shrub Swamp	Montane Bogs and Fens
	R8.59	3627	Wollemi Plateau Yertchuk-Stringybark Woodland	Sydney Hinterland Dry Sclerophyll Forests
	R8.82	3633	Mellong Sand Swamp Woodland	Sydney Sand Flats Dry Sclerophyll Forests

Bioregion	Final retained group	PCT ID	PCT name	Vegetation class
	R8.18	3583	Hunter Coast Lowland Scribbly Gum Forest	Sydney Coastal Dry Sclerophyll Forests
	R8.61	3631	Kurri Sand-Clay Woodland	Sydney Sand Flats Dry Sclerophyll Forests
NSW North Coast	R8.16	3802	Lower North Sandplain Wallum Heath	Wallum Sand Heaths
	R8.26	3913	Northern Sandplain Wet Heath	Coastal Heath Swamps
	R8.51	3906	Northern Lowland Clay Wet Heath	Coastal Heath Swamps
	R8.23	3570	Coorabakh Conglomerate Banksia Forest	North Coast Dry Sclerophyll Forests
South Eastern Queensland	R8.76	3577	Yuraygir Range Bloodwood-Stringybark Forest	North Coast Dry Sclerophyll Forests
	R8.101	3568	Clarence Sandstone Stringybark Heathy Woodland	North Coast Dry Sclerophyll Forests
	R8.25a	3787	Byron Graminoid Clay Heath	Coastal Headland Heaths
	R8.17	3801	Far North Sandplain Wallum Heath	Wallum Sand Heaths
	R8.119	3571	Mount Warning Caldera Scribbly Gum Woodland	North Coast Dry Sclerophyll Forests
New England Tablelands	R8.54	3684	Timbarra Granite Strawberry Gum-Stringybark Woodland	Northern Escarpment Dry Sclerophyll Forests

7.1.9 RCP9: Coast and Hinterland Moist Grassy Forests

RCP9 is the most extensive of the coastal RCPs in eastern NSW and is found between the Victorian and Queensland borders inland to the coastal escarpments and hinterland ranges. It includes a diverse set of assemblages that together encompass many of the grassy wet sclerophyll forests of eastern NSW. These are associated with moderately fertile to fertile soils often in sheltered or semi sheltered locations, including gullies and silty alluvial soils of escarpment streams and coastal river flats. The RCP is strongly influenced by a coastal climate, with warm temperatures (median annual mean temperature 16.1°C) and median mean annual rainfall of 1,130 mm. The elevation range is large (0–1,340 m asl; median 150 m asl) and extends from low-lying coastal flats into escarpment ranges. It occurs on high peaks above 1,000 m on richer soils such as volcanic caps and flows, but generally only where coastal influences moderate temperature and maintain high rainfall such as the southern highlands, Blue Mountains basalt caps, and subtropical environments of the far north coast.

The plant assemblages in RCP9 are characterised by very tall to extremely tall eucalypt forests with a sparse to mid dense shrub layer comprising a mix of mesophyll and sclerophyll species. A fern–forb–grass rich ground cover is a very frequent attribute of many of the assemblages in the region. The tree canopy comprises a high number of eucalypts from coastal NSW, with species frequently from the stringybark, angophora, mahogany, ironbark, red gum, blue gum, peppermint and grey gum groups. *Angophora floribunda, Eucalyptus saligna, E. tereticornis* and *Syncarpia glomulifera* are examples of species recorded frequently, but rarely together. Species with a northern distribution, such as *E. siderophloia, E. microcorys* and *E. pilularis*, and southern species such as *E. elata, E. cypellocarpa* and *E.* smithii, show partitioning between the north and south coasts. Other species form an understorey of small trees, with *Allocasuarina* spp. and *Acacia* spp. frequent in this stratum often with hardy mesophyll species including *Backhousia* spp., *Glochidion* spp., *Myrsine* spp. or *Acmena smithii*. Occasionally these species replace the eucalypt canopy in very protected sites in hinterland ranges receiving lower rainfall. Low elevation creek flats invariably include an additional prominent mid stratum of *Melaleuca* spp. and/or *Lophostemon suaveolens* on the north coast. *Casuarina cunninghamiana* can dominate along narrow ribbons of riverbank habitat in hinterland valleys.

The lower shrub layer also commonly includes mesic species such as *Pittosporum* spp., *Notelaea* spp. and *Breynia oblongifolia*, in combination with sclerophyll species such as *Leucopogon* spp., *Persoonia* spp. and *Exocarpos cupressiformis*. Warm and wet environments may include occasional palms such as *Livistona australis*. Ferns are frequently a dominant component of the ground cover with *Calochlaena dubia* and *Pteridium esculentum* the most common and abundant. Other smaller ferns are also common including species of the genera *Adiantum*, *Blechnum* and *Pellaea*. Other frequent ground covers include *Microlaena stipoides*, *Oplismenus imbecillis, Entolasia* spp., *Poa* spp., *Dichondra repens*, *Eustrephus latifolius, Lomandra longifolia, Pandorea pandorana* subsp. *pandorana* and *Dianella caerulea*.

We identified 152 final retained groups within RCP9, 36 (24%) of which were assigned placeholder status. Groups within the RCP are allocated to 8 different vegetation formations, with Wet Sclerophyll Forests representing close to half of all groups. The Northern Hinterland Wet Sclerophyll Forests vegetation class covers the low to mid elevations of the northern bioregions and contains over twice as many groups as those found in the southern counterpart the South Coast Wet Sclerophyll Forests. Groups are assigned to an additional 7 wet sclerophyll forest classes across the climatic and elevation range of the RCP, the largest of which are the North Coast Wet Sclerophyll Forests, Southern Tableland Wet Sclerophyll Forests and Southern Lowland Wet Sclerophyll Forests. In general, the northern wet sclerophyll forest classes are characterised by warmer and wetter climates than those of the south coast with annual mean temperatures higher by several degrees Celsius and mean annual rainfall greater by 300 mm.

The Forested Wetlands are the second most frequently assigned vegetation formation to groups in RCP9. Final retained groups within this formation are allocated to 3 vegetation classes, with the Coastal Floodplain Wetlands comprising the highest number of groups. These assemblages are closely allied to the Wet Sclerophyll Forests formation, but are found on lowland alluvial soils associated with river flats and swamp depressions, where periodically flooded soils support a range of grassy and herbaceous very tall eucalypt forests and layered eucalypt and melaleuca swamp forests. The formation also includes Eastern Riverine Forests, dominated by *Casuarina cunninghamiana* subsp. *cunninghamiana* which is found in narrow riparian strips throughout the region.

RCP9 includes 20 groups assigned to the Dry Sclerophyll Forests vegetation formation; however, many of these represent sheltered or fire protected variants within this formation. These groups are dispersed across 10 vegetation classes that reflect the major geographic and climatic patterns within the RCP. The Central Gorge Dry Sclerophyll Forests and Northern Gorge Dry Sclerophyll Forests include assemblages characterised by mesophyll shrubs and grassy ground covers that are typical of RCP9. Similarly the Coastal Dune Dry Sclerophyll Forests and South Coast Sands Dry Sclerophyll Forests include forests that have mesic and sclerophyll shrubs common to littoral rainforests and may be locally common in long unburnt areas.

The Rainforests vegetation formation has also been assigned to a handful of groups in RCP9. While most rainforests occur within the very wet RCP5 region, the drier hinterland environments in RCP9 include pockets of relatively species-poor dry rainforest. These are typically rocky sheltered slopes and gullies found along hinterland or escarpment ranges and are very frequently dominated by dense cover of *Backhousia myrtifolia* or other hardy species including *Ficus rubiginosa*. These are included within the Dry Rainforests vegetation class and are found across the north–south extent of the RCP. In addition, a small number of groups from the Littoral Rainforests class are associated with headlands on the north and south coast.

RCP9 is widespread and adjoins many other RCPs in different parts of its range. It is replaced by RCP5 in the wettest and most sheltered environments, while in more exposed topographic situations with lower mean annual rainfall it gives way to RCP1. Along the southern and northern coastal escarpments as elevations approach 1,000 m asl or higher, RCP9 is adjoined by RCP4 and RCP3 respectively.

Table 19 Some examples of final regained groups within RCP9 Coast and Hinterland Moist Grassy forests

Bioregion	Final retained group	PCT ID	PCT name	Vegetation class
South East Corner	R9.43	3792	Far Southeast Headland Scrub	Coastal Headland Heaths
	R9.16	3185	Far South Riverflat Wet Forest	South Coast Wet Sclerophyll Forests
	R9.9d	4112	Southeast Dry Rainforest	Dry Rainforests
	R9.12	3181	Bega Wet Shrub Forest	South Coast Wet Sclerophyll Forests
	R9.38	3188	South Coast Riverflat Peppermint Forest	South Coast Wet Sclerophyll Forests
	R9.63	3190	South Coast Hinterland Monkey Gum Wet Fern Forest	South Coast Wet Sclerophyll Forests
	R9.105	3271	Shoalhaven Spotted Gum-Blackbutt Moist Forest	Southern Lowland Wet Sclerophyll forests
Sydney Basin	R9.45	4049	South Coast Floodplain Grassy Swamp Forest	Coastal Floodplain Wetlands
	R9.56	4019	Coastal Alluvial Bangalay Forest	Coastal Floodplain Wetlands
	R9.22	4052	South Coast Low Hills Red Gum Grassy Forest	Coastal Valley Grassy Woodlands
	R9.140	3327	Illawarra Lowland Red Gum Grassy Forest	Coastal Valley Grassy Woodlands
	R9.36	3477	Burragorang Gorges Moist Fern Forest	Central Gorge Dry Sclerophyll Forests
	R9.51	3155	Illawarra North-Pittwater Bangalay Moist Forest	Northern Hinterland Wet Sclerophyll Forests
	R9.37	3223	Southern Highlands Shale-Basalt Wet Forest	Southern Escarpment Wet Sclerophyll Forests

Bioregion	Final retained group	PCT ID	PCT name	Vegetation class
	R9.137	3222	Southern Highlands Shale Margins Moist Forest	Southern Escarpment Wet Sclerophyll Forests
	R9.78	3266	Nattai-Morton Sandstone Peppermint Gully Forest	Southern Lowland Wet Sclerophyll forests
	R9.17	3140	Blue Mountains Sandstone Turpentine Moist Forest	North Coast Wet Sclerophyll Forests
	R9.138	3258	Sydney Basin Creekflat Blue Gum-Apple Forest	Northern Hinterland Wet Sclerophyll Forests
	R9.44	3210	Blue Mountains Cool Wet Eucalypt Forest	Southern Escarpment Wet Sclerophyll Forests
	R9.52	3110	Greater Sydney Enriched Grey Myrtle Dry Rainforest	Dry Rainforests
	R9.40	3262	Sydney Turpentine Ironbark Forest	Northern Hinterland Wet Sclerophyll Forests
	R9.88	3136	Blue Gum High Forest	North Coast Wet Sclerophyll Forests
	R9.62	3263	Watagan Range Turpentine-Mahogany Grassy Forest	Northern Hinterland Wet Sclerophyll Forests
	R9.101b	3328	Lower Hunter Red Gum-Paperbark Riverflat Forest	Coastal Valley Grassy Woodlands
	R9.60	3241	Lower North White Mahogany-Spotted Gum Moist Forest	Northern Hinterland Wet Sclerophyll Forests
NSW North Coast	R9.1	3285	Lower North Escarpment Blue Gum Grassy Forest	Northern Hinterland Wet Sclerophyll Forests
	R9.129	3207	Northern Escarpment Layered Blackbutt Fern Forest	Northern Escarpment Wet Sclerophyll Forests
	R9.2	3284	Liverpool Range Ribbon Gum-Stringybark Forest	Northern Tableland Wet Sclerophyll Forests
	R9.4	3250	Northern Foothills Blackbutt Grassy Forest	Northern Hinterland Wet Sclerophyll Forests
	R9.103	4006	Northern Paperbark-Swamp Mahogany Saw-sedge Forest	Coastal Swamp Forests
	R9.139	4020	Coastal Creekflat Layered Grass-Sedge Swamp Forest	Coastal Floodplain Wetlands
	R9.21	3546	Coastal Sands Littoral Scrub-Forest	Coastal Dune Dry Sclerophyll Forests
South Eastern Highlands	R9.36	3477	Burragorang Gorges Moist Fern Forest	Central Gorge Dry Sclerophyll Forests

Bioregion	Final retained group	PCT ID	PCT name	Vegetation class
South Eastern Queensland	R9.79	4046	Northern Lowland Swamp Turpentine-Red Gum Forest	Coastal Floodplain Wetlands
	R9.57	3233	Far North Hinterland Grey Gum Grassy Forest	Northern Hinterland Wet Sclerophyll Forests
	R9.115	3252	Northern Hinterland Grey Gum-Mahogany Grassy Forest	Northern Hinterland Wet Sclerophyll Forests
	R9.54	3132	Northern Sands Tuckeroo-Banksia Forest	Littoral Rainforests
	R9.121	3248	Northern Blackbutt-Turpentine Shrub Forest	Northern Hinterland Wet Sclerophyll Forests

7.1.10 RCP10: mixed habitat specialist groups

RCP10 represents a diverse set of floristic assemblages that were weakly related to the environmental variables used to construct the RCP models. This subset of groups does not retain a regional identity and is not mapped. The groups are habitat specialists, including assemblages occurring in non-woody wetlands, rock outcrops and saline environments.

There were 79 final retained groups within RCP10, assigned to 21 vegetation classes across 9 formations. The common thread uniting the diverse and disparate groups in this residual subset is a reliance on a specialised habitat of limited area, including rock outcrops, saline and estuarine environments, frequently inundated wetlands, alpine peaks and bogs, coastal headland cliffs and dunes, and high, cool and very wet peaks. The assemblages of RCP10 are typically dominated by specialised plant species with limited distributions that are rarely recorded outside a narrow environmental range.

Frequent freshwater inundation exerts a strong influence on compositional attributes of more than half of the groups in RCP10. It includes 34 groups assigned to the Freshwater Wetlands vegetation formation including the eastern classes Coastal Freshwater Lagoons, Coastal Heath Swamps and Montane Bogs and Fens, as well as Inland Floodplain Swamps and Inland Floodplain Shrublands. It also includes 14 groups assigned to the Forested Wetlands formation through the Coastal Floodplain Wetlands, Coastal Swamp Forests, Eastern Riverine Forests and Inland Riverine Forests classes.

The RCP10 subset also includes almost all final retained groups in the Saline Wetlands vegetation formation, including all groups in the Saltmarshes class and most groups in the Mangrove Swamps vegetation class (a single group of this latter class is in RCP5).

Across other environments, the RCP10 subset includes groups assigned to Heathlands, Dry Sclerophyll Forests, Rainforests and Grasslands vegetation formations. The 7 groups assigned to the Heathlands formation represent a set of assemblages restricted to areas of skeletal soil over exposed rock, often relatively species poor and with local endemic species. Two groups in the Dry Sclerophyll Forests formation are similarly restricted to distinctive stony, dry environments. RCP10 groups in the Rainforests formation are all within the Cool Temperate Rainforests vegetation class and are characterised by specialised species restricted to small areas on high, cold and wet escarpment peaks. In the Grasslands formation, RCP10 groups include a group in the Temperate Montane Grasslands class associated with a distinctive subalpine limestone environment, and groups in the Maritime Grasslands class dominated by a unique set of salt-tolerant foredune and headland plants.

RCP10 also includes groups in the Semi-arid Woodlands and Arid Shrublands formations, which are dominated by species rare in our classification analysis dataset but represent eastern outliers of assemblages that occur extensively across western bioregions.

Table 20 Some examples of final retained groups within RCP10 mixed habitat specialist groups

Bioregion	Final retained group	PCT ID	PCT name	Vegetation class
Trans bioregional	R10.24	4026	Estuarine Sea Rush Swamp Oak Forest	Coastal Floodplain Wetlands
	R10.30	4000	Northern Estuarine Paperbark Sedge Forest	Coastal Swamp Forests
	R10.135	3960	Coast Sands Cladium Sedgeland	Coastal Freshwater Lagoons
	R10.46	3975	Southern Lower Floodplain Freshwater Wetland	Coastal Freshwater Lagoons
	R10.22	4091	Grey Mangrove-River Mangrove Forest	Mangrove Swamps
	R10.54	4097	Samphire Saltmarsh	Saltmarshes
	R10.47	3410	Spinifex Strandline Grassland	Maritime Grasslands
	R10.38	3932	Central and Southern Tableland Swamp Meadow Complex	Montane Bogs and Fens
	R10.227	n/a	(draft) Lower Slopes and Plains Coolabah-Lignum-Eleocharis Wetlands	Inland Riverine Forests
NSW North Coast	R10.22a	4140	Far North Mangrove Forest	Mangrove Swamps
	R10.141	3856	Woodenbong Plugs Rocky Scrub	Northern Montane Heaths
	R10.11	3457	Curricabark Serpentinite Mallee Spinifex Scrub	Northern Gorge Dry Sclerophyll Forests
NSW North Coast and New England Tablelands	R10.52	3052	Northern Escarpment Antarctic Beech Rainforest	Cool Temperate Rainforests
	R10.114	3944	New England Tableland Carex Fens	Montane Bogs and Fens
New England Tablelands	R10.196a	3846	Tenterfield Plateau Kunzea Scrub	Northern Montane Heaths
Sydney Basin	R10.201	3916	Sandstone Cliff Soak	Coastal Heath Swamps
	R10.46a	3958	Castlereagh Gravel Sedgeland	Coastal Freshwater Lagoons

Bioregion	Final retained group	PCT ID	PCT name	Vegetation class
Sydney Basin and South East Corner	R10.53	4040	South Coast Selliera-Sea Rush Swamp Oak Saltmarsh	Saltmarshes
South Eastern Highlands	R10.208	3980	Southern Lacustrine Herbfield	Montane Lakes
Australian Alps	R10.57	3412	Kosciuszko Limestone Grassland	Temperate Montane Grasslands

7.2 Relationships between final retained groups and legacy classification units

We applied a focused effort in our classification processes to allow units from large plot-based legacy classification projects to survive in our final retained groups, but achieved only moderate success against this objective. Our measures suggest that 60–80% of well-defined (≥15 plots) legacy classification units from regional-level classification projects are likely to be recognisable in our final retained groups (see Table 7). This inference is based on the numbers of legacy classification units that share ≥70% of their member plots with a single final retained group (very strongly related) or with 2 final retained groups (strongly related).

This legacy relationship strength measure appears to be coarse, being based solely on shared member plots. It does not directly indicate the extent to which a final retained group reflects the floristic composition, environmental attributes and spatial distribution of a legacy classification unit; however, member plot assignments are the basic components of the compared legacy classification projects and the current classification, and thus ultimately govern group characteristics.

Broad patterns of relationship strength across different legacy classification projects relate to factors including classification scale, sampling coverage and completeness, and data inclusion standards.

Some divergence between the units of multiple separate legacy classification projects and a single comprehensive classification was inevitable given the wide range of classification scales applied by the various legacy projects. The south coast – Illawarra region legacy classification units of Tozer et al. (2010) had relatively high group variance, or floristic heterogeneity (see Figure 9), indicating greater acceptance of within-unit floristic variation. These units had the highest average number of member plots per unit of all analysed regional-level legacy classifications, and the lowest proportion of units defined by small numbers of member plots. In contrast, the classification approach of the Northern Rivers region project (OEH 2012) produced the most units of all assessed legacy classification projects, with relatively low group variance, and almost half of the units identified were defined by fewer than 5 member plots. That project explicitly included expert input steps to modify plot membership of types or to construct new types, with less reliance on standard floristic survey plot data.

Our classification applied a single classification scale. We had no objective means to choose any particular legacy classification project as a preferred approach from the wide spectrum of legacy scales covering different parts of our study area; our final retained groups sit towards the centre of the scale spectrum (see Figure 10). However, in relating legacy units to our final retained groups, the nature of the relationship strength measure used means that fine-scale legacy classification units defined by few plots are more likely to show strong relationships with final retained groups than broadly defined legacy classification units, which are more likely to have been broken up across final retained groups.

Local to sub-regional legacy classification projects and those focused on specific types of vegetation, such as north coast wallum (Griffith et al. 2003), the Cessnock–Kurri area (Bell & Driscoll 2007), the Tenterfield area reserves (Hunter 2000), Australian Alps treeless vegetation (McDougall & Walsh 2007) and the western Blue Mountains (DEC 2006), had 79–100% of their units very strongly or strongly related to final retained groups in the current study. The relatively high levels of retention of the units of these local to sub-regional and thematic studies may be related to their comparatively high sampling densities, finer scale of sampling stratification, or narrow focus on a single targeted environment.

Differences between legacy classification units and final retained groups are in part due to large increases in the number and distribution of available analysis plots in many of the regions covered by legacy classification projects. Classification units were relatively stable in parts of our study area where plot density was already relatively high, such as western Sydney and the north coast wallum heaths. In contrast, legacy classification units based on limited or biased past sample coverage are more likely to have been modified following the addition of many new analysis plots targeting previous gaps.

Our accumulated analysis dataset included at least 75% of all plots used in any of the compared legacy classification projects, but only 60% of our 51,000 analysis plots had previously been used in any legacy classification project and assigned to a legacy classification unit. The data context for our revised eastern NSW classification was therefore very different to all compared legacy classification projects, with a very large combined dataset that included large numbers of new and previously unclassified analysis plots, including many new plots from previously unsampled environments and assemblages.

Densities of plots that were available to regional legacy classification projects varied from 0.44 standard floristic survey plots per 1,000 ha on the south coast and tablelands (Gellie 2005) up to 10 plots per 1,000 ha in the Sydney metropolitan area (OEH 2012), and as high as 25 plots per 1,000 ha in the local study of Tenterfield area reserves (Hunter 2000). All of the areas over which regional legacy classification projects applied have since had additional investment in vegetation field survey, with significantly more plot data now available across the study areas of older projects. For example, across the south coast – Illawarra study area of Tozer et al. (2010), roughly 4,559 additional analysis plots (a 56% increase) were available to the current project; 5,394 additional plots were available (a 109% increase) across the greater Hunter region of Sivertsen et al. (2011); and 3,494 more plots (a 61% increase) were available in the Northern Rivers region of OEH (2012).

Another source of change between legacy units and our final retained groups relates to a general tendency for types to be relatively poorly defined at or near study area boundaries. These edge areas will commonly include environmental envelopes (and vegetation types) that extend beyond a study area boundary, and the few samples available for classification from edge areas may not reveal the full distinctiveness found across the complete distribution of the envelope/type. With our study area overlapping and extending beyond the boundaries of a large number of legacy classification study areas (including some gaps not previously classified) (see Figure 3), there was a relatively high potential for change as the classified plot data from the legacy units and located near boundaries was cast into a much broader context. Of course, our very large study area has its own boundaries; however, these are significantly less than the combined total of all of the incorporated legacy study area boundaries.

For some legacy classification units, differences in classification outcomes will also have been influenced by differing data inclusion standards between those applied by legacy projects and the current study. Legacy classifications sometimes leveraged non-standard data to address shortfalls in available standard data, often in particular environments;

however, our standards generally rejected such data. In some cases we replaced the rejected samples with new additional standard floristic survey plots, but our classification results did not readily replicate the legacy units that had been defined by a significant proportion of non-standard samples.

The current study also applied some other differences in data treatments to those used by legacy classification projects. Although our development of a taxonomic treatment began with various assignments applied by legacy classification projects as a starting point, from these we developed a treatment to be applied across all of eastern NSW and included accepted changes in taxonomic understanding of various plant groups that had occurred in intervening time periods. Another difference applied to around 3,000 plots on the north coast that had been used in the analysis of OEH (2012), for which we identified that original data had been recorded in 2 subplots. We retrieved the subplot separation from original data sources and applied it in BioNet, allowing us to reduce the potential influence of larger plot sizes on clustering outcomes.

Based on our secondary objective, the clustering strategy applied in this study sought to maximise the potential for legacy classification units to be retained from the commencement of the analysis. The wide variation in legacy classification scales made some change inevitable, and our initial classification scale was more likely to impact legacy classification units with relatively high levels of floristic heterogeneity. Some of those units were partially retrieved by our iterative approach, which dissolved starting clusters where they failed to satisfy our threshold tests for floristic and environmental separation from related clusters. The strategy we employed also explicitly included environmental data at the earliest stages of the analysis through the partitioning of RCPs based on species–environment relationships across all of eastern NSW. This approach allowed construction of a classification using subsets of data representing greater floristic and environmental homogeneity than was possible for the bioregional study areas that underpinned the larger legacy classification projects. For example, we analysed assemblage patterns across all subalpine environments, rather than a bioregion subset of subalpine environments being combined with subsets of tableland and escarpment environments. The inclusion of environment data in the construction and evaluation of candidate groups also provided an independent means to evaluate the fidelity of member plots to a group’s position on environmental gradients, and to identify potential outliers independent of the clustering based on floristic composition alone.

The very large geographic area covered by our classification provides a new state-level data context that overcomes many of the limitations in developing a single set of types from the previous patchwork of multiple separate regional legacy classifications. As discussed above, each project applies abrupt boundaries to the understanding of plant assemblages, even those where buffers were applied to study areas. These issues are compounded where legacy study areas overlapped, so sample data was used to define alternative classification units from competing classification sources. Some 6,974 plots in our classification analysis dataset had been assigned by more than one legacy classification project, with some individual plots used in the definitions of up to 4 different units in separate legacy projects.

Although our classification resolves problems related to overlapping boundaries of previous regional legacy classification projects in eastern NSW, it does of course have its own boundaries, so that similar ‘edge’ and ‘overlap’ issues will need to be considered across the western edge of our study area, and if applying our final retained groups to continental-scale classifications across state jurisdictional boundaries.

7.3 Future stability of our classification groups

As new standard floristic survey plots in the eastern NSW study area are added to the Flora surveys module of the BioNet Atlas application over time they will be periodically audited, subject to the same review and classification methods described above, and where possible assigned to an existing, or where appropriate new, PCT (see Section 8.3). This will include targeted sampling of previously poorly sampled areas and assemblages.

No typology is strictly 'future-proof', and the addition of new data always has the potential to change a classification, particularly in situations where overall sampling density is relatively low or uneven. Areas of high sample density tend to be more stable to the addition of new data. The multiple iterations of adding new data during our analysis process has indicated that groups with more than about 20 member plots tend to be robust to new data and only a small proportion of previous assignments would change. Groups with placeholder status are more likely to have changes in plot membership in the future.

We examined environmental gradients using our RCP analysis, which provided the initial data partitions representing major discontinuities in combined floristic and environmental patterns. Our experience with the addition of new data accrued during the course of the project suggests this classification framework is relatively robust to new data.

For the classification of individual groups, we considered gradients in the context of the most floristically and environmentally similar groups.

Some improvement in the stability of classification groups to addition of new plot data might potentially be expected by including consideration of environmental gradient space in the recognition and definition of new groups. However, our observations during analyses suggest that available environmental predictors alone are not always sufficient for group definition. Recognition of clusters along environmental gradients can be context-dependent and complex at the scale of groups dealt with here, and relationships between vegetation patterns and available environmental covariates are not always certain.

8. Conclusions

8.1 Summary

Past vegetation classification in eastern NSW has developed as a patchwork of separate and overlapping legacy classification projects. The current project has effectively replaced these sources with a single seamless classification of all available standard floristic survey plot data across coast, tableland and western slopes bioregions.

This approach has become possible due to a combination of factors:

- a centralised, flexible and accessible database of floristic survey plot data, now representing a very valuable accumulation of data from many thousands of past surveys
- an accessible and largely stable plant taxonomy in NSW widely applied by field surveyors
- improvements in the scale and accuracy of environmental covariate spatial data
- improvements in data analysis software.

This revised classification of native vegetation assemblages of eastern NSW has identified 1,205 final retained groups across a combined study area of 10 IBRA bioregions, including 1,067 coast and tablelands groups and 138 western slopes groups.

This new classification offers considerable advantages over legacy classification projects for identifying a unified and comprehensive set of vegetation types of eastern NSW. These include:

- a move from more than 10 separate classifications (with overlaps and gaps) to a single classification
- a move from over 10 separate methods and classification scales, to a single consistent approach
- a single classification removes any need for additional interpretation to be applied in creating a single unified coverage
- the new classification takes advantage of significant improvements in sampling coverage and density compared to all legacy classification projects, with the potential to identify new types not previously sampled and described and to improve definition and description of known types
- the new classification includes identification and correction of errors in a substantial amount of plot data that had been used by past classifications in uncorrected form
- the new classification is entirely based on plot data stored in the Flora surveys module of the BioNet Atlas application, which is publicly available online
- the plot assignments to groups (plot membership) of the new classification are explicit and publicly accessible
- the descriptions of groups, including floristic composition, structure, distribution and environmental range, are based on those explicit member plot assignments.

Our primary objective in this work was to classify and describe native plant community types of eastern NSW at a consistent level (plant association), with the types identifiable based on full-floristic species composition and other features. The final retained groups identified by this classification work are proposed as revised PCTs for eastern NSW, and the first stage of incorporating these groups into the PCT master list for coast and tablelands bioregions is described by DPE (2022b). An online tool, known as the ‘Plot to PCT Assignment Tool’, has been developed to allow users to compare new standard floristic survey plots against final retained groups using floristic data and other features of these groups (see DPE 2022c). At the time of publication of this paper the tool can only be used for coast and tablelands groups, but will be updated to include western slopes groups in later stages of development.

8.2 A new online tool for identifying plant communities

A robust and repeatable diagnosis of PCTs is a primary task for many users of the NSW vegetation classification typologies. To date, biodiversity assessment methods have promoted the collection of standard floristic survey data, but have had no accompanying method to guide the assignment of collected plots to best-fitting PCTs. It has been a subjective and complex task. Manual matching of floristic and environmental attributes for more than a handful of communities simultaneously is difficult, and some users have relied on a few simple floristic attributes, such as dominant canopy species, to guide selections. The problem was exacerbated by some Approved PCT (2018) typological information that provided limited descriptions or only partial inventory of the assemblage.

We have constructed a web-based tool to provide a more objective, quantitative approach to diagnosing PCTs using methods that mirror those applied to our classification revisions (see DPE 2022c). The tool requires the upload of standard floristic survey plot data exported from the Flora surveys module of the BioNet Atlas application using purpose-built functions. On upload to the tool, automated data checks identify any missing data and flag any misalignment with the taxonomic treatment applied in the eastern NSW classification. K-means clustering algorithms evaluate similarity between the species assemblage of each uploaded plot and the centroids of each final retained group in a single step, returning the Bray–Curtis distance to centroid value for up to 10 closest matching groups. As at October 2021 the tool can only be used for the 1,067 coast and tablelands groups, but will be updated to include western slopes groups in later stages of development. The tool allows users to interrogate each matched group individually, through links to detailed descriptions and species summary data including median cover–abundance scores, frequency of occurrence and species growth form group. Reference member plot locations for each group may be compared to the locations of the uploaded plots, and group choice data selected within the map viewer. The degree of fit for each group choice can also be assessed by evaluating the environmental domain for each matched group (using elevation, annual mean temperature and mean annual rainfall) against those variables at the uploaded plot locations. Plots are most plausibly matched to groups that record the strongest floristic compositional similarity metrics, and matching environmental domains. The floristic matching metrics, environmental domain assessments, and corresponding PCT data are downloadable from the tool in tabular form.

8.3 Maintenance schedules and new PCT development

The plot-based eastern NSW PCT classification will be subject to a maintenance cycle that aims to ensure the PCT master list, and PCT data, retains currency and is responsive to new information in a timely way. The maintenance cycle will result in new member plots being added to PCT definitions where they satisfy compositional and environmental thresholds. Where new standard floristic survey plots are outside thresholds for existing groups, they will be evaluated and assessed as to whether they represent new types that are candidates for addition to the PCT master list. PCTs with placeholder status, and regions with comparatively sparse analysis plot data, will be a focus for the collection of new standard floristic plots as resources allow.

We expect submission to the Flora surveys module of standard floristic survey plot data arising from biodiversity assessment and surveys will increase with improvements in mobile data collection options and the continued legislative mandate for the collection of standard quantitative data to support land-use decisions.

9. Glossary

Term	Definition
BioNet	The NSW biodiversity data repository administered by DPE
BioNet Vegetation Classification public application	The application (user interface) where public users can access the PCT master list and PCT summary data
BioNet Vegetation Classification edit application	The application (user interface) where DPE staff undertake edits to the PCT master list and PCT data. PCT data is published from the edit application to the public application
Flora surveys module of the BioNet Atlas application	The application (user interface) where users can access and edit flora survey data in the Systematic Surveys data collection
PCT	Plant community type. The finest level of classification in the NSW vegetation classification hierarchy
PCT master list	The cumulative set of PCTs in the BioNet Vegetation Classification applications, including 'PCT definition status' of Approved, Draft-Working, Decommissioned
Approved PCT (2018)	An Approved PCT in the BioNet Vegetation Classification public application on 1 November 2018
Draft-Working PCT (2018)	A Draft-Working PCT in the BioNet Vegetation Classification edit application on 7 November 2018
legacy classification project	Any previous classification effort, some of which have been cited by Approved PCTs (2018)
legacy classification unit	A unit (type) defined by a legacy classification project. Unit(s) may be cited by Approved PCTs (2018). Units may be plot-based or qualitative
cited classification project	A classification project cited by PCT(s) in the BioNet Vegetation Classification application fields ‘classification source’, ‘profile source’, and ‘full reference details’
cited classification unit	The individual classification units in the original classification project cited by the PCT
standard floristic survey plot	A plot that represents a search of a bounded area, usually in the range of 400–1,000 m^2, within which all vascular plants are identified to the finest taxonomic level possible, with standardised estimates made of the abundance and projected foliage cover of each taxon present, and where those estimates can be reliably converted to a common cover–abundance scale of modified Braun-Blanquet (BB) cover–abundance 1–6. This includes plots that follow the survey standards defined by Sivertsen (2009)
supplementary floristic survey plot	A plot completed using bounded area methods within which all vascular plants are identified to the finest taxonomic level possible, but the species abundance/frequency estimates are non-standard (i.e. are presence/absence OR only allow approximate conversion to a common cover–abundance scale of modified Braun-Blanquet (BB) cover–abundance 1–6. Plot size is fixed, but in some cases is smaller or larger than the 400 m^2 standard

Term	Definition
analysis plot	A plot included in the eastern NSW analysis set. Comprises ‘standard floristic survey plots’ and ‘supplementary floristic survey plots’, excluding those situated in highly disturbed environments, sampled in seasons unsuitable for target vegetation, or dominated by incomplete identifications (genus-only ‘spp.’ records)
rejected sample	A sample that does not meet the standards for inclusion as an ‘analysis plot’ in this study
group	A set of analysis plots that comprise the defined membership of a plant assemblage pattern following cluster analysis
final retained groups	The set of groups retained (i.e. not retired/dismembered) in the final classification in this study. Comprises ‘coast and tablelands groups’ and ‘western slopes groups’
coast and tablelands group	A final retained group that has one or more plots located within any of the coast and tablelands bioregions. These groups have become ‘ENSW v1.1 groups’
western slopes group	A final retained group that does not have any plots located within the coast and tablelands bioregions, as at 29 September 2021
member plot	A plot that is part of the defined membership of a group or a legacy classification unit
Primary member plot	A plot that has a distance to centroid value to its member group of 0.695 or less. These plots are entered into BioNet with a ‘PCT assignment category’ of Primary. An exception is non-woody freshwater wetland groups, some of which include some Primary member plots that have greater than 0.695 distance to centroid value to their member group
Secondary member plot	A plot that has a distance to centroid value to its member group of greater than 0.695. These plots are entered into BioNet with a ‘PCT assignment category’ of Secondary
RCP	A set of plots that have relative homogeneity in species composition and that can be predicted by environmental variables. RCPs (regions of common species probability profile) are identified by modelling plot x species data as a function of environmental variables. This study identified 9 RCPs across eastern NSW, labelled RCP1, RCP2…RCP9. A remainder set of plots was labelled RCP10 for convenience
eastern NSW	Parts of NSW that fall within one of the following 10 IBRA v7 bioregions (DAWE 2021): the Australian Alps, New England Tablelands, NSW North Coast, South East Corner, South Eastern Highlands, South Eastern Queensland, Sydney Basin, Brigalow Belt South, Nandewar and NSW South Western Slopes. ‘Eastern NSW’ is comprised of the ‘coast and tablelands bioregions’ and the ‘western slopes bioregions’. Note that although plot data from the Australian Capital Territory was included and classified, the PCT classification does not apply under ACT legislation
coast and tablelands bioregions	Parts of NSW that fall within one of the following 7 IBRA v7 bioregions (DAWE 2021): the Australian Alps, New England Tablelands, NSW North Coast, South East Corner, South Eastern Highlands, South Eastern Queensland, Sydney Basin

Term	Definition
western slopes bioregions	Parts of NSW that fall within one of the following 3 IBRA v7 bioregions (DAWE 2021): Brigalow Belt South, Nandewar and NSW South Western Slopes
eastern NSW PCT classification v1.1	The new PCT classification for the coast and tablelands bioregions, published in BioNet in June 2022 (see DPE 2022b)
eastern NSW PCT classification v1.1 region	The area over which the eastern NSW PCT classification v1.1 applies, being the coast and tablelands bioregions
ENSW v1.1 groups	The set of 1,067 final retained groups, representing native plant assemblages, defined by analysis plots within the eastern NSW PCT classification v1.1 region (coast and tablelands bioregions)
eastern NSW PCT classification v1.2	Future version of the quantitative PCT classification that will include types in the western slopes bioregions (i.e. will cover all 10 bioregions in eastern NSW)

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11. More information

- BioNet
- BioNet Atlas application
- BioNet Vegetation Classification
- BioNet Vegetation Classification public application
- Bush Fire Environmental Assessment Code
- Flora surveys module
- NSW Biodiversity Offsets Scheme
- NSW Integrated BioNet Vegetation Data
- PlantNet
- Australian Plant Name Index

Appendix A Summary of the data types used during data preparation stages to categorise flora survey samples held in the Flora surveys module of the BioNet Atlas application

Data type	General description of data type
Type 1a	Bounded 400 m^2 systematic full-floristic plots with species importance estimates that can be reliably transformed to a common cover–abundance (CA) scale (modified Braun-Blanquet (BB) CA 1–6)
Type 1b	Bounded 400 m^2 systematic full-floristic plots, but records either **presence/absence** or species importance estimates that only provide approximate comparison to BB CA 1–6. Examples include scoring methods applying fewer than 6 classes or estimates of cover (%) only
Type 2a	Plots completed using systematic full-floristic, bounded-area methods, with scoring system convertible to BB CA 1–6 scale, but fixed plot size is **smaller** or **larger** than the standard 400 m^2 search area, e.g. north coast state forest plots of 20 m x 50 m; treeless alpine 5 m x 5 m plots
Type 2b	Plots completed using systematic full-floristic, bounded-area methods, but fixed plot size is **smaller** or **larger** than the standard 400 m^2 search area **and** either records **presence/absence** or species importance estimates that only provide approximate comparison to BB CA 1–6; examples as for Type 1b
Type 1x	As for 1a/b, but plots situated in highly disturbed environments, or sampled in seasons unsuitable for target vegetation, or dominated by incomplete identifications (genus-only 'spp.' records)
Type 2x	As for 2a/b, but plots situated in highly disturbed environments, or sampled in seasons unsuitable for target vegetation, or are dominated by incomplete identifications (genus-only 'spp.' records)
Type 3	Full-floristic samples, with scoring system convertible to BB CA 1–6 scale, which are of a defined area but **not of a fixed size** – especially whole-wetland samples, e.g. Monaro lakes, north coast floodplain wetlands
Type 4	Random meander or transect or polygon lists – attempts to characterise the vegetation of a particular mapping polygon/ stratification unit/environmental domain or other field-interpreted area
Type 5	Partial floristics – commonly involves either a list of dominant canopy tree species and tall shrubs (for API validation work), or list of dominants in each stratum (U, M, L) plus an attempt to assign a PCT or other pre-determined classification unit. Examples include field observations using rapid assessment of vegetation characteristics within unspecified search areas

Appendix B Transformations applied to convert species importance scores to a common scale

Equivalence transformations were applied to convert species importance score values from various original (as recorded) cover–abundance scales to a common 6-point modified Braun-Blanquet scale (BB CA 1–6) for use in analysis. These transformations were applied to standard floristic survey data when exporting from the Flora surveys module of the BioNet Atlas application.

A subset of plots were identified as 'alternative CA' data, as their original scales could only loosely be transformed to the chosen BB CA 1–6 scale.

Note that this table shows only those species importance score methods used by surveys that were identified as standard floristic survey data or alternative CA data and accepted for inclusion in our analyses.

	Species importance score method in the Flora surveys module	Cover–abundance scores and meaning					
Common BB CA 1–6 scale	**Cover 1 to 6**	**1: present and uncommon**	**2: common and up to 5% cover**	**3: up to 20% cover**	**4: up to 50% cover**	**5: up to 75% cover**	**6: over 75% cover**
Standard floristic survey data scales	Cover 1 to 6 (a)	1: present and uncommon	2: common and up to 5%	3: up to 25%	4: up to 50%	5: up to 75%	6: >75%
	Cover 1 to 7	1: 1 or few individuals and up to 5%	2: uncommon, up to 5%; 3: common and up to 5%	4: very common and up to 5% OR up to 20%	5: ≤50%	6: ≤75%	7: >75%
	Cover 1 to 7 (a)	1: rare, erratic, well below 5%; 2: occasional up to 5%	3: common and up to 5%	4: up to 25%	5: up to 50%	6: up to 75%	7: >75%
	Cover 1 to 7 (c)	1: <5% rare/few individuals; 2: <5% uncommon	3: <5%, common; 41: <5%, very abundant	42: 5–25%	5: 25–50%	6: 50–75%	7: 75–100%

	Species importance score method in the Flora surveys module	Cover–abundance scores and meaning					
Common BB CA 1–6 scale	**Cover 1 to 6**	**1: present and uncommon**	**2: common and up to 5% cover**	**3: up to 20% cover**	**4: up to 50% cover**	**5: up to 75% cover**	**6: over 75% cover**
	Cover 1 to 7 (d)	1: <5% cover and <4 plants; 2: <5% cover and uncommon	3: <5% cover and common	4: 5–19%	5: 20–49%	6: 50–74%	7: 75–100%
	Cover 1 to 7 (e)	1: up to 5% and rare or few individuals; 2: up to 5%, uncommon	3: up to 5%, common; 41: up to 5%, very abundant	42: 5–20%	5:20–50%	6:50–75%	7:75–100%
	Cover 1 to 7 (f)	1: rare, up to 5%	2: common, up to 5%	3: 6–15%; 4: 16–25%	5: 26–50%	6: 51–75%	7: 76–100%
	Cover 1 to 7 (g)	1: rare, erratic, well below 5%; 2: occasional, up to 5%	3: common and up to 5%	4: up to 20%	5: up to 50%	6: up to 70%	7: >70%
	Cover 1 to 8	1: rare	2: occasional; 3: common but less than 5%; 4: very common but less than 5%	5: 5–25%	6: 26–50%	7: 51–75%	8: 76–100%
	Cover 1 to 8 (a)	1:<5%, <6 ind.	2:<5%, 6–20 ind.; 3:<5%, 21–100 ind.; 4: <5%, >100 ind.	5: 5–25%	6: 26–50%	7: 51–75%	8: 76–100%
	Cover 5 to 9 Hunter councils (modified)	51: <5% rare	52: <5%, uncommon to abundant	6: 5–25%	7: 25–50%	8: 50–75%	9: 75–100%

	Species importance score method in the Flora surveys module	Cover–abundance scores and meaning					
Common BB CA 1–6 scale	**Cover 1 to 6**	**1: present and uncommon**	**2: common and up to 5% cover**	**3: up to 20% cover**	**4: up to 50% cover**	**5: up to 75% cover**	**6: over 75% cover**
	Cover 1 to 10 (a)	1: <1% cover;	2: 1–5%	3: 5–10%; 4: 10–15%; 5: 15–25%	6: 25–33%; 7: 33–50%	8: 50–75%	9: 75–99%; 10: 100%
	Species actuals	0–5%, <6 ind.	0–5%, 6+ ind.	5.1–25%	25.1–50%	50.1–75%	75.1–100%
Alternative CA data scales	Cover 1 to 5	1: up to 5%	–	2: up to 20%	3: up to 50%	4: up to 75%	5: >75%
	Cover 1 to 5 (a)	1:<2%	2: 2–10%	3:10–25%	4:25–50%	5: 50–100%	–
	Cover 1 to 6 (b)	1: up to 1%	2: up to 5%	3: up to 25%	4: up to 50%	5: up to 75%	6: >75%
	Cover 1 to 6 (c)	1: 1 to 5%	–	2: 6 to 25%	3: 26 to 50%	4: 51 to 75%	5: 76 to 95%

Appendix C Environmental predictor variable grids included in analyses

Grid label	Description of variable	Units	Reference source
ce_radhp_f	Highest period radiation (bio21) – the largest radiation estimate for all weeks	Wm2	Generated using ANUCLIM (Xu & Hutchinson 2011)
ce_radlp_f	Lowest period radiation (bio22) – the lowest radiation estimate for all weeks	Wm2	
ce_radseas_f	Radiation seasonality: coefficient of variation (bio23) – the standard deviation of the weekly radiation estimates expressed as a percentage of the mean of those estimates (i.e. the annual mean)	C of V	
ct_temp_maxsum_f	Average daily max temperature – summer	°C	Australian Bureau of Meteorology (BoM)
ct_temp_maxwin_f	Average daily max temperature – winter	°C	
ct_temp_minwin_f	Average daily min temperature – winter	°C	
ct_temp_minsum_f	Average daily min temperature – summer	°C	
fltm2_ann	Mean annual number of days with a minimum temperature below –2°C	days/year	
ct_tempann_f	Annual mean temperature (bio1)	°C	Generated using ANUCLIM (Xu & Hutchinson 2011)
ct_tempannrnge_f	Temperature annual range: difference between bio5 and bio6 (bio7)	°C	
ct_tempdiurn_f	Mean diurnal range (mean(period max–min)) (bio2)	°C	
ct_tempiso_f	Isothermality 2/7 (bio3)	unitless	
ct_tempmtcp_f	Min temperature of coldest period (bio6)	°C	
ct_tempmtwp_f	Max temperature of warmest period (bio5)	°C	
cw_clim_etaaann_f	Average areal actual evapotranspiration – annual	mm	BoM
cw_clim_etapann_f	Average areal potential evapotranspiration – annual	mm	
cw_precipann_f	Average annual precipitation (bio12)	mm	Generated using ANUCLIM (Xu & Hutchinson 2011)
cw_precipdp_f	Precipitation of driest period (bio14)	mm	
cw_precipseas_f	Precipitation of seasonality: coefficient of variation (bio15)	C of V	
cw_precipwp_f	Precipitation of wettest period (bio13)	mm	
cw_rain_sumwin_f	Average rainfall – summer–winter ratio	mm	Derived from BoM
cw_rainspr_f	Average rainfall – spring	mm	BoM
cw_rainsum_f	Average rainfall – summer	mm	
d_coast_disa_f	Distance from NSW east coast	m	Generated from NSW
d_flooded	Distance (Euclidean) from seasonally flooded waterbodies	m	

Grid label	Description of variable	Units	Reference source
d_permwater	Distance (Euclidean) from permanent waterbodies	m	Office of Water data
d_strahler19	Euclidean distance to 1st order streams and above	m	Derived from NSW Office of Water data
d_strahler29	Euclidean distance to 2nd order streams and above	m	
d_strahler49	Euclidean distance to 4th order streams and above	m	
d_strahler69	Euclidean distance to 6th order streams and above	m	
gp_k_fillspl_f	Filtered potassium (K), gaps filled in using geographically weighted regression model and spline function	pct	Geoscience Australia
gp_th_fillspl_f	Filtered thorium (Th), gaps filled in using geographically weighted regression model and spline function	ppm	
gp_u_fillspl_f	Filtered uranium (U), gaps filled in using geographically weighted regression model and spline function	ppm	
lf_aspect_tr_f	Beer's aspect – transformation of aspect to a continuous scaled variable. Changed for the southern hemisphere by setting maximum value (2) to SE slopes (coolest) and minimum (0) to NW slopes (warmest)	index	Derived 1 sec SRTM
lf_cti_f	Compound topographic index or CTI also known as wetness index, topographic wetness index. Based on DEM-H (for flow direction and accumulation)	index	Derived 1 sec SRTM
lf_curv_f	Curvature or slope of the slope: defines concave, convex and flat. A positive curvature indicates the surface is upwardly convex at that cell. A negative curvature indicates the surface is upwardly concave at that cell. A value of 0 indicates the surface is flat	index	
lf_curv_prof_f	Curvature in profile (the direction of the maximum slope)	index	
lf_dems1s_f	Elevation in metres above sea level – 1 sec SRTM smoothed DEM (DEM-S)	m	SRTM – GeoScience Australia
lf_exp315_f	Exposure to the NW (low = exposed (drier forests); high = sheltered (moister forests))	index	Ashcroft & Gollan (2012)
lf_logre10_f	Cold air drainage	index	
lf_rough0100_f	Neighbourhood topographical roughness based on the standard deviation of elevation in a circular 100 m neighbourhood. Derived from DEM-S	index	Derived 1 sec SRTM – GeoScience Australia

Grid label	Description of variable	Units	Reference source
lf_rough0500_f	Neighbourhood topographical roughness based on the standard deviation of elevation in a circular 500 m neighbourhood. Derived from DEM-S	index	
lf_rough1000_f	Neighbourhood topographical roughness based on the standard deviation of elevation in a circular 1,000 m neighbourhood. Derived from DEM-S	index	
lf_slope_deg_f	Slope in degrees. Derived from DEM-S	degrees	
lf_tpi0120_f	Topographic position index using neighbourhood of 120 m radius	index	
lf_tpi0250_f	Topographic position index using neighbourhood of 250 m radius	index	
lf_tpi0500_f	Topographic position index using neighbourhood of 500 m radius	index	
lf_tpi1000_f	Topographic position index using neighbourhood of 1,000 m radius	index	
lf_tpi2000_f	Topographic position index using neighbourhood of 2,000 m radius	index	
sw_weath_index_f	A weathering intensity index using airborne gamma-ray spectrometry and digital terrain analysis	index	Wilford (2012)
defAnnual	Annual evapotranspiration deficit (ETD) is the difference between PET (potential evapotranspiration) and AET (actual evapotranspiration).	mm	Tozer et al. (2017) derived from spatial models of observational data (BoM; Dyer 2009)
aetAnnual	Actual evapotranspiration (AET), a function of precipitation, radiation and water storage capacity of the soil based on texture and depth, represents the available water supply. AET correlates strongly with net primary production	mm	
filsurplusAnn	Annual surplus is the amount of rainfall in excess of the requirements for both evapotranspiration and soil moisture recharge	mm	
cw_prescott_f	Prescott index	index	CSIRO SLGA release Aug. 2016

Ashcroft MB and Gollan JR (2012) 'Fine-resolution (25 m) topoclimatic grids of near-surface (5 cm) extreme temperatures and humidities across various habitats in a large (200 × 300 km) and diverse region', *Int J Climatol*, 32:2,134–2,148.

BoM – Australian Bureau of Meteorology, Gridded climate data, www.bom.gov.au/climate/averages/climatology/gridded-data-info/gridded-climate-data.shtml.

CSIRO Soil and Landscape Grid of Australia, www.clw.csiro.au/aclep/soilandlandscapegrid.

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NSW Office of Water – hydro line spatial data, www.industry.nsw.gov.au/water/licensing-trade/hydroline-spatial-data.

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Gallant J, Dowling T, Read A, Wilson N, Tickle P and Inskeep C (2011) *1 Second SRTM-Derived Digital Elevation Models User Guide*, Geoscience Australia, Canberra, www.ga.gov.au/products/servlet/controller?event=GEOCAT_DETAILS&catno=72759.

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Note that many of the above grids are available from:
https://datasets.seed.nsw.gov.au/dataset/svtm-modelling-grid-collection

Appendix D Testing and selecting an algorithm for clustering within RCPs

We tested 6 different clustering algorithms using subsets of the legacy classification units from Northern Rivers region (NRR) (OEH 2012) and South Coast – Illawarra region (SCIVI) (Tozer et al. 2010) against a set of 10 evaluation measures. The subsets included both small (1,676 plots in 28 communities for NRR, 1,300 plots in 28 communities for SCIVI) and larger subsets of data (7,326 plots in 285 communities and 8,217 plots in 176 communities, respectively). We compared the results of the clustering algorithms to the legacy classifications for the same subsets of data in each of these classification schemas. For all comparisons we used the same number of groups as there are communities in the legacy classification for the data. In all cases we used a Bray–Curtis dissimilarity measure.

The clustering algorithms tested were hierarchical agglomerative with flexible UPGMA (Belbin 1995), several non-hierarchical methods including centroid (ALOC (Belbin 1995), optpart (Roberts 2015)) and medoid-based methods, fuzzy non-hierarchical clustering (De Cáceres et al. 2010) with legacy classification as fixed groups, and Chameleon clustering (Karypis et al. 1999). To compare the results we selected 10 evaluation measures based on the results and discussion in Aho et al. (2008) and Roberts (2015), including both community (also known as geometric) and species (non-geometric) measures, the latter including model-based evaluation (Lyons et al. 2016). We compared the cluster composition of selected methods with communities defined by the legacy classification using the Goodman–Kruskal lambda index (Goodman & Kruskal 1979). Except for a single non-hierarchical method that used the ‘ALOC’ module in PATN (Belbin 1995), all methods and evaluation were done using functions and scripts in R (R Core Team 2020).

There is no single evaluation measure to be preferred on theoretical considerations and all measure different characteristics of clustering results. Our results suggest that no single clustering method performed best across all measures and that the various clustering methods performed similarly, within a narrow range compared to the theoretical range of the evaluation measures. We found that the non-hierarchical centroid-based algorithms gave the best results overall if evaluated by community measures, that medoid-based methods performed poorly compared to all other methods, and that hierarchical classifications gave slightly better results than non-hierarchical methods in relation to some measures of diagnostic species. However, we found that species-based measures were more difficult to interpret and global measures may not readily translate to ease of diagnosis of vegetation types.

Based on the Goodman–Kruskal lambda index, no single method was clearly best at reproducing legacy classification units with the data subsets that we used. All methods provided a similar degree of correspondence between composition of clusters and composition of legacy units, of approximately 0.6. This included cases where the method was equivalent to that used in deriving the legacy classification units. Much of the discordance was due to one-to-many or many-to-one relationships among clusters rather than unstructured differences in composition. We attributed the relatively low correspondence to a changed context (subsets of data), and to post-clustering subjective modifications to group composition to derive legacy units.

In respect of our objectives, non-hierarchical methods have the advantage of more readily accommodating new data with minimal disruption to the initial classification. We selected a non-hierarchical centroid-based method, using the ALOC module in PATN, as the basis for our clustering strategy. This method was consistently among the best performers for most of the evaluation measures we used. It also aligned with the secondary project objective of minimising disruption to existing PCTs based on legacy classification units. It was at least as effective as alternative methods in the extent to which it reproduced legacy classification units (as measured by Goodman-Kruskal lambda index) and a number of legacy classification projects had applied a similar k-means hierarchical method in development of their groups.

Appendix E Removal of plot overlap between initial groups

Following initial group review, we applied a process to remove plot overlap between extended RCPs.

Overlap between extended RCPs existed in 2 forms. Approximately 20% of plots had been included in more than one RCP, resulting from our approach to minimise the potential loss of legacy classification information through the RCP data partition (as described in Section 4.2). A proportion of plots also had their closest centroid in a group other than their initially assigned RCP. Both of these situations were regarded as RCP overlap plots.

To ensure each plot had only one assignment, and that it was assigned to the RCP with the closest group centroid, the following series of steps, consistent with the method used by ‘ALOC’ (Belbin 1995), was implemented using scripts in R:

1. For all overlap plots, plot by plot, remove each plot from the data, recalculate centroids and distance to centroid values, then assign the plot to its closest centroid across all groups in the combined set of RCPs, to give each plot a single assignment.
2. Use assignments from step 1 to recalculate centroids and distances for all groups and all plots and assign each plot to its closest revised centroid. This changed assignments for some plots that were not RCP overlap plots, because it compared to revised centroids.
3. Exclude plots for which the smallest distance to centroid value is >0.695 (2,627plots), recalculate centroids based on remaining plots, then assign plots to closest ‘cleaned’ centroids. This resulted in 489 reassignments from step 2.

Appendix F Provision for formation of new groups from the addition of new and ‘noise’ plot data

Analysis round 2 involved the addition of 2,356 new plots to the analysis dataset, including 1,241 new GAP_EAST plots resulting from (i) gap analysis and targeted sampling of poorly sampled and high land-use pressure landscapes (including focus on private lands), and (ii) targeted sampling of thematic gaps where previous surveys had used non-standard methods (Floyd rainforest random meander transects, south coast littoral rainforests, Jervis Bay sand deposits). New plots were exported from BioNet through the standard taxonomic assignment and added to the classification analysis dataset.

The addition of these new plots included provision for the potential formation of new groups. Of the 2,356 plots, most were assigned to an existing group because they were within the threshold distance to centroid value (Bray–Curtis dissimilarity value of ≤0.695); however, 438 plots had their closest distance to any of the previously defined centroids greater than our threshold (>0.695) for Primary membership of a group, and at least some of these potentially represented previously unsampled new groups. We clustered these plots using the same threshold (radius 0.78) as for our initial clustering and defined 143 groups, many of which were singleton or comprised few plots. We then reviewed each of these potential new groups, differentiated and labelled as RCP11 groups for convenience.

New groups were reviewed using the same methods applied to the review of initial groups, based on principles of environmental consistency, floristic distinctiveness from related groups and consideration of observer and disturbance artefacts. However, review did not include consideration of legacy assignments, which did not exist for these new data. Some 52 of the groups were retained or modified as new groups, but 44 of these comprised one or few plots and were given placeholder status. Assignments to these new groups were then added to the data and the distance to centroid values to all groups (both previous and new) calculated for all the new plots, which were then assigned to the group with closest centroid. This resulted in 779 of the new plots being reassigned, in many cases to one of the new groups. This result was consistent with the focus of new sampling in previously unsampled or undersampled environments, such as Tweed valley and other coastal valley lowlands, where we expected that new groups would exist.

Approximately 3,400 plots that had been set aside as potential ‘noise’ in earlier steps were also reintroduced to the analysis dataset in round 2. This included 1,658 plots set aside due to minimum pairwise dissimilarity above the 95th percentile for the plot’s RCP, and 1,746 plots classed as RCP10 leftovers. These were assigned in the same iterative process used for previous assignments, involving assign to closest group centroid, review, redefine centroids and check assignments; however, in this case we considered it much less likely that sets of plots would define new groups. For the plots that exceeded our threshold value for distance to revised centroids following addition of the new data, we chose to review individual plot assignments as a more efficient method of review (rather than clustering these plots and then reviewing a large number of small, heterogeneous or singleton clusters). In this review, we assigned above-threshold plots to new placeholder groups if they sampled distinct or otherwise unsampled environments. Our assessment in this case was subjective because there were insufficient data for analysis.

Appendix G Calculation of group accuracy and reliability

Calculation of group accuracy and reliability values was based on Primary member plots at the completion of each review round, with input data being all Primary member plots assigned to groups with ≥15 Primary member plots. These data were sampled with replacement and the duplicates removed. This was repeated with 10 different samples. If a sample had any group with <5 plots, it was rejected and a new sample taken. The sample in each case was approximately 65% of all Primary member plots. For each sample these plots were used to calculate new centroids, and accuracy and reliability were estimated by assigning the remaining plots (approx. 35%) to these new centroids and comparing with original assignments. From the set of 10 random samples, define ‘A’ as the mean number of all plots in the target group that have their closest distance to the centroid of that group and for which d≤0.695. These are the plots that would be correctly diagnosed as belonging to the group using closest distance only. Define ‘B’ as the mean number of plots of the target group that have their closest distance to the centroid of a different group. These are the plots that would be incorrectly diagnosed as belonging to a different group using closest distance only. If d>0.695 for the target group, the plot is counted as not being assigned to the target group for that sample and is added to B. Define ‘C’ as the mean number of plots for which the closest distance to centroid is for the target group and is ≤0.695, but which are assigned to other groups. These are the plots that would be incorrectly assigned to the target group at the threshold. ‘Accuracy’ is defined as the proportion of all plots in the target group that are correctly diagnosed at the threshold (A/(A+B)) and ‘reliability’ defined as the proportion of all plots that meet the threshold that belong to the target group (A/(A+C)). These are equivalent to 1-‘error of omission’ and 1-‘error of commission’, respectively.

Appendix H Evaluation of final retained groups in relation to environmental factors

Following completion of round 4 review of groups and plot assignments, we undertook an evaluation of the environmental characteristics of the final retained groups. We first made a systematic assessment of the extent to which each of the 54 environmental factors was useful for discriminating among groups within an RCP. As a measure of discrimination between 2 groups, for each environmental factor we used a simple descriptive statistic, the ratio of the absolute value of the difference in medians to the maximum interquartile range for the factor for either of the 2 groups. If this ratio >1, the 2 groups overlap by no more than 25% in values of that factor, so ratios >1 suggest the factor is potentially useful in discriminating between 2 groups. To assess each environmental factor, we calculated the proportion of all possible pairwise comparisons within each RCP (excluding same-group pairs) that had a ratio >1. We used this proportion as a measure of how likely it is for the RCP that the factor could discriminate between any 2 groups. We also calculated this proportion using only pairs of floristically closely related groups within an RCP, as a measure of the extent to which an environmental factor could discriminate among any 2 floristically closely similar groups. We chose environmental factors with consistently high proportions across multiple RCPs as those that were most useful for characterising and evaluating group environmental relationships. For each group and each of our chosen factors, we defined environmental outliers as values either greater than 3 x (third quartile-median) above the third quartile or less than 3 x (median-first quartile) below the first quartile. This is similar to the commonly used outlier criterion of 1.5 x interquartile range above and below the third and first quartiles respectively, except that it allows for highly skewed distributions. We evaluated groups based on the proportion of outliers for each environmental factor and we checked extreme outlier plots for possible reassignment.

Appendix I Most frequent species of tree, shrub and ground cover plants recorded in plots assigned to each of 9 RCPs

Each species name is followed by the frequency of occurrence of that species within plots assigned to the RCP.

RCP10 is not included here because it does not have a distinct floristic character; it consists of plots that could not be satisfactorily assigned to one of the 9 RCPs, and represents widely variable floristic assemblages whose distribution is tied to factors not included in the RCP model inputs.

RCP	Trees	Shrubs	Ground
RCP1	*Eucalyptus tereticornis* (0.34), *Corymbia maculata* (0.25), *Allocasuarina torulosa* (0.25), *Eucalyptus crebra* (0.21), *Eucalyptus moluccana* (0.2), *Eucalyptus fibrosa* (0.18), *Eucalyptus punctata* (0.14), *Angophora floribunda* (0.14), *Alphitonia excelsa* (0.13), *Eucalyptus eugenioides* (0.13) and *Eucalyptus siderophloia* (0.12)	*Bursaria spinosa* (0.42), *Breynia oblongifolia* (0.34), *Persoonia linearis* (0.22), *Acacia implexa* (0.19), *Daviesia ulicifolia* (0.17), *Leucopogon juniperinus* (0.15), *Ozothamnus diosmifolius* (0.14), *Lissanthe strigosa* (0.13), *Notelaea longifolia* (0.13), *Denhamia silvestris* (0.13), *Eremophila debilis* (0.13), *Jacksonia scoparia* (0.13), *Indigofera australis* (0.12), *Rubus parvifolius* (0.11), *Exocarpos cupressiformis* (0.11), *Acacia falcata* (0.11), *Hibbertia obtusifolia* (0.11) and *Phyllanthus hirtellus* (0.1)	*Microlaena stipoides* (0.61), *Cheilanthes sieberi* subsp. *sieberi* (0.6), *Themeda triandra* (0.57), *Lobelia purpurascens* (0.57), *Dichondra repens* (0.54), *Glycine clandestina* (0.52), *Desmodium varians* (0.51), *Cymbopogon refractus* (0.49), *Aristida vagans* (0.44), *Entolasia stricta* (0.44), *Lomandra multiflora* subsp. *multiflora* (0.44), *Vernonia cinerea* (0.43), *Imperata cylindrica* (0.36), *Lomandra filiformis* (0.35) and *Lomandra longifolia* (0.35)
RCP2	*Callitris endlicheri* (0.41), *Eucalyptus macrorhyncha* (0.24), *Eucalyptus crebra* (0.2), *Eucalyptus rossii* (0.16), *Eucalyptus fibrosa* (0.14), *Corymbia trachyphloia* (0.13), *Angophora floribunda* (0.13) and *Eucalyptus blakelyi* (0.11)	*Hibbertia obtusifolia* (0.48), *Brachyloma daphnoides* (0.46), *Melichrus urceolatus* (0.43), *Leucopogon muticus* (0.3), *Calytrix tetragona* (0.25), *Styphelia triflora* (0.22), *Persoonia linearis* (0.21), *Cassinia sifton* (0.2), *Phyllanthus hirtellus* (0.19), *Dodonaea viscosa* (0.18), *Lissanthe strigosa* (0.18), *Platysace ericoides* (0.17), *Acacia buxifolia* (0.15), *Monotoca scoparia* (0.13), *Persoonia sericea* (0.12), *Astroloma humifusum* (0.11), *Pimelea linifolia* (0.11), *Acacia penninervis* (0.11) and *Grevillea floribunda* subsp. *floribunda* (0.11)	*Lomandra filiformis* (0.54), *Cheilanthes sieberi* subsp. *sieberi* (0.47), *Pomax umbellata* (0.46), *Dianella revoluta* (0.45), *Lomandra multiflora* subsp. *multiflora* (0.45), *Goodenia hederacea* (0.44), *Lepidosperma laterale* (0.31), *Aristida ramosa* (0.3), *Rytidosperma pallidum* (0.29), *Microlaena stipoides* (0.28), *Dichelachne micrantha* (0.25), *Hardenbergia violacea* (0.25), *Poa sieberiana* (0.24) and *Gonocarpus tetragynus* (0.23)

RCP	Trees	Shrubs	Ground
RCP3	*Eucalyptus campanulata* (0.57), *Allocasuarina littoralis* (0.27), *Banksia integrifolia* (0.25), *Allocasuarina torulosa* (0.2), *Eucalyptus cameronii* (0.19), *Eucalyptus obliqua* (0.19), *Eucalyptus caliginosa* (0.19), *Eucalyptus brunnea* (0.18), *Eucalyptus radiata* (0.16), *Eucalyptus saligna* (0.15) and *Eucalyptus microcorys* (0.12)	*Leucopogon lanceolatus* (0.67), *Rubus parvifolius* (0.42), *Lomatia silaifolia* (0.32), *Hibbertia obtusifolia* (0.24), *Polyscias sambucifolia* (0.24), *Calochlaena dubia* (0.2), *Monotoca scoparia* (0.2), *Podolobium ilicifolium* (0.16), *Persoonia oleoides* (0.14), *Acacia falciformis* (0.14), *Acacia filicifolia* (0.13), *Denhamia silvestris* (0.13), *Acacia irrorata* (0.12), *Indigofera australis* (0.12), *Bossiaea neo-anglica* (0.12), *Melichrus urceolatus* (0.11), *Hakea eriantha* (0.11) *and Persoonia linearis* (0.1)	*Pteridium esculentum* (0.76), *Lomandra longifolia* (0.7), *Poa sieberiana* (0.68), *Desmodium varians* (0.6), *Viola betonicifolia* (0.58), *Imperata cylindrica* (0.58), *Hardenbergia violacea* (0.54), *Dianella caerulea* (0.53), *Glycine clandestina* (0.52), *Lobelia purpurascens* (0.48), *Themeda triandra* (0.48), *Microlaena stipoides* (0.4), *Poranthera microphylla* (0.39), *Geranium solanderi* (0.39), *Gonocarpus tetragynus* (0.38), *Billardiera scandens* (0.37) *and Lepidosperma laterale* (0.36)
RCP4	*Eucalyptus dalrympleana* (0.18), *Acacia melanoxylon* (0.18), *Eucalyptus pauciflora* (0.18), *Eucalyptus viminalis* (0.15), *Eucalyptus radiata* (0.14), *Eucalyptus macrorhyncha* (0.14), *Eucalyptus dives* (0.13), *Eucalyptus cypellocarpa* (0.12) and *Eucalyptus fastigata* (0.11)	*Hibbertia obtusifolia* (0.27), *Acacia dealbata* (0.26), *Leucopogon lanceolatus* (0.23), *Rubus parvifolius* (0.18), *Bursaria spinosa* (0.15), *Coprosma quadrifida* (0.14), *Cassinia aculeata* (0.12), *Monotoca scoparia* (0.11), *Cassinia longifolia* (0.11), *Melichrus urceolatus* (0.11), *Acacia falciformis* (0.11), *Lomatia myricoides* (0.11), *Exocarpos strictus* (0.11), *Acrotriche serrulata* (0.11) and *Persoonia linearis* (0.1)	*Poa sieberiana* (0.53), *Lomandra longifolia* (0.5), *Microlaena stipoides* (0.49), *Pteridium esculentum* (0.45), *Hydrocotyle laxiflora* (0.45), *Gonocarpus tetragynus* (0.42), *Glycine clandestina* (0.38), *Dichondra repens* (0.37), *Acaena novae-zelandiae* (0.35), *Poranthera microphylla* (0.34), *Geranium solanderi* (0.33), *Viola betonicifolia* (0.32), *Hypericum gramineum* (0.32), *Viola hederacea* (0.31), *Lomandra filiformis* (0.3), *Stellaria pungens* (0.29), *Desmodium varians* (0.28), *Clematis aristata* (0.27) and *Senecio prenanthoides* (0.25)
RCP5	*Acmena smithii* (0.51), *Guioa semiglauca* (0.32), *Cryptocarya microneura* (0.29), *Lophostemon confertus* (0.28), *Syncarpia glomulifera* (0.23), *Cryptocarya glaucescens* (0.23), *Doryphora sassafras* (0.23), *Archontophoenix cunninghamiana* (0.22), *Livistona australis* (0.22), *Schizomeria ovata* (0.2), *Diploglottis australis* (0.2), *Eucalyptus microcorys* (0.2), *Allocasuarina torulosa* (0.19), *Caldcluvia paniculosa* (0.19), *Ceratopetalum apetalum* (0.18), *Eucalyptus saligna* (0.18), *Acacia melanoxylon* (0.16), *Sarcopteryx stipata* (0.15), *Alphitonia excelsa* (0.14), *Polyosma cunninghamii* (0.13) and *Polyscias elegans* (0.12)	*Synoum glandulosum* subsp. *glandulosum* (0.45), *Pittosporum multiflorum* (0.4), *Eupomatia laurina* (0.33), *Wilkiea huegeliana* (0.31), *Breynia oblongifolia* (0.31), *Trochocarpa laurina* (0.28), *Psychotria loniceroides* (0.27), *Calochlaena dubia* (0.27), *Pittosporum undulatum* (0.27), *Ficus coronata* (0.26), *Pittosporum revolutum* (0.26), *Notelaea longifolia* (0.25), *Elaeocarpus reticulatus* (0.25), *Diospyros australis* (0.23), *Cyathea australis* (0.22), *Myrsine variabilis* (0.22), *Cordyline stricta* (0.22), *Cryptocarya rigida* (0.22), *Neolitsea dealbata* (0.21), *Alectryon subcinereus* (0.21) and *Rhodamnia rubescens* (0.21)	*Smilax australis* (0.62), *Gynochthodes jasminoides* (0.56), *Geitonoplesium cymosum* (0.48), *Cissus hypoglauca* (0.47), *Blechnum cartilagineum* (0.46), *Pandorea pandorana* subsp. *pandorana* (0.44), *Cissus antarctica* (0.43), *Blechnum neohollandicum* (0.41), *Gymnostachys anceps* (0.37), *Eustrephus latifolius* (0.37), *Dioscorea transversa* (0.36), *Pseuderanthemum variabile* (0.35), *Lomandra longifolia* (0.35) and *Parsonsia straminea* (0.35)

RCP	Trees	Shrubs	Ground
RCP6	*Callitris glaucophylla* (0.35), *Eucalyptus albens* (0.25), *Brachychiton populneus* (0.21), *Angophora floribunda* (0.16), *Eucalyptus melliodora* (0.14), *Eucalyptus blakelyi* (0.13), *Eucalyptus crebra* (0.13), *Eucalyptus melanophloia* (0.1) and *Eucalyptus dealbata* (0.1)	*Notelaea microcarpa* (0.37), *Olearia elliptica* subsp. *elliptica* (0.23), *Pimelea neo-anglica* (0.2), *Dodonaea viscosa* (0.19), *Hibbertia obtusifolia* (0.17), *Melichrus urceolatus* (0.17), *Swainsona galegifolia* (0.16), *Cassinia quinquefaria* (0.13), *Geijera parviflora* (0.13), *Eremophila debilis* (0.12), *Bursaria spinosa* (0.12), *Acacia deanei* (0.11), *Maireana microphylla* (0.1) and *Acacia implexa* (0.1)	*Aristida ramosa* (0.54), *Cheilanthes sieberi* subsp. *sieberi* (0.5), *Austrostipa scabra* (0.48), *Cymbopogon refractus* (0.45), *Desmodium varians* (0.43), *Dichondra repens* (0.37), *Glycine tabacina* (0.36), *Desmodium brachypodum* (0.34), *Lomandra multiflora* subsp. *multiflora* (0.32), *Microlaena stipoides* (0.32), *Oxalis perennans* (0.31) and *Cyperus gracilis* (0.31)
RCP7	*Allocasuarina littoralis* (0.37), *Angophora costata* (0.35), *Corymbia gummifera* (0.34), *Syncarpia glomulifera* (0.21), *Eucalyptus piperita* (0.19), *Eucalyptus punctata* (0.17), *Eucalyptus pilularis* (0.17), *Allocasuarina torulosa* (0.17), *Eucalyptus globoidea* (0.14), *Eucalyptus sieberi* (0.14), *Banksia serrata* (0.13), *Eucalyptus agglomerata* (0.12) and *Angophora floribunda* (0.11)	*Persoonia linearis* (0.55), *Phyllanthus hirtellus* (0.35), *Leucopogon lanceolatus* (0.33), *Podolobium ilicifolium* (0.26), *Pimelea linifolia* (0.26), *Platysace lanceolata* (0.25), *Acacia ulicifolia* (0.25), *Banksia spinulosa* (0.24), *Acacia longifolia* (0.24), *Lomatia silaifolia* (0.22), *Dodonaea triquetra* (0.22), *Persoonia levis* (0.21), *Polyscias sambucifolia* (0.2), *Leptospermum trinervium* (0.2) and *Elaeocarpus reticulatus* (0.2)	*Entolasia stricta* (0.73), *Dianella caerulea* (0.7), *Lomandra longifolia* (0.56), *Billardiera scandens* (0.55), *Pteridium esculentum* (0.54), *Lepidosperma laterale* (0.51), *Themeda triandra* (0.4), *Hardenbergia violacea* (0.37), *Imperata cylindrica* (0.36), *Lomandra multiflora* subsp. *multiflora* (0.34), *Microlaena stipoides* (0.34), *Pomax umbellata* (0.34) and *Glycine clandestina* (0.32)
RCP8	*Corymbia gummifera* (0.48), *Banksia serrata* (0.35), *Angophora costata* (0.26), *Allocasuarina littoralis* (0.24), *Eucalyptus piperita* (0.23), *Eucalyptus sieberi* (0.17), *Eucalyptus haemastoma* (0.13) and *Ceratopetalum gummiferum* (0.12)	*Leptospermum trinervium* (0.64), *Banksia spinulosa* (0.49), *Pimelea linifolia* (0.48), *Persoonia levis* (0.48), *Hakea dactyloides* (0.45), *Lambertia formosa* (0.42), *Platysace linearifolia* (0.41), *Isopogon anemonifolius* (0.37), *Monotoca scoparia* (0.37), *Acacia suaveolens* (0.36), *Acacia ulicifolia* (0.34), *Phyllanthus hirtellus* (0.34), *Dillwynia retorta* (0.33) and *Lomatia silaifolia* (0.32)	*Entolasia stricta* (0.66), *Lomandra obliqua* (0.42), *Dampiera stricta* (0.42), *Patersonia sericea* (0.35), *Cyathochaeta diandra* (0.35), *Lomandra glauca* (0.34), *Billardiera scandens* (0.34), *Lepidosperma laterale* (0.33), *Lepyrodia scariosa* (0.33), *Cassytha glabella* (0.32) and *Pteridium esculentum* (0.31)
RCP9	*Allocasuarina torulosa* (0.37), *Syncarpia glomulifera* (0.24), *Angophora floribunda* (0.19), *Eucalyptus microcorys* (0.16), *Eucalyptus pilularis* (0.14), *Corymbia maculata* (0.13), *Eucalyptus acmenoides* (0.11) and *Eucalyptus saligna* (0.11)	*Breynia oblongifolia* (0.52), *Rubus parvifolius* (0.29), *Notelaea longifolia* (0.27), *Pittosporum undulatum* (0.25), *Persoonia linearis* (0.24), *Pittosporum revolutum* (0.24), *Calochlaena dubia* (0.23), *Polyscias sambucifolia* (0.22), *Myrsine variabilis* (0.22), *Elaeocarpus reticulatus* (0.21), *Glochidion ferdinandi* (0.2), *Indigofera australis* (0.18), *Leucopogon lanceolatus* (0.17), *Denhamia silvestris* (0.16) and *Acacia irrorata* (0.15)	*Lomandra longifolia* (0.66), *Dianella caerulea* (0.62), *Eustrephus latifolius* (0.55), *Pteridium esculentum* (0.53), *Oplismenus imbecillis* (0.51), *Lobelia purpurascens* (0.5), *Glycine clandestina* (0.5), *Geitonoplesium cymosum* (0.49), *Desmodium varians* (0.48), *Imperata cylindrica* (0.46), *Microlaena stipoides* (0.46), *Dichondra repens* (0.46), *Pandorea pandorana* subsp. *pandorana* (0.41), *Smilax australis* (0.36) and *Entolasia stricta* (0.36)

Appendix J Summary environmental covariate data from plots assigned to each RCP

See Appendix C for explanation of variables.

RCP	Measure	Elevation (m asl)	Topographic roughness index for a 1,000 m neighbourhood	Ratio of average summer–winter rainfall	Annual precipitation (mm/annum)	Winter average daily minimum temperature (°C)	Annual evapo-transpiration deficit	Annual actual evapo-transpiration	Prescott index (water balance)	Mean annual frost days (min temp≤–2°C)
R1	max	1,066	203	3.70	2,227	10.51	730	1,419	2.42	29.55
R1	mean	223	38	2.07	956	4.98	290	984	0.92	1.87
R1	median	143	24	1.94	910	5.16	257	961	0.88	0.12
R1	min	0	1	0.95	578	–0.47	–14	177	0.51	0.00
R2	max	1,484	162	2.96	1,282	7.92	839	1,235	1.44	64.59
R2	mean	605	30	1.61	714	2.08	527	728	0.66	10.72
R2	median	569	23	1.69	696	2.15	544	718	0.64	8.19
R2	min	128	1	0.44	446	–2.73	100	470	0.39	0.00
R3	max	1,491	183	3.41	1,896	4.73	528	1,301	2.58	34.46
R3	mean	1,036	55	2.32	1,062	2.07	245	1,043	1.13	13.41
R3	median	1,034	47	2.31	1,039	2.11	252	1,047	1.09	14.05
R3	min	433	8	1.18	800	–0.46	9	749	0.76	0.20
R4	max	2,222	202	3.09	2,701	5.36	805	1,278	4.41	126.54
R4	mean	992	49	1.06	1,026	–0.27	226	892	1.14	32.40
R4	median	981	43	1.06	959	0.18	204	904	1.03	22.32
R4	min	194	1	0.42	510	–5.34	15	522	0.46	0.00
R5	max	1,439	221	3.50	2,636	11.42	594	1,570	2.98	40.85
R5	mean	304	53	1.93	1,394	6.25	111	1,188	1.38	1.56

RCP	Measure	Elevation (m asl)	Topographic roughness index for a 1,000 m neighbourhood	Ratio of average summer–winter rainfall	Annual precipitation (mm/annum)	Winter average daily minimum temperature (°C)	Annual evapo-transpiration deficit	Annual actual evapo-transpiration	Prescott index (water balance)	Mean annual frost days (min temp≤–2°C)
R5	median	189	46	1.96	1,346	6.44	92	1,201	1.34	0.03
R5	min	0	0	0.84	692	–0.32	–28	146	0.62	0.00
R6	max	1,246	168	3.35	1,177	5.97	907	1,144	1.19	74.89
R6	mean	478	28	1.73	670	2.69	600	693	0.59	9.21
R6	median	425	20	1.84	665	2.88	612	693	0.58	6.86
R6	min	39	0	0.50	397	–2.97	88	422	0.28	0.03
R7	max	1,301	216	3.27	2,642	11.46	616	1,553	3.24	30.04
R7	mean	212	32	1.51	1,149	6.13	179	1,056	1.12	0.83
R7	median	87	23	1.41	1,125	6.97	155	1,072	1.08	0.00
R7	min	0	0	0.82	649	–0.13	–25	198	0.60	0.00
R8	max	1,281	181	3.04	2,469	11.36	581	1,500	2.64	32.31
R8	mean	264	27	1.51	1,165	6.06	161	1,083	1.14	1.17
R8	median	144	22	1.43	1,166	6.56	156	1,103	1.15	0.00
R8	min	0	1	0.82	687	–0.58	–26	183	0.66	0.00
R9	max	1,343	183	3.65	2,293	11.45	711	1,536	2.46	47.68
R9	mean	249	44	1.69	1,143	5.53	178	1,064	1.12	1.39
R9	median	150	37	1.55	1,129	5.89	155	1,091	1.09	0.03
R9	min	0	0	0.82	586	–1.57	–26	156	0.51	0.00
R10	max	1,525	178	3.19	2,651	11.34	910	1,528	3.17	75.05
R10	mean	170	16	1.52	1,172	6.76	178	1,001	1.13	2.64
R10	median	3	8	1.39	1,178	7.82	149	1,101	1.12	0.00
R10	min	0	0	0.57	410	–2.84	–28	195	0.28	0.00

Appendix K Number of final retained groups, from each of 10 RCPs, assigned to NSW vegetation classes and formations (sensu Keith 2004)

Vegetation class	RCP										Total
	1	2	3	4	5	6	7	8	9	10	
Vegetation formation: Rainforests											
Subtropical Rainforests					24						**24**
Northern Warm Temperate Rainforests					20				1		**21**
Southern Warm Temperate Rainforests					3						**3**
Cool Temperate Rainforests				1	4					4	**9**
Dry Rainforests	2				35	4			12		**53**
Western Vine Thickets						8					**8**
Littoral Rainforests					13				2		**15**
Vegetation formation: Wet Sclerophyll Forests (Shrubby sub-formation)											
North Coast Wet Sclerophyll Forests	2				33		1		10		**46**
South Coast Wet Sclerophyll Forests				1	1		3		13		**18**
Northern Escarpment Wet Sclerophyll Forests					8		1		2		**11**
Southern Escarpment Wet Sclerophyll Forests	2			10	1				8		**21**
Vegetation formation: Wet Sclerophyll Forests (Grassy sub-formation)											
Northern Hinterland Wet Sclerophyll Forests	8				6		2	1	30		**47**
Southern Lowland Wet Sclerophyll forests					1		4		5		**10**
Northern Tableland Wet Sclerophyll Forests			7	4		1			2		**14**
Southern Tableland Wet Sclerophyll Forests				14					1		**15**
Montane Wet Sclerophyll Forests				4					1		**5**
Vegetation formation: Grassy Woodlands											
Coastal Valley Grassy Woodlands	17	1				1	1		5		**25**
Tableland Clay Grassy Woodlands			1	9		2					**12**

Vegetation class	RCP										Total
	1	2	3	4	5	6	7	8	9	10	
New England Grassy Woodlands		2		3		7					**12**
Southern Tableland Grassy Woodlands		1		10		1					**12**
Subalpine Woodlands				7							**7**
Western Slopes Grassy Woodlands				1		27			1		**29**
Floodplain Transition Woodlands						7					**7**
Vegetation formation: Grasslands											
Maritime Grasslands	1						2		1	3	**7**
Temperate Montane Grasslands				2		3				1	**6**
Western Slopes Grasslands						5					**5**
Riverine Plain Grasslands						2					**2**
Semi-arid Floodplain Grasslands						2					**2**
Vegetation formation: Dry Sclerophyll Forests (Shrub/grass sub-formation)											
Clarence Dry Sclerophyll Forests	10								1		**11**
Hunter-Macleay Dry Sclerophyll Forests	8					1	7				**16**
Cumberland Dry Sclerophyll Forests	1										**1**
Southern Hinterland Dry Sclerophyll Forests				4					1		**5**
Northern Gorge Dry Sclerophyll Forests	13		1			2			1	1	**18**
Central Gorge Dry Sclerophyll Forests	10	6		2		2	2		6		**28**
New England Dry Sclerophyll Forests			8						1		**9**
North-west Slopes Dry Sclerophyll Woodlands	2	7				22					**31**
Upper Riverina Dry Sclerophyll Forests		5		5		3					**13**
Pilliga Outwash Dry Sclerophyll Forests		6				8					**14**

Vegetation class	RCP										Total
	1	2	3	4	5	6	7	8	9	10	
Vegetation formation: Dry Sclerophyll Forests (Shrubby sub-formation)											
Coastal Dune Dry Sclerophyll Forests	2				1		6	2	2		**13**
North Coast Dry Sclerophyll Forests							11	9			**20**
Sydney Coastal Dry Sclerophyll Forests		1					7	13			**21**
Sydney Hinterland Dry Sclerophyll Forests	2	2					14	10			**28**
Sydney Sand Flats Dry Sclerophyll Forests	2						1	6	1		**10**
South Coast Sands Dry Sclerophyll Forests							2		2		**4**
South East Dry Sclerophyll Forests		2		4	1		16	3	2		**28**
Southern Wattle Dry Sclerophyll Forests									3	1	**4**
Northern Escarpment Dry Sclerophyll Forests			5		1		3	2			**11**
Sydney Montane Dry Sclerophyll Forests		1		1			3	6			**11**
Northern Tableland Dry Sclerophyll Forests		28				7					**35**
Southern Tableland Dry Sclerophyll Forests		7		11							**18**
Western Slopes Dry Sclerophyll Forests	5	54				7					**66**
Yetman Dry Sclerophyll Forests		5				1					**6**
Vegetation formation: Heathlands											
Coastal Headland Heaths	1						1	5	3		**10**
Wallum Sand Heaths							1	7			**8**
Sydney Coastal Heaths								9			**9**
South Coast Heaths								3			**3**
Northern Montane Heaths	7	9	1	2	2	1	5	4	4	6	**41**
Sydney Montane Heaths		2				1		7			**10**
Southern Montane Heaths	2	6					2	1		1	**12**
Vegetation formation: Alpine Complex											
Alpine Heaths				4							**4**
Alpine Fjaeldmarks				2							**2**
Alpine Herbfields				7							**7**
Alpine Bogs and Fens				3							**3**

Vegetation class	RCP										Total
	1	2	3	4	5	6	7	8	9	10	
Vegetation formation: Freshwater Wetlands											
Coastal Heath Swamps	1						1	22	1	5	**30**
Montane Bogs and Fens	1	4	2	14			3	4		3	**31**
Coastal Freshwater Lagoons							2	1	1	20	**24**
Montane Lakes				1						3	**4**
Inland Floodplain Swamps										2	**2**
Inland Floodplain Shrublands						2				1	**3**
Vegetation formation: Forested Wetlands											
Coastal Swamp Forests					7		12	3	3	4	**29**
Coastal Floodplain Wetlands	6				5	1	3		19	6	**40**
Eastern Riverine Forests	3			3	6	6		2	7	2	**29**
Inland Riverine Forests		1				3				2	**6**
Vegetation formation: Saline Wetlands											
Mangrove Swamps					1					2	**3**
Saltmarshes										10	**10**
Vegetation formation: Semi-arid Woodlands (Grassy sub-formation)											
Inland Floodplain Woodlands						1					**1**
Riverine Plain Woodlands						4					**4**
Brigalow Clay Plain Woodlands						1					**1**
Vegetation formation: Semi-arid Woodlands (Shrubby sub-formation)											
North-west Alluvial Sand Woodlands						1					**1**
Inland Rocky Hill Woodlands		1				2					**3**
Subtropical Semi-arid Woodlands						2					**2**
Western Peneplain Woodlands						1					**1**
Sand Plain Mallee Woodlands										1	**1**
Vegetation formation: Arid Shrublands (Chenopod sub-formation)											
Riverine Chenopod Shrublands						3				1	**4**
Totals	**108**	**151**	**25**	**129**	**173**	**152**	**116**	**120**	**152**	**79**	**1,205**