DEPARTMENT OF PLANNING, INDUSTRY & ENVIRONMENT

Function Attribute Benchmarks for the Biodiversity Assessment Method

Data audit, compilation and analysis

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Cover photo: Remnants of logged trees covered in moss, Barrington Tops National Park. John Spencer/DPIE

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Contents

List of tables

List of figures

1. Background

The Biodiversity Assessment Method (BAM) is a key regulatory instrument of the *Biodiversity Conservation Act 2016* which took full effect on August 25, 2017. The BAM establishes a framework for evaluating the condition or 'integrity' of native vegetation at a site. Attributes measured at sites are compared to reference states or ‘benchmark’ values to determine their relative condition.

The use of benchmark values to assess vegetation condition has been a key feature of historical biodiversity assessment methods in New South Wales including the previously-used Native Vegetation Assessment Tool (NVAT) for the NSW Property Vegetation Planning System (BioMetric) and the BioBanking Assessment Method (BBAM). Development of the BAM involved the establishment of new evidenced-based benchmark data for measured attributes (OEH 2017).

2. Objectives

2.1 Evidence-based practice

Benchmark values underpinning previous systems are based largely on expert opinion. Values derived from subjective benchmarking processes have unknown confidence limits, are not open to scrutiny or testing and are not able to be improved or refined through targeted research.

In the last 25 years, independent vegetation studies conducted by multiple researchers have collected empirical data for attributes assessed by the BAM. Data from these past studies have the potential to provide quantitative evidence to justify benchmark values. This project aims to unlock the potential of this resource by gathering and evaluating data and assembling it into a standard form for analysis.

2.2 System improvement

BioNet is an existing central repository for data from various vegetation studies. BioNet provides both a source of data for calculating benchmarks but also a framework for evaluating and organising data newly discovered during the course of this project.

The BioNet data model operating prior to this project lacked the ability to capture, store or analyse some data necessary for calculating benchmarks. Additional database fields needed to enhance benchmarking capabilities have been identified by this project and are captured in ‘extension’ databases connected to BioNet.

This project will result in an organised information resource which is available for analysis now and into the future.

3. Scope

3.1 Function attributes

Attributes measured and scored by the BAM relate to three broad vegetation elements: composition, structure and function. This document is focused on data for the function attributes listed below (see Somerville et al. (2019) for composition and structure):

- Number of large trees
- Length of logs
- Litter cover
- Tree regeneration
- Tree stem size diversity

Only three of these attributes are directly compared to benchmark values in calculating the relative integrity or condition of a site: number of large trees, length of logs, and litter cover (Figure 1). Although tree stem size data is not a specific BAM input it is an important source of information for the development of diameter threshold values that define a 'large tree' in different vegetation types (Travers et al. 2018). Tree regeneration is a binary (yes/no) field in a BAM assessment and does not require a benchmark value.

3.2 Benchmark calculation level

The BAM aims to produce unique benchmark values for each attribute within each combination of Vegetation Class (Keith 2002, 2004) and IBRA7 Bioregion (ERIN 2012), termed a Regional Vegetation Class (RVC). Benchmark values for a total of 1710 such combinations have been provided. A complete list of Vegetation Classes and their modelled relative occurrence in Bioregions is provided in Appendix I.

Function attributes only apply to RVCs which contain a significant tree layer. This includes 68 Classes within 10 Formations described in NSW by Keith (2002, 2004) (Table 1). Although Heathlands are typically shrub dominated, four of the seven Heathlands Classes have a sufficient tree layer to justify the calculation of Function benchmarks.

As such, Function benchmarks have been generated for 1278 unique RVCs.

Table 1 Vegetation Formations and Classes in NSW

Formations for which Function benchmarks do not apply are shown in grey.

FID	Formation	Number of Classes
1	Rainforests	7
2	Wet sclerophyll forests (Grassy subformation)	5
3	Wet sclerophyll forests (Shrubby subformation)	4
4	Grassy woodlands	7
5	Dry sclerophyll forests (Shrub/grass subformation)	10
6	Dry sclerophyll forests (Shrubby subformation)	14
7	Semi-arid woodlands (Grassy subformation)	4
8	Semi-arid woodlands (Shrubby subformation)	9
9	Heathlands	4

FID	Formation	Number of Classes
10	Alpine complex	0
11	Grasslands	0
12	Freshwater wetlands	0
13	Forested wetlands	4
14	Saline wetlands	0
15	Arid shrublands (Acacia subformation)	0
16	Arid shrublands (Chenopod subformation)	0
	Total	**68**

4. Data compilation

4.1 Existing data

Prior to this project, the Flora surveys module of BioNet Atlas held a collection of approximately 6700 sites (Replicates) from 141 surveys with data on litter cover, woody debris (log) length, and/or stem sizes. Few sites contained data for all three attributes. The most common attribute recorded in the existing collection was woody debris length (46% of sites), followed by litter cover (36%) and stem sizes (28%).

4.2 New data

An audit commissioned by the Department in April 2016 identified a list of 22 datasets that potentially contained new Function attribute data (Peacock 2016). Initial discussions with custodians found that half of the identified datasets did not exist or were not available. Broadcast email requests sent to professional networks were an effective way of identifying additional data sources or potential leads to data sources. An additional 33 potential datasets were identified during the project and a complete list is provided in Appendix II.

4.3 Custodian contact and negotiation

A list of dataset custodians and/or contacts identified during this project are shown in Table 2. Efforts were made to contact custodians between July and December 2016 to determine the data availability, methods used for collection of Function attributes and any custodian-imposed conditions of use. Negotiations with custodians began 'from a position of data openness, with the prerogative in favour of data release, unless there is a specific, overriding reason for data not to be released' in accordance with the NSW Government's Open Data Policy.

Restrictions were imposed on three datasets shown in Table 3 that enables use by the BAM Benchmarking project but limits broader public release. Dataset security is implemented in BioNet Atlas and controlled by the BioNet Team.

Table 2 Custodians for Function attribute datasets identified during this project

Sector	Organisation	Contact name	Position
Consultant	Biolink Ecological Consultants	Stephen Phillips	Principal Consultant
	Eastcoast Flora Survey/University of Newcastle	Stephen Bell	Consultant/Conjoint Fellow
	Eco Logical Australia	Julian Wall	Principal Consultant
		Lachlan Copeland	Botanist
		Martin Stuart	Manager Coffs Coast
		Rob Humphries	Manager, BioBanking and Biocertification
	Umwelt Australia	Chris Allen	Principal Ecological Analyst
		Travis Peake	Practice Leader Ecology
	Vegetation Sciences Australia	Ross Peacock	Manager
Government	CSIRO Sustainable Ecosystems	Jacqui Stol	Senior Experimental Scientist
		Margaret Cawsey	Project Manager
	Department of Planning, Industry and Environment (Lands)	Brad Law	Principal Research Scientist, Forest Science
		Traecey Brassil	Technical Officer, Forest Science
		Caragh Threlfall	Research Officer
	Environmental Protection Agency NSW	Jacqui Miles	Manager, Strategic Regulation and Reform
		Michael Hood	Director
	Forestry Corporation of NSW	Mike Sutton	Manager, Forest Information and Planning
	Hunter Councils	Bradley Nolan	Director, Environment Division
	North West Local Land Services	Bronwyn Cameron	Team Leader, Strategic Land Services Systems
	Department of Planning, Industry and Environment	Chris Nadolny	Vegetation Ecologist (Northern Inland)
		Damon Oliver	Senior Team Leader – Threatened Species
		Dani Murphy	Environmental Scientist
		Daniel Connolly	Senior Team Leader
		Darren Shelly	Senior Threatened Species Officer
		Doug Binns	Senior Scientist
		Emma Gorrod	Principal Scientist
		Glenn Harpley	Senior Natural Resource Officer (Native Veg Systems)
		Grant Bywater	Principal Project Officer

Sector	Organisation	Contact name	Position
		Ian Oliver	Senior Team Leader
		James Val	Senior Scientist
		Jo White	Director, Science Strategy
		Karen Caves	Program Officer
		Krister Waern	Senior Operations Officer
		Maya Potapowicz	Flora Ecologist
		Megan McNellie	Senior Scientist
		Michael Somerville	Vegetation Scientist
		Miranda Kerr	Regional Biodiversity Conservation Officer
		Murray Ellis	Senior Scientist
		Peter Croft	NPWS Ranger
		Phil Wood	Senior Project Officer - BioBanking
	South East Local Land Services	Liz Clark	Senior Land Services Officer
University	Department of Planning, Industry and Environment/University of NSW	David Eldridge	Principal Scientist
	The Australian National University	Darren Le Roux	PhD Student
		David Freudenberger	Senior Lecturer
	The University of Adelaide	Anita Smyth	TERN Data Facilitator
	The University of New England	Caroline Gross	Professor
		John T Hunter	Associate Professor
		Michelle McKemey	PhD Student
	The University of New South Wales	Samantha Travers	Research Assistant
	The University of Sydney	Tina Bell	Associate Professor
	The University of Tasmania	David Bowman	Professor of Environmental Change Biology
		Jamey Furlaud	PhD Student
		Sam Wood	
	Western Sydney University	Matthias Boer	Associate Professor

Table 3 Datasets with restrictions imposed by custodian

Code	Title	Custodian	Restriction
D003	Private Native Forestry Biodiversity and Economic Outcomes Monitoring Study	Environmental Protection Agency NSW	Use by the BAM Benchmarking project only.
D034	Michelle McKemey PhD Sites NSW	Michelle McKemey	Temporary embargo placed on data release until 2020. Use by the BAM Benchmarking project permitted in the interim.
D035	Murrumbidgee Irrigation Area	The University of NSW (David Eldridge)/Murrumbidgee Irrigation	Use by the BAM Benchmarking project only.

5. Processing of new data

5.1 Formats

New data acquired by the project were in the form of hardcopy datasheets, excel spreadsheets and MS Access databases. Source files were stored in their original raw form in a project directory. Hardcopy datasheets were scanned and added to the digital file. Material associated with datasets including correspondence with custodians, raw data files, publications and derived information were organised into relevant folders on the project directory.

In some cases, data had previously been partly loaded into BioNet Atlas but Function attributes of interest to this project had been omitted from the record. Work was required to remediate existing BioNet Atlas data to make records complete.

5.2 Examination and evaluation

Datasets were examined to determine if they contained fields appropriate for direct upload into BioNet Atlas. Basic contextual data required by BioNet Atlas include location coordinates for sample quadrats and date of samples.

Cross checking also occurred to determine if data already existed in BioNet Atlas by matching site codes and location information.

Information on the survey methods was compiled to determine if methods were equivalent to those established by the Native Vegetation Interim Type Standard (Sivertsen 2009) (Table 4). Data generated by compatible methods can sometimes be transformed to comparable values for benchmark calculation; however, some assembled data were unusable because of incompatible collection methods.

5.3 Entry, manipulation and transformation

This process involved digitising data from hardcopy sheets or reports, organising data in spreadsheets to reduce data redundancy and improve integrity (normalisation), and/or transforming values to a standard metric (e.g. converting raw tree DBH values to counts per area within a size class).

A variety of tools were used for processing data including: MS Excel, MS Access, the BioNet Web Portal (Flora surveys module), stand-alone YETI databases, and ArcGIS.

5.4 Aggregation

Sample sites were allocated to a Bioregion and Vegetation Class. The bioregional occurrence of sample sites was derived from the geographical coordinates of the sample site. The Vegetation Class that sites were associated with were sometimes available from the source data. Some sites were allocated to Class through the State Vegetation Type Mapping Program and the State Vegetation Type Classification Program, as described by Somerville et al. (2019). Some sites were allocated to Vegetation Class as part of the Function Benchmark project through interrogation of vegetation data and/or contacting data custodians. Other sites were allocated to vegetation Formation or remained unallocated if insufficient information was available.

5.5 Archiving of source material

Once data had been uploaded to BioNet Atlas, the digital source material was transferred to a network location for longer term storage and management by the Biodiversity Information Systems Section of the Native Vegetation Information Science Branch.

Table 4 Function attribute survey methods

Attribute	Standard method (Sivertsen 2009)	BioNet field	Unit of measure	BioNet field type and validation	Biodiversity Assessment Method (BAM)
Number of trees with hollows	Estimated by counting the number of trees with hollows visible from the ground.	No. of trees with hollows	Count	Integer, 0-100.	20 x 50m plot (or equal to 1000m^2.)
Woody debris	Total length of woody material on the ground in the plot; >10 cm in diameter.	Woody debris	Length in metres	Integer	20 x 50 m plot
Litter cover	Two methods: 1. The per cent area of the plot covered by litter 2. Tally every 50 cm along the 50 m transect (100 points in total).	Liver cover	%	Integer	Average of five 1m^2 quadrats along centre line
Woody regeneration	Two measures are required: 1. The number of overstorey species regenerating (this includes shrubs when they comprise the overstorey) 2. Combined abundance of regenerating individuals (as per floristics sheet).	No. of upper stratum sp.	Count out of 100	Integer	20 x 50m plot (or equal to 1000m^2) (Presence/absence of regeneration only (stems <5cm DBH))
		Count	Count	Integer	
Woody stem sizes	Measured as diameter at breast height (DBH) – this is defined as the diameter of a tree at 1.37 m above the ground, measured from the high side of slope. Two options are available for recording this data:	5 <= Size < 10 - Count	Count	Integer	20 x 50m plot (or equal to 1000m^2) (Number of trees in stem classes)
		5 <= Size < 10 - Sizes	DBH in cm	Integer, multiple values with tab separator	
		10 <= Size < 20 - Count	Count	Integer	

Attribute	Standard method (Sivertsen 2009)	BioNet field	Unit of measure	BioNet field type and validation	Biodiversity Assessment Method (BAM)
	1. Measure and count the stems in each size class and record a total number of stems for each class; all stems over 30 cm DBH must be measured and recorded individually. 2. Measure and record the DBH of each tree in the plot individually (preferred).	10 <= Size < 20 - Sizes	DBH in cm	Integer, multiple values with tab separator	
		20 <= Size < 30 - Count	Count	Integer	
		20 <= Size < 30 - Sizes	DBH in cm	Integer, multiple values with tab separator	
		Size >= 30cm DBH - Count	Count	Integer	
		Size >= 30cm DBH - Sizes	DBH in cm	Integer, multiple values with tab separator	

6. Data structure and harmonisation

6.1 Flora surveys data structure

Within the Flora surveys module of BioNet Atlas, surveys are arranged as shown in Table 5. The finest scale used within the Function data is at the replicate level, i.e. no subplots were used. Replicates are stored in the Flora surveys module as individual site census level entries (i.e. with a unique identifier), with a field to indicate the replicate number.

Table 5 Structure of Function data within BioNet Atlas

Field	Description
Survey	Consistent methods that define how the basic components of the data are arranged.
Site	A specific location assessed by methods in the survey data.
Replicate	A time-distinct assessment conducted within a survey at a designated site. Temporally and spatially unique.
Subplot	Smaller spatial units of a site undertaken during a single replicate.

6.2 Constraints imposed by Flora surveys data model

The Flora surveys module follows criteria specified by the Native Vegetation Interim Type Standard (Sivertsen 2009). Data from some of the compiled studies do not conform to the Standard and incorporating these data into the Flora surveys module is problematic.

Four elements of the Flora surveys data model were found to limit the ability to store new Function data in the system:

- Fixed plot size of 0.04 ha for vegetative and non-vegetative (litter, bare ground and cryptogam) cover elements.
- Fixed plot size of 0.1 ha for trees with hollows and woody debris.
- Fixed stem size intervals – Four intervals: 5-10, 10-20, 20-30, 30+cm DBH.
- Inability to capture attributes at the ‘tree stem’ level (e.g. number of hollows in individual stems).

6.3 Typical variations from the Interim Type Standard

Common ways that data compiled for this project varied from the standard were found to include:

- Cover attributes assessed in a plot different to 0.04 ha.
- Cover attributes assessed by point-intercept method different to 50 m transect with 50 cm intervals.
- Plot size unique to attribute (litter, woody debris and trees with hollows attributes may each be assessed in a different sized plot).
- The number of stem size intervals differed.

- The break point between stem size intervals differed and could not be aligned to the standard.
- Valuable data available at the level of the ‘tree stem’ such as species.

6.4 General approach to non-standard data

Function attribute values that use the same units of measure (%, count, cm, m) were imported into existing Flora surveys fields even though the size of the plot or transect used varied from the Standard. Additional metadata descriptors were implemented for each attribute in an extension database (see Section 7.1) to enable standardisation of values between different surveys post entry.

6.5 Litter cover

The existing Flora surveys model allows for the measurement of litter cover through visual estimate of a fixed area plot or by point-intercept along a transect. Variation from the standard plot size or transect length is not catered for. However, as the final value is expressed as a percentage, litter cover data captured using alternate methods are comparable to existing Flora surveys data and can be inserted into the existing fields without applying any transformation.

Unlike other Function attributes, different replicates of litter cover (i.e. temporal re-surveys) were permitted within the same site. It was considered that litter cover had sufficient temporal variability for replicates from different years to be treated as independent data points.

Additional metadata fields have been added to describe the area of the plot or length of point-intersect transect used in the assessment.

6.6 Woody debris length

Although woody debris (length of logs) values collected from different sized plots often uses the same metric (metres) they are not directly comparable to existing data in this field.

Two options exist for storing this data (a) transform the values to fit the existing field, or (b) enter the original value and provide an additional metadata field to describe the plot size so that data can be transformed if needed. Option (b) was adopted as it retains the original form of the data. Additional metadata fields have been added to the Function extension database that: describe the area of the plot used to assess woody debris, and define a ‘log’, i.e. minimum diameter and minimum length measured.

Where multiple replicates of woody debris data were present at the same site, only replicate 1 was included in the dataset. It was considered that subsequent replicates were not sufficiently independent and may skew benchmark calculations. Replicate 1 was chosen as it allowed for the greatest number of data points (e.g. ‘control’ surveys prior to experimental activities).

6.7 Stem sizes intervals

Differences in the number of stem size intervals or break point between intervals make some data incompatible with the current structure.

A potential future complication is that the BAM has adopted a new system for recording woody stems in size class intervals as shown in Table 6.

Table 6 BAM woody stems in size class intervals

Type Standard (Sivertsen, 2009)	BAM
5-9 cm	5-9 cm
10-19 cm	10-19 cm
20-29 cm	20-29 cm
30+ cm	30-49 cm
	50-79 cm
	80+ cm

Unless new data conformed to the four intervals used by the Type Standard or contained individual DBH values then generally data could not be used by the project. This resulted in the main rejection of data.

For compatible data, additional metadata fields were added to the extension database that described the area of the plot used to assess stem sizes.

Where multiple replicates of stem size data were present at the same site, only replicate 1 was included in the dataset. It was considered that subsequent replicates were not sufficiently independent and may skew benchmark calculations. Replicate 1 was chosen as it allowed for the greatest number of data points (e.g. 'control' surveys prior to experimental activities).

6.8 Stem level attributes

Currently, the only attribute recorded by the Flora surveys module at the level of the stem is diameter at breast height (DBH).

The ability to record additional attributes at the stem level is needed and the following new fields have been implemented in the extension database:

- Stem identification number/code
- Species name
- Number of hollows
- Dead or living stem

7. Data systems

Four relational databases used to manage and analyse Function data generated by this project are described below.

7.1 BioNet Atlas Extension Database

The BioNet Atlas Extension Database developed by Phil Gleeson consists of a series of 'Views' of data contained in BioNet Atlas (Table 7). The system enables live connections to data contained in the Flora surveys module via a MS Access desktop application. This ensures that members of the project team obtained data from a single authoritative source for analysis.

Table 7 BioNet Atlas Extension Database objects

Name	Type	Description
vwCensus	View	A view of selected attributes recorded at the Replicate (Site Census) level. Function attributes available in this view include: litter cover, woody debris (log) length, no. trees with hollows, woody regeneration (species) and woody regeneration (abundance).
vwCensus_simple	View	A simplified view of vwCensus which provides information about site locations, quadrat sizes, sample dates for replicates and sample methods.
vwCensusItems	View	A view of woody stem size data. The view contains a mix of two types of values: counts of stems in specified size classes and individual stem diameters in cm.
vwSighting	View	A view of floristic records and cover – abundance attributes. Not used by the Function benchmarking project.
vwSiteDisturbance	View	A view of disturbance information recorded during site replicate surveys. Although not used to date, this data is potentially useful for identifying unsuitable reference sites due to their modified state. Disturbance data is not consistently recorded for each replicate.
vwSiteHistory	View	A view of site history and land use information recorded during Site replicate surveys. This data may also assist in identifying unsuitable reference sites.
vwSurvey	View	A view of flora surveys contained in BioNet Atlas including information about survey methods and principle people responsible for conducting the field survey.

7.2 Function Dataset Register

A database for registering new datasets and tracking progress towards upload to the Flora surveys module. Database objects are described in Table 8.

Table 8 Function Dataset Register database objects

Name	Type	Description
tbl_Dataset	Table	A list of datasets identified during this project. Key information contained in this table includes a unique dataset identification code, a textual description of the survey and an estimate of the number of sites it contains.
tbl_Dataset_Census	Table	A table for tracking the relationship between datasets and the records in flora survey that are created from them.
tbl_Dataset_People	Table	A table for tracking the relationship between datasets and people. People's relationship to datasets (role) can be characterised as 'primary contact', 'secondary contact', 'data broker', or 'data processor'.
tbl_People	Table	A list of people, contact details and organisations that they represent.
Tbl_Progress	Table	A table for tracking the changing status of dataset processing activities for each dataset. Datasets can also be tagged as a 'priority' for processing in this table.
vwCensus_simple	View	A linked view from the BioNet Atlas Extension Database.
qry_MasterDatasetList	Query	A master list of datasets that includes information on primary contacts.
qry_ProgressReport	Query	A current status report for all datasets. Only the most recent (or 'Active') status notes are shown.
frm_Datasets	Form	A simple user interface for recording information about people's role in datasets and notes on the progress of processing activities.
subfrm_DatasetCensus	Form	A child or subform used by the parent form 'frm_Datasets'.
subfrm_DatasetPeople	Form	A child or subform used by the parent form 'frm_Datasets'.
subfrm_Progress	Form	A child or subform used by the parent form 'frm_Datasets'.

7.3 Function Extension Database

The Function Extension Database records additional attributes related to Function data that are not currently captured under the Flora surveys data model.

Two types of additional fields have been implemented in this database:

1. Metadata that documents survey methods and parameters required for interpretation and standardisation of the data between surveys (Table 9)
2. Attributes at the level of an individual woody stem which have not previous been captured by Flora surveys (Table 10).

Database objects are described in Table 11.

Table 9 New fields for capturing metadata at the survey level

Field Name	Data Type	Description	Units
SurveyID (PK)	Short Text	Name of survey in the Flora surveys module of BioNet Atlas.	
STM_PlotArea	Number	Area of plot used to assess woody stem abundance.	Hectares (ha)
STM_MinDBH	Number	Minimum stem diameter at breast height (DBH) measured.	Centimetres (cm)
STM_DetSml	Yes/No	Individual stem diameters less than 30cm have been recorded.	
STM_DetLrg	Yes/No	Individual stem diameters greater than 30cm have been recorded.	
HBT_MinHDiam	Number	Minimum diameter of hollow opening required to designate a tree as hollow bearing.	Centimetres (cm)
HBT_PlotArea	Number	Area of plot used to assess hollow bearing tree abundance.	Hectares (ha)
CWD_PlotArea	Number	Area of plot used to assess cumulative length of logs.	Hectares (ha)
CWD_MinDiam	Number	Minimum diameter of log required to be included in cumulative length measures.	Centimetres (cm)
CWD_MinLeng	Number	Minimum length of log required to be included in cumulative length measures.	Metres (m)
REG_PlotArea	Number	Area of plot used to assess abundance of regenerating canopy trees.	Hectares (ha)
REG_MinDBH	Number	Minimum stem diameter at breast height (DBH) counted as a regenerating stem.	Centimetres (cm)
REG_MaxDBH	Number	Maximum stem diameter at breast height (DBH) counted as a regenerating stem.	Centimetres (cm)
LIT_Method	Short Text	Method used to assess litter cover. Either (a) fixed area plot, or (b) point-intercept transect.	
LIT_PlotArea	Number	Area of plot used to assess woody stem abundance.	Hectares (ha)
LIT_TranLen	Number	Length of point-intercept transect used to assess litter cover.	Metres (m)

Table 10 New fields for recording attributes of woody stems

Field Name	Data Type	Description	Units
CensusItemID	Number	Record identifier for stem from the Flora surveys module of BioNet Atlas.	
TreeCode	Short Text	Unique identifier for tree stem within plot. Adopt field code from source study where possible.	
HollowCnt	Number	Count of the number of hollows present in tree/stem.	
Height	Number	Height of tree/stem.	Metres (m)

Field Name	Data Type	Description	Units
SpeciesCode	Short Text	Plant species code from Census of Australian Plants (CAPS).	
LiveDead	Short Text	Is the stem alive or dead (standing timber)?	

Table 11 Function Extension Database objects

Name	Type	Description
tbl_FunctionMetadata	Table	Survey level metadata that documents sample methods and plot sizes used to assess Function attributes (Table 9).
tbl_StemAttributes	Table	Additional attributes at the level of an individual woody stem not previously captured by flora surveys (Table 10).
vwCensus_simple	View	A linked view from the BioNet Atlas Extension Database.
vwCensusItems	View	A linked view from the BioNet Atlas Extension Database.
frm_FunctionMetadata	Form	A simple user interface for viewing or editing survey level metadata.

7.4 Function Analysis Database

The Function Analysis Database is a database for compiling data into a standard form suitable for analysis. Transformations required to standardise measures from non-standard samples are applied in this database. Table 12 provides details of the Function Analysis Database objects.

Table 12 Function Analysis Database objects

Group	Name	Type	Description
BioNet Atlas Extension Database	vwCensus	View	Linked views from the BioNet Atlas Extension Database.
	vwCensus_simple	View	
	vwCensusItems	View	
	vwSiteDisturbance	View	
	vwSiteHistory	View	
	vwSurvey	View	
Plot Allocation	SiteID_PCTAllocations	Table	Linked tables from the Plot to PCT Allocation Database.
	Tbl_Sites_IBRAv7	Table	
	tblKeithClass2004	Table	
	tblKeithFormation	Table	
	tblPCT_KeithClass	Table	
	qry_NSWSitestoKC	Query	A query which displays vegetation type allocations (Formation, Class and PCT) for each Site.
	qry_Site_IBRA		A query which identifies the location details (latitude/longitude and Bioregion) for each Site.

Group	Name	Type	Description
Function Extension Database	tbl_FunctionMetadata	Table	Linked table from the Function Extension Database.
Data Availability	qry_SiteRepsWithFunctionData	Query	A query that evaluates whether site replicates contain data for logs, litter, hollow bearing trees and stem sizes. Site coordinates and Class allocations are included in the output.
Data Preparation	tbl_StemDataTypes	Table	A lookup table describing the 3 categories that replicates can be grouped into based on the stem data record type.
	tbl_10cmDiameterIntervals	Table	A lookup table describing 26 stem diameter intervals used to standardise pooled data.
	qry_CensusItems_CrossTab	Query	A cross tab query that pivots VWCensusItems into a summary table with one replicate per row.
	qry_Census_StemDataType	Query	A query which automatically groups replicates into one of three stem data type categories.
Outputs	qry_Litter	Query	A compilation of litter cover values from all available samples. Class and Bioregion for samples are included in the output.
	qry_logs	Query	A compilation of woody debris length values from all available samples. Data from different plot sizes is standardised to 0.1ha. Class and Bioregion are included in the output.
	qry_allStems_Date	Query	A compilation of stem data from all available samples. Sites were classified into 'stem data type' according to how stem data was collected (e.g. by size class or by individual diameters), and all valid data used. Class and Bioregion allocations for samples are included in the output. Note: standardisation to 0.1 ha is applied in the R analysis stage for this attribute.

7.5 The BAM Benchmarks Project Database

The BAM Benchmarks Project Database contains all benchmark data (structure, composition and function) for each RVC in NSW. All Function benchmark outputs were provided for inclusion in the BAM Benchmarks Project Database. For each relevant RVC, these comprised:

- Litter cover (%) benchmark value
- Total length of fallen logs (m) benchmark value
- Number of large trees benchmark value

- Large tree threshold size (dbh cm)
- Confidence (see Section 9.2)
- Hierarchy at which each benchmark was generated (see Section 9.1).

Details of the BAM Benchmarks Project Database are provided in Somerville et al. (2019).

8. Available dataset

Benchmarks are nominally generated for each Regional Vegetation Class (RVC). As such, Function data generally only becomes available for inclusion in benchmark calculations once the following conditions are met:

- sites are allocated to a Vegetation Class
- sites are allocated to a Bioregion
- data are uploaded to the Flora surveys module of BioNet Atlas.

Section 9 details the hierarchy of benchmark calculation that is followed where there is insufficient data to provide benchmarks at an RVC level. At lower levels in this hierarchy (e.g. Formation level), data may be used that is unallocated to Bioregion.

Data were extracted from BioNet Atlas on July 3, 2017 for publication of benchmarks at August 25, 2017.

8.1 Spatial distribution of samples

The number of sites available by bioregion for generation of benchmark values for Function attributes is shown in Table 13.

Table 13 Number of sites within bioregions with Function attribute data

Bioregion	Log length	Litter cover	Stem sizes
Australian Alps	29	37	0
Brigalow Belt South	537	785	213
Broken Hill Complex	46	46	13
Channel Country	5	5	1
Cobar Peneplain	186	158	80
Darling Riverine Plains	485	434	186
Mulga Lands	103	108	74
Murray Darling Depression	78	86	21
Nandewar	391	390	23
New England Tablelands	125	137	145
NSW North Coast	535	922	627
NSW South Western Slopes	411	340	194
Riverina	795	2104	471
Simpson Strzelecki Dunefields	0	0	0
South East Corner	19	184	16
South Eastern Highlands	275	274	45
South Eastern Queensland	2	18	63
Sydney Basin	345	943	130
Total	**4367**	**6971**	**2302**

Figure 1 shows the spatial distribution of sites with data for selected Function attributes. This analysis shows a significant deficit of Function data (<100 combined data points) from the Australian Alps, Channel Country, Simpson Strzelecki Dunefields and South East Queensland Bioregions. Stem size data from the Broken Hill Complex, Murray Darling Depression, Nandewar and South East Corner Bioregions were also lacking.

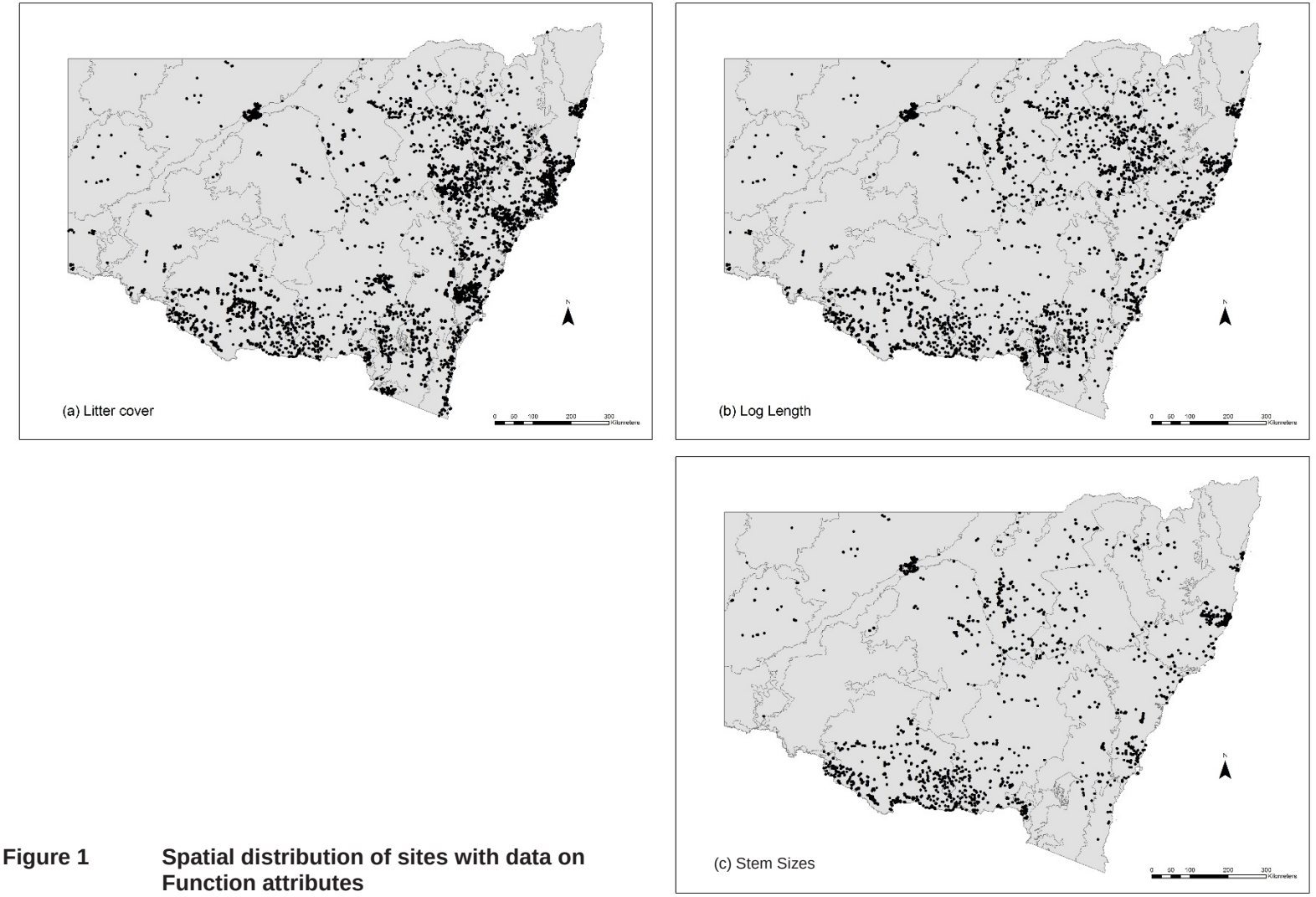

Figure 1 **Spatial distribution of sites with data on Function attributes**

8.2 Vegetation Classes represented in samples

The number of sites containing Function attribute data from each Vegetation Class is shown in Table 14.

Table 14 Number of sites within vegetation classes with Function attribute data

Formation	Vegetation Class	Function relevance	Log length	Litter cover	Stem sizes
Alpine complex	Alpine Bogs and Fens	N	0	2	0
	Alpine Heaths	N	0	0	0
	Alpine Herbfields	N	1	3	0
Arid shrublands (Acacia subformation)	Gibber Transition Shrublands	N	8	8	8
	North-west Plain Shrublands	N	9	9	6
	Sand Plain Mulga Shrublands	N	54	56	27
	Stony Desert Mulga Shrublands	N	12	13	8
Arid shrublands (Chenopod subformation)	Aeolian Chenopod Shrublands	N	7	30	0
	Gibber Chenopod Shrublands	N	10	10	0
	Riverine Chenopod Shrublands	N	268	386	69
Dry sclerophyll forests (Shrub/grass subformation)	Central Gorge Dry Sclerophyll Forests	Y	1	43	1
	Clarence Dry Sclerophyll Forests	Y	4	4	24
	Cumberland Dry Sclerophyll Forests	Y	1	1	0
	Hunter-Macleay Dry Sclerophyll Forests	Y	33	136	23
	New England Dry Sclerophyll Forests	Y	27	31	22
	Northern Gorge Dry Sclerophyll Forests	Y	12	37	3
	North-west Slopes Dry Sclerophyll Woodlands	Y	112	133	3
	Pilliga Outwash Dry Sclerophyll Forests	Y	41	41	24
	Southern Hinterland Dry Sclerophyll Forests	Y	0	1	0
	Upper Riverina Dry Sclerophyll Forests	Y	77	54	14
Dry sclerophyll forests (Shrubby subformation)	Coastal Dune Dry Sclerophyll Forests	Y	37	48	17
	North Coast Dry Sclerophyll Forests	Y	14	11	20
	Northern Escarpment Dry Sclerophyll Forests	Y	2	5	30

Formation	Vegetation Class	Function relevance	Log length	Litter cover	Stem sizes
	Northern Tableland Dry Sclerophyll Forests	Y	40	36	14
	South Coast Sands Dry Sclerophyll Forests	Y	7	13	4
	South East Dry Sclerophyll Forests	Y	18	22	2
	Southern Tableland Dry Sclerophyll Forests	Y	100	71	16
	Southern Wattle Dry Sclerophyll Forests	Y	0	1	0
	Sydney Coastal Dry Sclerophyll Forests	Y	15	51	6
	Sydney Hinterland Dry Sclerophyll Forests	Y	8	68	1
	Sydney Montane Dry Sclerophyll Forests	Y	8	41	7
	Sydney Sand Flats Dry Sclerophyll Forests	Y	4	14	3
	Western Slopes Dry Sclerophyll Forests	Y	124	217	154
	Yetman Dry Sclerophyll Forests	Y	0	0	1
Forested wetlands	Coastal Floodplain Wetlands	Y	70	70	31
	Coastal Swamp Forests	Y	75	110	43
	Eastern Riverine Forests	Y	217	263	20
	Inland Riverine Forests	Y	425	345	149
Freshwater wetlands	Coastal Freshwater Lagoons	N	8	7	1
	Coastal Heath Swamps	N	9	13	4
	Inland Floodplain Shrublands	N	212	163	52
	Inland Floodplain Swamps	N	8	28	2
	Montane Bogs and Fens	N	20	26	8
	Montane Lakes	N	3	3	0
Grasslands	Maritime Grasslands	N	0	0	0
	Riverine Plain Grasslands	N	126	960	92
	Semi-arid Floodplain Grasslands	N	84	85	26
	Temperate Montane Grasslands	N	9	15	9
	Western Slopes Grasslands	N	45	99	7
Grassy woodlands	Coastal Valley Grassy Woodlands	Y	70	182	38
	Floodplain Transition Woodlands	Y	169	165	129
	New England Grassy Woodlands	Y	44	75	7
	Southern Tableland Grassy Woodlands	Y	38	37	11

Formation	Vegetation Class	Function relevance	Log length	Litter cover	Stem sizes
	Subalpine Woodlands	Y	46	47	1
	Tableland Clay Grassy Woodlands	Y	20	24	8
	Western Slopes Grassy Woodlands	Y	409	550	83
Heathlands	Coastal Headland Heaths	N	10	46	3
	Northern Montane Heaths	Y	2	4	4
	South Coast Heaths	N	0	2	0
	Southern Montane Heaths	N	3	6	2
	Sydney Coastal Heaths	Y	2	11	0
	Sydney Montane Heaths	Y	0	9	0
	Wallum Sand Heaths	Y	29	34	4
Rainforests	Cool Temperate Rainforests	Y	1	2	8
	Dry Rainforests	Y	47	66	39
	Littoral Rainforests	Y	19	20	9
	Northern Warm Temperate Rainforests	Y	32	69	66
	Southern Warm Temperate Rainforests	Y	1	4	1
	Subtropical Rainforests	Y	27	32	30
	Western Vine Thickets	Y	6	5	1
Saline wetlands	Inland Saline Lakes	N	15	145	2
	Mangrove Swamps	N	8	3	7
	Saltmarshes	N	11	15	7
Semi-arid woodlands (Grassy subformation)	Brigalow Clay Plain Woodlands	Y	33	28	1
	Inland Floodplain Woodlands	Y	129	208	122
	North-west Floodplain Woodlands	Y	172	170	91
	Riverine Plain Woodlands	Y	43	53	19
Semi-arid woodlands (Shrubby subformation)	Desert Woodlands	Y	0	0	0
	Dune Mallee Woodlands	Y	45	53	0
	Inland Rocky Hill Woodlands	Y	24	24	18
	North-west Alluvial Sand Woodlands	Y	10	10	1
	Riverine Sandhill Woodlands	Y	77	140	68
	Sand Plain Mallee Woodlands	Y	12	12	9
	Semi-arid Sand Plain Woodlands	Y	27	32	27
	Subtropical Semi-arid Woodlands	Y	2	2	0
	Western Peneplain Woodlands	Y	151	146	69
	Montane Wet Sclerophyll Forests	Y	1	1	0

Formation	Vegetation Class	Function relevance	Log length	Litter cover	Stem sizes
Wet sclerophyll forests (Grassy subformation)	Northern Hinterland Wet Sclerophyll Forests	Y	87	263	139
	Northern Tableland Wet Sclerophyll Forests	Y	16	33	96
	Southern Lowland Wet Sclerophyll forests	Y	7	27	5
	Southern Tableland Wet Sclerophyll Forests	Y	21	26	4
Wet sclerophyll forests (Shrubby subformation)	North Coast Wet Sclerophyll Forests	Y	115	269	127
	Northern Escarpment Wet Sclerophyll Forests	Y	40	44	91
	South Coast Wet Sclerophyll Forests	Y	5	65	2
	Southern Escarpment Wet Sclerophyll Forests	Y	10	29	2
Total			**4401**	**6971**	**2302**

Some sites containing Function attribute data are unallocated to any Vegetation Class or Formation which means that they are not available for benchmark calculations. Note that as they have not been allocated to Class, some may represent vegetation types where Function data does not apply (e.g. grasslands).

Table 15 Number of sites unallocated to Class in each Bioregion

Bioregion	Log length	Litter cover	Stem sizes
Australian Alps	19	20	0
Brigalow Belt South	3	17	1
Broken Hill Complex	3	3	0
Channel Country	0	0	0
Cobar Peneplain	4	6	1
Darling Riverine Plains	27	225	5
Mulga Lands	4	4	2
Murray Darling Depression	4	4	4
Nandewar	0	0	0
New England Tablelands	21	66	20
NSW North Coast	162	238	173
NSW South Western Slopes	22	15	0
Riverina	113	660	113
Simpson Strzelecki Dunefields	0	0	0
South East Corner	0	17	0
South Eastern Highlands	171	242	3
South Eastern Queensland	27	82	73
Sydney Basin	146	276	66
Total	**726**	**1875**	**461**

9. Calculation of benchmarks

9.1 Hierarchical calculation of benchmarks

The benchmark generation process for structure and composition attributes contained sufficient numbers of data points such that modelled data could be used. Modelled values could be thus calculated for RVCs that had few or no site data. Function attributes had many fewer data and modelling was not considered appropriate. An alternative 'hierarchical' approach was designed to allow attribution of benchmark values for each RVC even where there were insufficient site data at this level.

At least 30 data points (replicates) were required to generate the benchmark values at the RVC level. RVC combinations with fewer than 30 data points inherited benchmark values from calculations at the Class level, regardless of Bioregion. If the Class had fewer than 30 data points, amalgamated data from the relevant combination of Formation-Bioregion was used. Where there were less than 30 data points at the Formation-Bioregion level, amalgamated data from the corresponding Formation was used. This hierarchical structure is shown in Table 16.

Table 16 Hierarchy for Function benchmark calculation

Hierarchy	Stratification
1	Regional Vegetation Class (RVC)
2	Class
3	Formation-Bioregion
4	Formation

Using this method, it was possible to generate benchmark values for all theoretical RVC combinations. The validation threshold of 30 data points was determined based on bootstrapping analysis from RVC combinations that had more than 50 records (see Appendix III).

9.2 Confidence levels

For each benchmark, a confidence level was attributed based on a) the level in the vegetation type classification hierarchy at which benchmark values were calculated, and b) the number of data points from which the benchmark values were generated. The matrix used to generate this confidence level is presented as Table 17. The accuracy of benchmark values were assumed to increase as the resolution of classification becomes finer (from Formation to RVC) and the number of plots becomes greater.

Table 17 Benchmark confidence levels

		Hierarchy			
		Formation	Formation-Bioregion	Class	RVC
Number of data points	**<30**	Very Low	N/A	N/A	N/A
	30-99	Low	Low	Moderate	High
	100-200	Low	Moderate	High	High
	>200	Moderate	High	High	Very High

9.3 Selection of the ‘large tree’ threshold

An assessment of the number of ‘large’ trees at a site requires the establishment of a size threshold to define a ‘large’ tree. The size at which a tree develops hollows for fauna habitat is an important factor in defining large trees. Large trees are assumed to be an appropriate surrogate for the ‘trees with hollows’ used in previous biodiversity assessment systems, but size of tree can be more consistently and objectively measured by assessors. Hollows are an important habitat feature of large trees, but large trees are also important for their influence on microclimate, provision of niche habitat features (e.g. bark) and superior flowering and fruiting.

A number of studies have shown the probability of hollow formation to vary with tree species; logically it follows that the probability of hollow formation also varies with vegetation type. A comprehensive and novel meta-analysis was conducted on the relationship between tree diameter and hollow presence to model the size of tree in each vegetation Formation and Class that had the potential to develop hollows (Travers et al. 2018). These modelled data were placed into classes based on the lower bound of the standard BAM size classes (i.e. 10 cm, 20 cm, 30 cm, 50 cm, 80 cm) and guided final decisions on large tree thresholds. Thus, a ‘large tree threshold’ was determined for each vegetation Class. Generally, more productive environments (e.g. wet sclerophyll forests) had higher large tree thresholds than less productive environments (e.g. semi-arid woodlands, heathlands). All large tree thresholds are presented in Table 18.

In other jurisdictions (e.g. Victoria) large tree thresholds and benchmarks have been calculated for eucalypt and non-eucalypt tree species. Sufficient data on stem diameter by tree species is not currently available for calculating separate thresholds for eucalypt and non-eucalypt tree species in New South Wales. Recommended improvements to the Flora surveys module of BioNet Atlas that enable capture and storage of data on stem diameter and tree species may allow calculation of these attributes in the future.

Table 18 Large tree thresholds for vegetation Class

Formation	Class	Large Tree Threshold (cm)
Alpine complex	Alpine Bogs and Fens	N/A
	Alpine Fjaeldmarks	
	Alpine Heaths	
	Alpine Herbfields	
Arid shrublands (Acacia subformation)	Gibber Transition Shrublands	N/A
	North-west Plain Shrublands	
	Sand Plain Mulga Shrublands	
	Stony Desert Mulga Shrublands	
Arid shrublands (Chenopod subformation)	Aeolian Chenopod Shrublands	N/A
	Gibber Chenopod Shrublands	
	Riverine Chenopod Shrublands	
Dry sclerophyll forests (Shrub/grass subformation)	Central Gorge Dry Sclerophyll Forests	50
	Clarence Dry Sclerophyll Forests	50

Formation	Class	Large Tree Threshold (cm)
	Cumberland Dry Sclerophyll Forests	50
	Hunter-Macleay Dry Sclerophyll Forests	50
	New England Dry Sclerophyll Forests	50
	Northern Gorge Dry Sclerophyll Forests	50
	North-west Slopes Dry Sclerophyll Woodlands	50
	Pilliga Outwash Dry Sclerophyll Forests	50
	Southern Hinterland Dry Sclerophyll Forests	50
	Upper Riverina Dry Sclerophyll Forests	50
Dry sclerophyll forests (Shrubby subformation)	Coastal Dune Dry Sclerophyll Forests	50
	North Coast Dry Sclerophyll Forests	50
	Northern Escarpment Dry Sclerophyll Forests	50
	Northern Tableland Dry Sclerophyll Forests	50
	South Coast Sands Dry Sclerophyll Forests	50
	South East Dry Sclerophyll Forests	50
	Southern Tableland Dry Sclerophyll Forests	50
	Southern Wattle Dry Sclerophyll Forests	50
	Sydney Coastal Dry Sclerophyll Forests	50
	Sydney Hinterland Dry Sclerophyll Forests	50
	Sydney Montane Dry Sclerophyll Forests	50
	Sydney Sand Flats Dry Sclerophyll Forests	50
	Western Slopes Dry Sclerophyll Forests	50
	Yetman Dry Sclerophyll Forests	50
Forested wetlands	Coastal Floodplain Wetlands	50

Formation	Class	Large Tree Threshold (cm)
	Coastal Swamp Forests	50
	Eastern Riverine Forests	50
	Inland Riverine Forests	50
Freshwater wetlands	Coastal Freshwater Lagoons	N/A
	Coastal Heath Swamps	
	Inland Floodplain Shrublands	
	Inland Floodplain Swamps	
	Montane Bogs and Fens	
	Montane Lakes	
Grasslands	Maritime Grasslands	N/A
	Riverine Plain Grasslands	
	Semi-arid Floodplain Grasslands	
	Temperate Montane Grasslands	
	Western Slopes Grasslands	
Grassy woodlands	Coastal Valley Grassy Woodlands	50
	Floodplain Transition Woodlands	50
	New England Grassy Woodlands	50
	Southern Tableland Grassy Woodlands	50
	Subalpine Woodlands	50
	Tableland Clay Grassy Woodlands	50
	Western Slopes Grassy Woodlands	50
Heathlands	Coastal Headland Heaths	N/A
	Northern Montane Heaths	30
	South Coast Heaths	N/A
	Southern Montane Heaths	N/A
	Sydney Coastal Heaths	30
	Sydney Montane Heaths	30
	Wallum Sand Heaths	30
Rainforests	Cool Temperate Rainforests	50
	Dry Rainforests	50
	Littoral Rainforests	50

Formation	Class	Large Tree Threshold (cm)
	Northern Warm Temperate Rainforests	50
	Southern Warm Temperate Rainforests	50
	Subtropical Rainforests	50
	Western Vine Thickets *	30
Saline wetlands	Inland Saline Lakes	N/A
	Mangrove Swamps	
	Saltmarshes	
	Seagrass Meadows	
Semi-arid woodlands (Grassy subformation)	Brigalow Clay Plain Woodlands	30
	Inland Floodplain Woodlands	50
	North-west Floodplain Woodlands	30
	Riverine Plain Woodlands	30
Semi-arid woodlands (Shrubby subformation)	Desert Woodlands	30
	Dune Mallee Woodlands	30
	Inland Rocky Hill Woodlands	30
	North-west Alluvial Sand Woodlands	30
	Riverine Sandhill Woodlands	30
	Sand Plain Mallee Woodlands	30
	Semi-arid Sand Plain Woodlands	30
	Subtropical Semi-arid Woodlands	30
	Western Peneplain Woodlands	30
Wet sclerophyll forests (Grassy subformation)	Montane Wet Sclerophyll Forests	80
	Northern Hinterland Wet Sclerophyll Forests	80
	Northern Tableland Wet Sclerophyll Forests	80
	Southern Lowland Wet Sclerophyll Forests	80
	Southern Tableland Wet Sclerophyll Forests	80
Wet sclerophyll forests (Shrubby subformation)	North Coast Wet Sclerophyll Forests	80
	Northern Escarpment Wet Sclerophyll Forests	80

Formation	Class	Large Tree Threshold (cm)
	South Coast Wet Sclerophyll Forests	80
	Southern Escarpment Wet Sclerophyll Forests	80

* Western Vine Thickets large tree threshold was set at 30 cm dbh and number of large trees was set to six based on expert knowledge

9.4 Statistical procedure

Data preparation was performed in the Function Analysis Database and involved pooling values from different studies into a single table for each attribute: woody debris length, litter cover and stem sizes. All values were standardised to a 20 x 50 m (0.1 ha) quadrat equivalent.

MS Excel and R statistical software were used to calculate the benchmarks as the 75th percentile value for the following three attributes:

- Woody debris length (m)
- Litter cover (%)
- Number of large trees

The rationale for basing the Function benchmarks on the 75th percentile is provided in Oliver et al. (2019).

9.5 Data process

Benchmarks were calculated and presented using the following process:

- Queries for each attribute were run on the Function Analysis Database. This database has a live connection to the BioNet Atlas and BioNet Vegetation Classification databases, therefore contains all available data.
- Query results were exported as a 'comma separated values' (.csv) file.
- R scripts were used to process the data, perform the analysis, and present the results in a standard format. Benchmarks at the 75th percentile were generated for all theoretically possible RVC combinations. Function benchmark results were exported from R as a .csv file.
- Function benchmark .csv files were incorporated into the broader BAM Benchmarks Project Database (including structure and composition benchmarks).
- Benchmarks data for function, structure and composition are exported for each RVC (with associated metadata) for use in the BAM calculator and publication via the online BioNet Vegetation Classification application.

Further details of relevant queries and raw data files are presented in Appendix IV.

10. Issues and limitations

10.1 Condition of sites used in Function benchmark calculations

Calculations of Function attributes were undertaken using the best available data. Contextual information about the relative ecological condition of sites where source data was collected was not always available, or in a form that could be used to filter and exclude substandard data from calculation dataset. Where data were from sites that were obviously highly modified (e.g. following forest thinning trials) these data was excluded.

10.2 Non-standard data

Some datasets compiled for this project contained measures of Function attributes that could not be transformed and integrated into BioNet Atlas due to incompatible survey methods. Although these data will not contribute to benchmark calculations there could be opportunities to use these data for related analyses or independent validation of benchmark values. Examples of common non-standard methods encountered include:

- Stem basal area – this measure provides an average total cross-sectional area of all stems in a stand. It provides no information about the relative size distribution of stems which is required for calculating a count of large trees.
- Stem counts in interval classes only – this approach only specifies a 'count' of stems above a size threshold (e.g. 30+ cm) with no records of individual stem diameters. The distribution of stems in the largest interval classes is unknown.
- Woody debris abundance measured as proportion of plot's total area or point-intercepts along a transect – this approach produces a relative per cent value which is incompatible with the linear meters metric used by the Interim Type Standard.

10.3 Legacy data

While the data incorporated in these calculations have undergone comprehensive quality control, some information from legacy data sources is not always provided (e.g. method for estimating litter cover). Data analysts have used their best judgement in these cases and have either a) filtered data where the method of collection is unknown, or b) included data and annotated the metadata to reflect the level of knowledge.

10.4 Lack of resolution within vegetation type

A significant assumption underpinning the current benchmarking approach is that Plant Community Types (PCTs) within the same RVC possess similar Function attribute values. It is known that some PCTs do not fit neatly into the Class system developed by Keith (2002) and have characteristics of multiple classes. Benchmark values calculated at the Class level may not always accurately reflect the Function attributes of these individual types. However, the BAM allows assessors to generate relevant local benchmarks where this is more appropriate, particularly where the confidence levels are low or very low.

10.5 Updating benchmark values

It is the intent of the BAM benchmarks project that the values be updated as more data is made available. In some cases, these updates may result in a benchmark being drawn from a higher resolution in the hierarchy and may result in a significantly different benchmark value. Policy needs to be developed as to how benchmark updates are incorporated into the legislative framework.

11. Recommendations

The following recommendations are provided to help ongoing elements of this project:

- Continue to acquire, compile, clean and upload additional data to the corporate database – data processing is time consuming but critical for ensuring that there is high degree of confidence in the dataset used to calculate benchmarks. The custodians of some data sets were unresponsive to initial enquiries; additional enquiries should be undertaken to see if they are willing to share the data. New sources of data will be identified over time and the BAM maintenance program requires resources to expand and improve the dataset used for benchmark calculations.
- Review and rationalisation of information management systems - a number of project specific databases were developed by this project for registration, storage and calculation of benchmarks. Some of the functions performed by these systems will be required when re-calculating benchmarks in future iterations. Information systems will need to be kept up to date to allow calculations to be rerun. For example, outputs generated by the Function Analysis Database are dependent on up to date content of the Function Dataset Register, Function Extension Database and Site to PCT Database. Databases were also developed by this project to address deficiencies in the current BioNet. Some of the functions may be incorporated into future versions of BioNet which would avoid the need for maintenance of separate systems.
- Filter for highly modified sites – despite inconsistent recording, contextual information in BioNet provides a way of identifying severely disturbed sites. A systematic approach or ruleset that uses available contextual data to identify highly modified sites could be developed. When highly modified sites are known they can either be removed from the calculation dataset, or testing undertaken to determine their effect on outputs.
- New fields in BioNet to support collection of Function attributes – this project has implemented new metadata fields at the survey level and new attribute fields at the stem level, aimed at improving the ability to capture and analyse Function attribute data. Any future redevelopment of BioNet should also consider adopting this approach. Metadata about the methods used to collect Function attribute values (e.g. plot size) is currently stored in the BioNet extension database and not visible to most users via the BioNet portal. It is important that this information be provided to users to avoid misinterpretation of data.
- Addition of sites as BAM assessments are completed – as assessments are undertaken using the BAM, processes should be designed so that assessment data is transferred to BioNet, with appropriate QA/QC.
- Explore modelling of Function data – although the data used to generate Function benchmarks were from a relatively small number of sites, the robust modelling used for composition and structure components may be useful to employ. Trials should be conducted for modelling Function attributes to assess how modelling compares to the hierarchical method of benchmark calculation.

12. References

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13. Appendices

13.1 Appendix I Modelled occurrence of Vegetation Classes in Bioregions

The predicted occurrence of Vegetation Classes within Bioregions calculated from Keith (2002) is presented in the table below. Values shown in the table are the relative proportion of the total area expressed as a percentage.

Table 19 Modelled occurrence of Vegetation Classes in Bioregions

FID	Formation	CID	Class	Function	AUA	BBS	BHC	CHC	COP	DRP	MUL	MDD	NAN	NET	NNC	NSS	RIV	SSD	SEC	SEH	SEQ	SYB
1	Rainforests	NSW001	Subtropical RF	Y										8.5	38	0.1					30	24
		NSW002	Northern Warm Temperate RF	Y										3.4	19					1.9	3.2	72
		NSW003	Cool Temperate RF	Y	0.4								0.7	14	31				22	25	6.1	2
		NSW004	Dry RF	Y		1.7							4.1	5.9	15				8.2	42	2.5	21
		NSW005	Littoral RF	Y											32						20	49
		NSW075	Southern Warm Temperate RF	Y															82	6.3		12
		NSW119	Western Vine Thickets	Y		58							42									
2	Wet sclerophyll forests (Grassy subformation)	NSW010	Northern Tableland WSF	Y		2.1							1.4	33	57						6.3	0.8
		NSW011	Southern Tableland WSF	Y	18											4.3			4.5	68		5.8
		NSW021	Northern Hinterland WSF	Y		0.1							0.2	3.3	32						11	53
		NSW024	Southern Lowland WSF	Y															77	0.6		22
		NSW078	Montane WSF	Y	31											1.2			26	41		
3	Wet sclerophyll forests (Shrubby subformation)	NSW006	North Coast WSF	Y									0.1	2.5	17					0.4	5.5	75
		NSW007	South Coast WSF	Y															94	4.8		0.7
		NSW008	Northern Escarpment WSF	Y									1.6	29	66						3.5	0.2

FID	Formation	CID	Class	Function	AUA	BBS	BHC	CHC	COP	DRP	MUL	MDD	NAN	NET	NNC	NSS	RIV	SSD	SEC	SEH	SEQ	SYB
		NSW009	Southern Escarpment WSF	Y	0.9											0.1			37	53		8.5
4	Grassy woodlands	NSW040	Tableland Clay Grassy Woodlands	Y	0.5	0.6							7.1	28	3.4	0.5			7.9	52		0.1
		NSW041	New England Grassy Woodlands	Y		0.1							4.9	87	6.3						0.6	0.6
		NSW042	Western Slopes Grassy Woodlands	Y		29				0.7			30	1.6	0.5	28	0.3			3.6		6.8
		NSW045	Subalpine Woodlands	Y	24								0.1	2.1	2.1	0.6			2.9	68		0.2
		NSW072	Coastal Valley Grassy Woodlands	Y		0.1								1.2	4.7				42	1.7	2.7	48
		NSW086	Southern Tableland Grassy Woodlands	Y	1.6											26			0.7	69		2.8
		NSW109	Floodplain Transition Woodlands	Y		13			5.5	32			0.2			35	14			0.1		
5	Dry sclerophyll forests (Shrub/grass subformation)	NSW030	Pilliga Outwash DSF	Y		56			5.1	38						0.6						
		NSW066	Northern Gorge DSF	Y		0.2							1	24	59						11	4.8
		NSW067	Clarence DSF	Y										9.1	43						49	
		NSW068	New England DSF	Y									1.8	69	28						0.6	
		NSW069	Hunter-Macleay DSF	Y		0.1								0.6	12							87
		NSW079	Central Gorge DSF	Y																59		41
		NSW080	Cumberland DSF	Y																0.7		99
		NSW081	Southern Hinterland DSF	Y															94	6.4		
		NSW084	Upper Riverina DSF	Y	2.4											56			12	27		3.5
		NSW113	North-west Slopes DSW	Y		49				0.7			36	2	1.5	4.9				2.4		3.8
6	Dry sclerophyll forests	NSW015	Sydney Coastal DSF	Y											2.9					1.1		96

FID	Formation	CID	Class	Function	AUA	BBS	BHC	CHC	COP	DRP	MUL	MDD	NAN	NET	NNC	NSS	RIV	SSD	SEC	SEH	SEQ	SYB
	(Shrubby subformation)	NSW016	Sydney Hinterland DSF	Y		0.2										0.5				6.8		93
		NSW017	Sydney Montane DSF	Y												0.8			7.9	24		67
		NSW019	Coastal Dune DSF	Y											60				0.9		14	26
		NSW020	North Coast DSF	Y										6.7	27						66	
		NSW022	South Coast Sands DSF	Y															61			39
		NSW025	Northern Escarpment DSF	Y									2.7	50	46						1.4	
		NSW026	South East DSF	Y															77	17		6
		NSW027	Northern Tableland DSF	Y		4.6							43	48	4.2	0.4						0.2
		NSW028	Southern Tableland DSF	Y	9					0.1						12			5.9	71		2
		NSW029	Western Slopes DSF	Y		39			1.1	1.8		0.2	32	0.1	0.1	18	0.2			1.2		6.5
		NSW064	Sydney Sand Flats DSF	Y		0.1									0.4							99
		NSW082	Southern Wattle DSF	Y															93	6.7		
		NSW106	Yetman DSF	Y		70				1.6			28	0.2								
7	Semi-arid woodlands (Grassy subformation)	NSW053	Inland Floodplain Woodlands	Y		0.2	1.8	2	12	23	2	9.5				4	45	1.2				
		NSW090	Riverine Plain Woodlands	Y		14			2.5	33		0.3	0.6			12	38					
		NSW097	North-west Floodplain Woodlands	Y		13		0.3	5	73	7.4	1.2	0.2									
		NSW101	Brigalow Clay Plain Woodlands	Y		76			0.1	17	7.1		0.1									
8	Semi-arid woodlands (Shrubby subformation)	NSW044	Western Peneplain Woodlands	Y		8.3			43	26	2	3.2	0.1			16	0.3					
		NSW061	Dune Mallee Woodlands	Y					24	2.1		67					6.3					
		NSW062	Sand Plain Mallee Woodlands	Y		0.4			26	4.2	0.1	57				2.1	11					

FID	Formation	CID	Class	Function	AUA	BBS	BHC	CHC	COP	DRP	MUL	MDD	NAN	NET	NNC	NSS	RIV	SSD	SEC	SEH	SEQ	SYB
		NSW063	Semi-arid Sand Plain Woodlands	Y			4		2	12	9.2	61					12					
		NSW088	Riverine Sandhill Woodlands	Y			0.3	0.1	1.7	0.1	0.5	9.1					88					
		NSW089	Inland Rocky Hill Woodlands	Y		1.5			60	0.7		4.1	0.9			33	0.3					
		NSW094	Subtropical Semi-arid Woodlands	Y		63				34	3.6											
		NSW095	Desert Woodlands	Y				4.8	14		81											
		NSW107	North-west Alluvial Sand Woodlands	Y		8.9				91	0.4											
9	Heathlands	NSW031	Wallum Sand Heaths	Y										1.3	44						15	39
		NSW032	Sydney Coastal Heaths	Y															2.5	0.9		97
		NSW033	Northern Montane Heaths	Y		28							63	4.4	3.9						0.7	
		NSW034	Sydney Montane Heaths	Y												2.6				19		78
		NSW035	Southern Montane Heaths	N															32	68		0.4
		NSW065	South Coast Heaths	N															10			
		NSW070	Coastal Headland Heaths	N										0.5	15				26		6.4	52
10	Alpine complex	NSW036	Alpine Heaths	N	75														1.7	23		
		NSW104	Alpine Fjaeldmarks	N	10																	
		NSW114	Alpine Herbfields	N	85														0.8	14		
		NSW115	Alpine Bogs and Fens	N	78														1.6	20		
11	Grasslands	NSW046	Temperate Montane Grasslands	N	12									0.4	0.2	0.5			5.1	82		0.1

FID	Formation	CID	Class	Function	AUA	BBS	BHC	CHC	COP	DRP	MUL	MDD	NAN	NET	NNC	NSS	RIV	SSD	SEC	SEH	SEQ	SYB
		NSW047	Semi-arid Floodplain Grasslands	N		39			0.9	56	4	0.1										
		NSW091	Riverine Plain Grasslands	N												0.1	100					
		NSW110	Western Slopes Grasslands	N		55			0.9	26	0.3	3.2	8.1			7						
		NSW116	Maritime Grasslands	N											28				23		3.1	45
12	Freshwater wetlands	NSW054	Coastal Heath Swamps	N										0.2	16				26	0.2	4.8	53
		NSW055	Montane Bogs and Fens	N	8.3									6	6.7	1			2.6	59	0.4	16
		NSW056	Coastal Freshwater Lagoons	N											16				2.7		13	69
		NSW074	Montane Lakes	N	4.9									58						37		
		NSW092	Inland Floodplain Shrublands	N		3.6	0.6	1.8	1.1	8.3	2	2.4				4.5	75	0.5				
		NSW108	Inland Floodplain Swamps	N		3			0.8	38	0.3	9.1				1	48					
13	Forested wetlands	NSW048	Coastal Swamp Forests	Y										0.3	41						16	42
		NSW050	Coastal Floodplain Wetlands	Y											7.5				19	0.1	5.1	69
		NSW051	Eastern Riverine Forests	Y	0.2	12				0.5			22	2.6	6.6	0.2			3.6	33	2.1	17
		NSW052	Inland Riverine Forests	Y		8.6			2.7	23		5	0.4			22	38			0.1		
14	Saline wetlands	NSW057	Inland Saline Lakes	N						1.4	85	8.1						5.4				
		NSW058	Mangrove Swamps	N											29				8		3.4	59
		NSW071	Saltmarshes	N											28				31		4.2	37
		NSW112	Seagrass Meadows	N											6.7				19		1.6	73
15	Arid shrublands	NSW099	Stony Desert Mulga Shrublands	N		2.3	16	6.6	12	8.3	42	10						1.9				

FID	Formation	CID	Class	Function	AUA	BBS	BHC	CHC	COP	DRP	MUL	MDD	NAN	NET	NNC	NSS	RIV	SSD	SEC	SEH	SEQ	SYB
	(Acacia subformation)	NSW100	Sand Plain Mulga Shrublands	N			14	14	14	4.4	21	21						11				
		NSW102	North-west Plain Shrublands	N					54	7.4	19	20										
		NSW103	Gibber Transition Shrublands	N		6.3			1.9	56	36											
16	Arid shrublands (Chenopod subformation)	NSW059	Riverine Chenopod Shrublands	N		0.2		0.4	2.7	8.4	0.3	8.1					80					
		NSW060	Aeolian Chenopod Shrublands	N			9.1	0.2	0.2	15	4.1	46					25	0.4				
		NSW098	Gibber Chenopod Shrublands	N			44	27		0.1	17	1.7						9.6				

13.2 Appendix II Source datasets

This table represents all identified data sources. Those in grey shading represent data that was a) unable to be provided, b) in a format unsuitable for use in this project, or c) incomplete and could not be remediated.

Table 20 Source datasets

Dcode	Short name	Long name	Description	Plot estimate
D001	Gondwana_RF	Gondwana Rainforests long term monitoring network	Long term plot monitoring network in Gondwana rainforests northern NSW.	150
D002	Bellangry_PNF	Private Native Forestry Harvesting Trial	H04207 Blackbutt growth and yield experiment.	6
D003	PNF_OutcomesMonitoring	Private Native Forestry Biodiversity and Economic Outcomes Monitoring Study	The PNF Code of Practice Outcomes Monitoring Project was conceived to test compliance with the Biodiversity Certification under the *Native Vegetation Act* (2003) of the PNF Code of Practice. The primary aim of the Project was to ensure the PNF Code was achieving its stated objectives of maintaining (or improving) wood supply and non-wood values of the PNF estate. Therefore, the Project was to assess changes or trends in wood supply and non-wood values occurring as a result of management of private native forests under the PNF Code.	45
D004	FCNSW_PermGrowthPlots	PGP (Permanent Growth Plot) Statewide Program	Permanently established and re-measured growth plots strategically located across representative forest types.	900
D005	FCNSW_Burning	FCNSW Frequent Burning and Fuel Equilibrium Studies	A series of long term experiments quantifying tree, shrub and fuel dynamic responses to frequent burning.	2072
D006	FCNSW_RRG_PGP	River Red Gum PGP (Permanent Growth Plot) Program	Permanently established and re-measured growth plots in south western RRG resource.	199
D007	OEH_RRG_Thinning	OEH River Red Gum Ecological Thinning Trial	Adaptive management research program aiming to investigate the impacts of ecological thinning on conservation attributes to improve the knowledge of how to manage the consequences of ongoing hydro-ecological drying on ecological character and biodiversity values.	66
D008	FCNSW_StrategicInventory	Native Forest Strategic Inventory	Strategic inventory of forest resources across the net harvestable State forest estate. Re-measured post-harvesting or post fire approximately every ten years.	3779
D009	BoodereeNP	Booderee National Park survey	Ecological survey training for MRes students.	11

Dcode	Short name	Long name	Description	Plot estimate
D010	MyallLakesNP	Myall Lakes North Survey	Floristic survey training for second-year students.	30
D011	DogPoundCreek	Dog Pound Creek Thornleigh Survey	25 permanent plots with full floristics and tree diameters used for teaching in threatened ecological communities.	25
D012	DLWC_Patra	DLWC Patra clearing investigation	Ecological study of alleged illegal clearing north of Newcastle. Ten floristic and ecological plots. Analysis completed of tree and hollow data.	10
D013	UNISYD_HR_Burning	Bush Fire and Natural Hazards CRC - impacts of prescribed burning	Research data set across south east NSW in progress examining impacts of hazard reduction on fuel mass, carbon, water and vegetation.	36
D014	TERN_AusPlots_Forest	Terrestrial Ecosystem Research Network (TERN) Ausplots Forest Monitoring Network	The TERN AusPlots Forest Monitoring Network aims to establish a continental scale plot based monitoring network that improves our understanding of tree growth, forest productivity and carbon dynamics in tall eucalypt forests in relation to continental scale environmental gradients. This permanent plot network provides the infrastructure and data for tracking all aspects of forest dynamics over long periods of time. Between October 2014 and March 2015, fuel load surveys were conducted in the 48 large 1 ha Ausplots Forest Monitoring Network plots in mature, highly productive tall eucalypt forests across the Australian continent.	13
D015	DPI_ForestResidues	DPI Forest Residues and Biodiversity Project	Study of impacts on biodiversity of removing forest harvesting residues for biofuel. The study addresses the impacts on biodiversity of a proposed biofuel recovery industry on the ecological values of residual coarse woody debris often left following timber harvesting. The residue of interest is defined by industry standards related to wood billet sizes of > 1.5m in length and > 10 cm diameter.	
D016	FCNSW_EIS_Program	NSW Forestry EIS program 1994-1996	Stratified plot based ecological sampling across NSW forest estate for TIIP Act EIS program.	2277
D017	CW_HollowTrees	Hollow Occurrence in Selected Tree Species in the Central West Catchment of NSW	A total of 1600 individual trees were measured, comprising 32 tree species (18 eucalypts, 14 non-eucalypts) from 21 sites across the central west catchment of New South Wales.	21
D018	TEC_Harvesting	Guidelines for Ecological Harvesting Plans for Threatened Ecological Communities	The project aimed to develop prescriptions supporting an Ecological Harvesting Plan allowing for ecological restoration works to improve the forest structure and biodiversity outcomes of a TEC. The focus was	12

Dcode	Short name	Long name	Description	Plot estimate
			developing stem density benchmarks to measure improvements in ecological condition.	
D019	WesternWoodland	NSW western woodland (Cypress) studies	A range of management and strategic inventory plot studies, ecological studies and intensive thinning studies in the northern and southern cypress woodlands. Data will allow stand structures and condition states in Callitris–Eucalyptus woodlands to be quantified.	
D020	CW_LACH_Benchmarks	Central West-Lachlan CMA benchmark pilot	150 plots collecting a range of ecological attribute data for benchmark condition stand development.	150
D021	OEH_Compliance	OEH Compliance investigations	Field ecological data sets collected for native vegetation compliance investigations.	
D022	JointOldGrowth	Joint Old Growth Forests Project	Ecological study of growth stage development and its characterisation in northern NSW forests. Jointly managed by Forestry Corporation of NSW and NSW NPWS.	148
D023	FCNSW_Silviculture	FCNSW Silviculture and growth dynamics experiments	One of Australia's most extensive experimental forest archives dating from the 1930's and encompassing all of the commercial forest types in New South Wales.	
D024	TERN_SuperSite	TERN - Australian SuperSite Network	Permanent monitoring plots from the Tumbarumba Wet Eucalypt and Cumberland Plain Eucalypt Woodland SuperSites.	2
D025	PADACS	PADACS Database Export	Export of Biometric data from the property vegetation plan (PVP), Agreements and Customer Service Database (PADACS).	
D026	Namoi_Thinning	Namoi CMA Thinning Benchmarks	Stem density data provided to the Department by LLS during development of the Thinning of Native Vegetation Code.	
D027	BioBankingCalculator	BioBanking Calculator	BioBanking Calculator Database.	
D028	SouthernRivers_Biometric	Southern Rivers CMA Biometric data	Copies of Biometric datasheets from Southern Rivers CMA.	13
D029	WoodlandRestoration	Warkworth Sands and Grey Box Woodland Restoration	Monitoring plots from Warkworth sands woodlands, cleared areas that once held that community and for grey box woodland in the hunter valley.	56
D030	Namoi_BenchmarkDB	Namoi Benchmarks Database	Benchmarks database developed by EcoLogical Australia for Namoi CMA.	952

Dcode	Short name	Long name	Description	Plot estimate
D031	Grazing_RiverinaCW	Impacts and benefits of domestic stock grazing in reserves	Impacts and benefits of domestic stock grazing on the ecology and biodiversity of River Red Gum, Black Box and Cypress Pine reserves in Central and Southern NSW.	451
D032	HunterCouncils	Hunter Councils Vegetation Mapping Program	Systematic vegetation samples from the Hunter Central and Lower North Coast region commissioned by Hunter Councils.	713
D033	Yantabulla	John T Hunter Yantabulla sites	Systematic vegetation samples collected by John T Hunter for various projects. A subset of data containing condition variables from the Yantabulla area was acquired.	55
D034	PhD_McKemey	Michelle McKemey PhD Sites NSW	Cultural burning: exploring Indigenous knowledge of country to support fire management in northern NSW and the Northern Territory.	30
D035	MurrumbidgeeIrrigation	Murrumbidgee Irrigation Area	Baseline survey of the condition and biodiversity of vegetation remnants in the Murrumbidgee Irrigation Area.	72
D036	NPWS_NorthWest	National Park Estate in North West NSW	A collection of various Function attribute data from national parks and reserves in North Western NSW.	
D037	NVMP_Hay	Native Vegetation Mapping Project - Hay	Additional attributes recorded by the Native Vegetation Mapping Project for the Hay 100,000 map sheet not captured in BioNet.	748
D038	PhD_Croft	Peter Croft PhD Sites	Habitat features of open forests and woodlands in relation to disturbance by fire.	92
D039	Pilliga_Indices	Landscape Health Indices - Pilliga	Data from a semi-arid eastern Australian woodland on common vegetation metrics (structure, composition and function; SCF).	43
D040	PortMacHastings_Airport	Port Macquarie Airport Biodiversity Certification - ELA	Sampling undertaken by EcoLogical Australia for biodiversity certification of Port Macquarie Airport Master Plan and Thrumster Area 13 Urban Release Area.	45
D041	PortMacHastings_LGA	Port Macquarie - Hastings LGA Mapping	Systematic full flora and rapid sampling for Vegetation of the Port Macquarie – Hastings Local Government Area.	632
D042	ScotiaMalleeWoodlands	Litter sampling in Mallee Woodland - Scotia	Line intercept sampling of litter cover from nine replicate sites in four communities: dune, swale, uncleared and cleared plain in Scotia Wildlife Sanctuary, south west NSW.	36
D043	FCNSW_BullsGroundBurning	SF_BullsGroundBurningStudy	Permanent monitoring plots within intensively managed forest in Landsdowne State Forest.	20

Dcode	Short name	Long name	Description	Plot estimate
D044	FCNSW_EdenBurning	SF_EdenBurningStudy	Permanent monitoring plots subjected to different logging and burning regimes in Yambulla State Forest.	20
D045	FCNSW_MountRoyal	SF_MountRoyal	Fauna Plot Habitat Assessment for Mount Royal Forest Management Area. Related to D016.	
D046	SF_EEC_Mapping	State Forests EEC Mapping	Quadrat sampling associated with a project to map EECs in state forests of eastern NSW.	448
D047	HunterValleyForests	Hunter Valley Floor Forests Monitoring	Monitoring of stem density and DBH from remnant vegetation used as mining offsets in the Hunter Valley.	34
D048	BioBank_Tangari	Tangari Biobank Site	Biometric data from Tangari Biobank Site near Glenn Innes.	33
D049	Umwelt_Veg	Umwelt Vegetation Survey data	A compilation of various systematic vegetation sampling data from various consultancy studies as supplied by Umwelt Australia.	482
D050	Canberra_LargeOldTrees	Large Old Trees in Urban Landscapes - Canberra	Tree stem sizes and hollow abundance in box-gum grassy woodland stratified across two dominant land uses (nature reserves and urban greenspace) and five geographic zones.	200
D051	Hollows_CW_Woodlands	Hollows in Central West Eucalypt Woodlands	Systematic hollow occurrence and abundance data from Central West Eucalypt Woodlands.	142
D052	BIP_Stage2_Biometric	Biodiversity Inventory Project - Stage 2 Biometric Data	A compilation of Biometric data from 68 private properties where landholders agreed to release data for benchmark analysis.	148
D053	SAND_Farmscapes	Savernake and Native Dog (SAND) Farmscapes Project	Biodiversity survey at 35 sites in remnant woodland and grassland between Berrigan and Corowa in the Riverina NSW.	35
D054	FC_NC_Monitoring	North Coast Forest Corporation Monitoring	Vegetation survey/monitoring program quadrats surveyed by Doug Binns on the NSW North Coast in 2009/2010 for Forestry Corporation of NSW.	115
D055	Callitris_CoverDiversity	Cypress Pine impact on plant diversity and cover	Study of plant cover and diversity in relation to density of *Callitris glaucophylla* (white cypress pine) along a rainfall gradient in eastern Australia.	83
D056	JohnHunter_ExtraSites	Additional floristic and structure sites purchased from John T Hunter	Data compiled from a variety of different sources that had not been previously incorporated into BioNet.	630

13.3 Appendix III Determining appropriate thresholds for benchmark hierarchy

The method detailed in this document identified a hierarchical method for generating benchmarks for each RVC (Section 9.1). Benchmarks would be generated at the finer levels (i.e. RVC) unless there were too few data records at that level; in which case, benchmarks would be generated as a coarser level (i.e. Class, Formation-Bioregion, Formation) until the threshold of data records was met. A bootstrapping analysis was conducted to guide the threshold number of sites which constitute an appropriate number within the benchmark hierarchy.

Data were used from litter and logs Class-Bioregion combinations with more than 50 data records. This comprised 16 combinations in the litter dataset and seven combinations in the logs dataset. The pool of sample sizes ranged from 50-113 for litter data and 50-133 for log data.

We sampled n records without replacement and calculated the 75th percentile benchmark value. This was repeated 1000 times and the benchmark mean and 95% confidence interval was calculated. This was conducted for n = 10, 15, 20, 25… until the number of records exceeded the number available. The results were plotted to determine appropriate thresholds. These plots are presented as Figure 2 (Logs) and Figure 3 (Litter).

While there was variability between RVC combinations, most combinations showed an inflection point at n = 25 or n = 30. This was demonstrated by a decrease in the confidence intervals from those seen at lower sample sizes. A further decrease in confidence interval size was seen in some combinations up to n = 50, however, this would have greatly reduced the number of combinations for which RVC level could be calculated. This data was reviewed by the project team and a threshold of n = 30 was determined to be appropriate for the benchmark hierarchy.

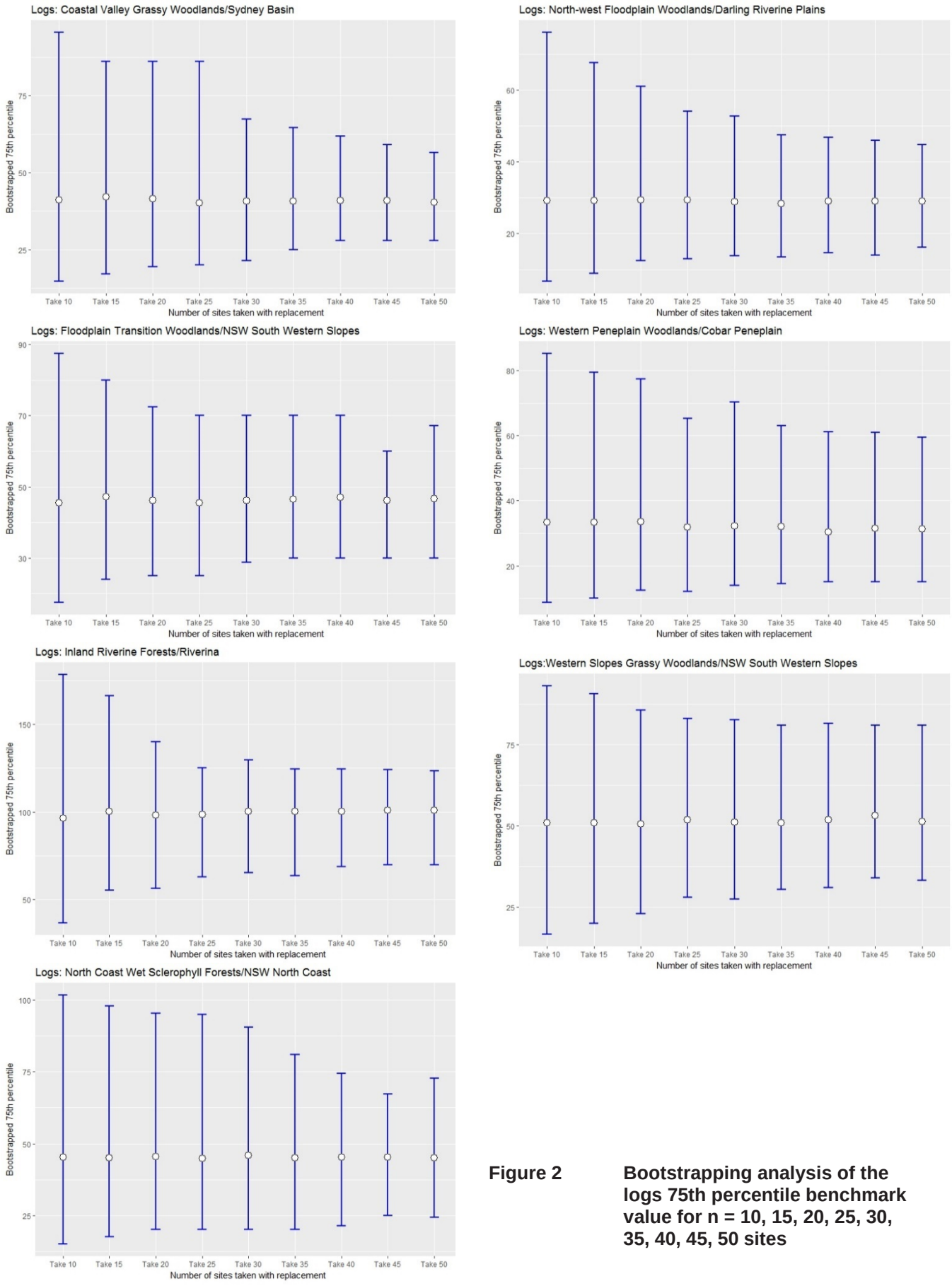
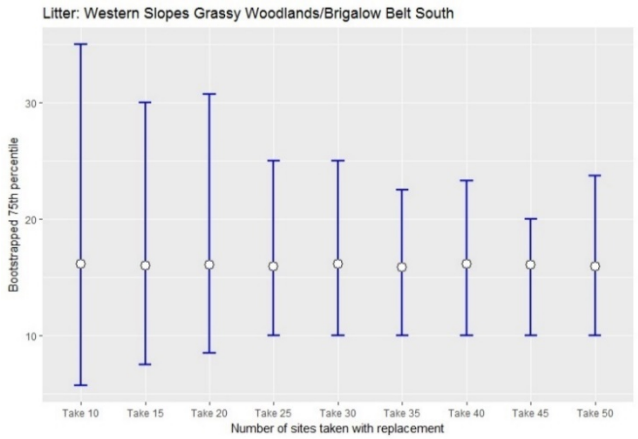
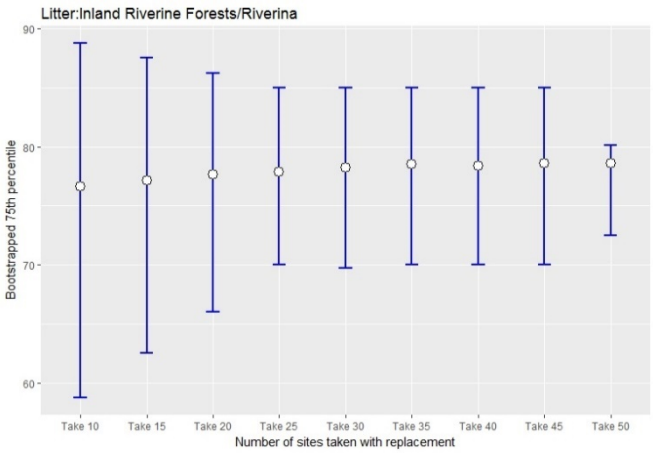
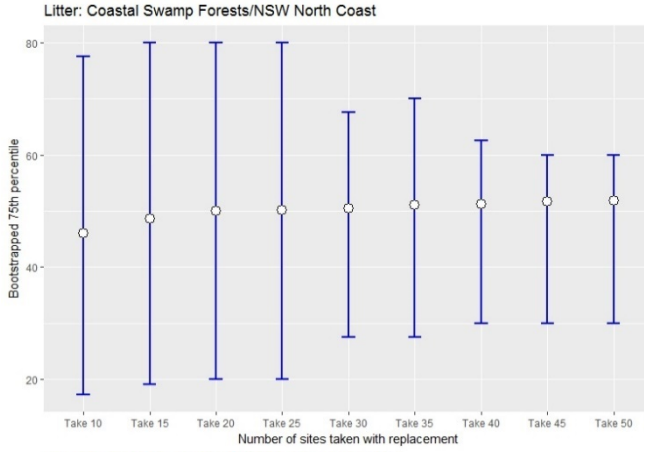
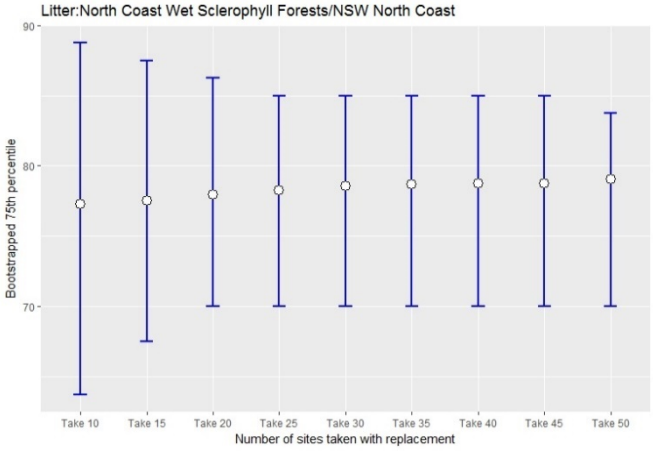


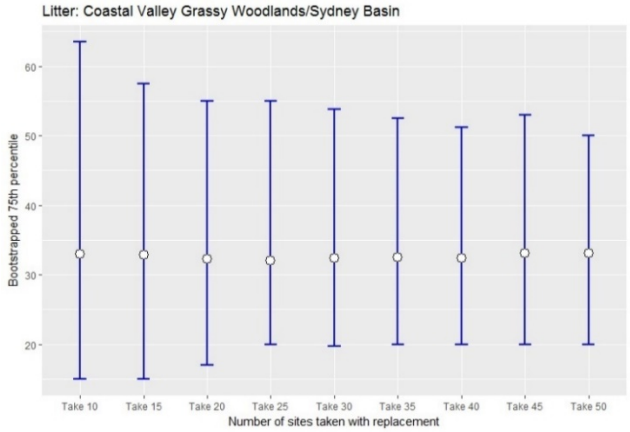
Figure 2 **Bootstrapping analysis of the logs 75th percentile benchmark value for n = 10, 15, 20, 25, 30, 35, 40, 45, 50 sites**

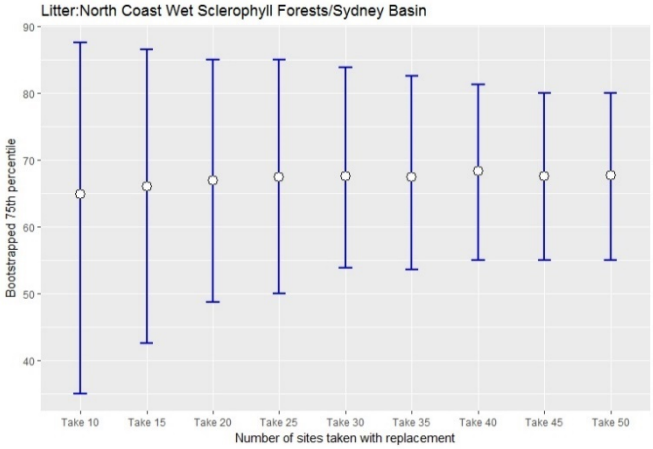

Litter: Western Slopes Grassy Woodlands/Brigalow Belt South
Bootstrapped 75th percentile
Number of sites taken with replacement
Take 10
Take 15
Take 20
Take 25
Take 30
Take 35
Take 40
Take 45
Take 50

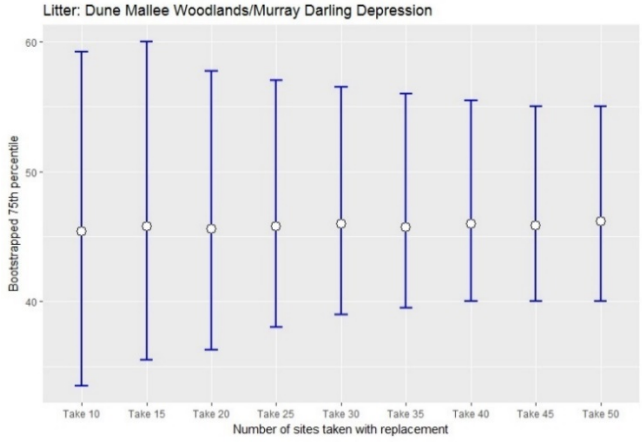

Litter:Inland Riverine Forests/Riverina
Bootstrapped 75th percentile
Number of sites taken with replacement

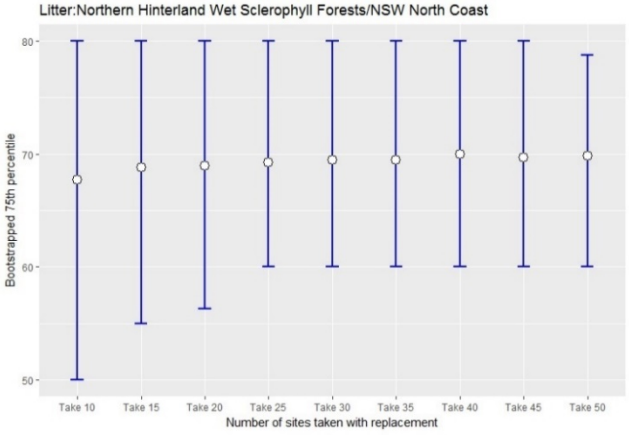

Litter: Coastal Swamp Forests/NSW North Coast
Bootstrapped 75th percentile
Number of sites taken with replacement


Litter:North Coast Wet Sclerophyll Forests/NSW North Coast
Bootstrapped 75th percentile
Number of sites taken with replacement


Litter: Coastal Valley Grassy Woodlands/Sydney Basin
Bootstrapped 75th percentile
Number of sites taken with replacement


Litter:North Coast Wet Sclerophyll Forests/Sydney Basin
Bootstrapped 75th percentile
Number of sites taken with replacement


Litter: Dune Mallee Woodlands/Murray Darling Depression
Bootstrapped 75th percentile
Number of sites taken with replacement


Litter:Northern Hinterland Wet Sclerophyll Forests/NSW North Coast
Bootstrapped 75th percentile
Number of sites taken with replacement

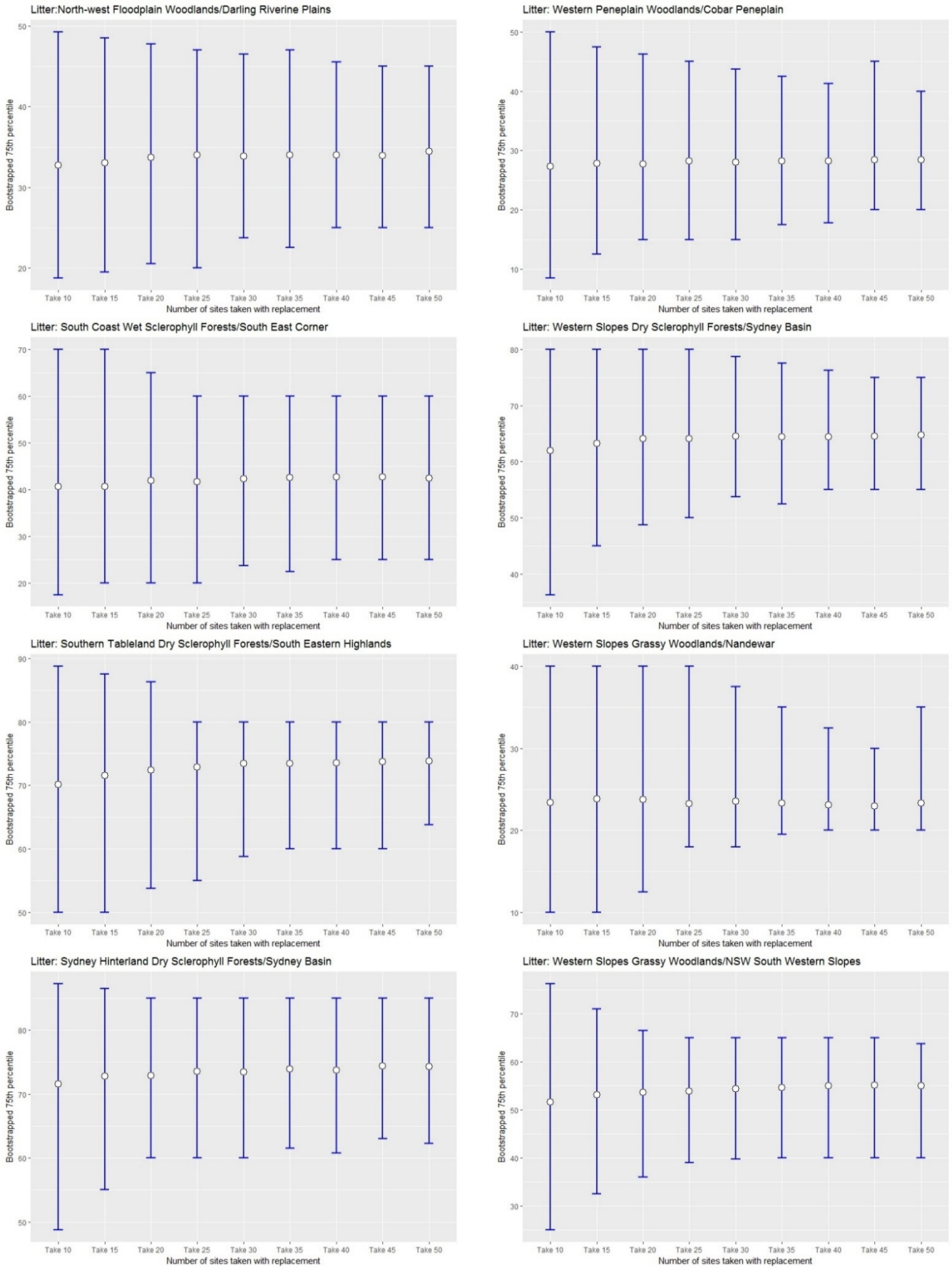


Figure 3 **Bootstrapping analysis of the litter 75th percentile benchmark value for n = 10, 15, 20, 25, 30, 35, 40, 45, 50 sites**

13.4 Appendix IV Data sources used in the generation of Function Benchmarks

Raw data files used in the creation of Function attributes can be found at;

- Vegetation Condition Benchmarks Litter raw data V1.2
- Vegetation Condition Benchmarks Logs raw data V1.2
- Vegetation Condition Benchmarks Stems raw data V1.2

Table 21 Data sources used in the generation of Function Benchmarks

Function attribute	Function analysis database query	Query export file	R script	R export file
Litter Cover	qry_Litter	qry_Litter.csv	benchmark7_CalcOnly_Litter_cw20170706.R	Benchmarks_litter_allPerc_allLevels.csv
Woody Debris	qry_Logs	qry_Logs.csv	benchmark7_CalcOnly_Logs_cw20170706.R	Benchmarks_logs_allPerc_allLevels.csv
Large Trees	qry_allStems_Date	qry_allStems_Date.csv	benchmark7_CalcOnly_Stems_cw20170706.R	LargeTrees_benchmarkdataNewFormat.csv