



Compilation and Validation of State Forests Flora Data – Eden CRA Region

A report undertaken for the NSW CRA/RFA Steering Committee

24 November 1997



COMPILATION AND VALIDATION OF STATE FORESTS FLORA DATA – EDEN CRA REGION

PREPARED BY STATE FORESTS OF NSW

**A report undertaken for the NSW CRA/RFA Steering
Committee
project number NE03/EH**

24 November 1997

Report Status

This report has been prepared as a working paper for the NSW CRA/RFA Steering Committee under the direction of the Environment and Heritage Technical Committee. It is recognised that it may contain errors that require correction but it is released to be consistent with the principle that information related to the comprehensive regional assessment process in New South Wales will be made publicly available.



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This project has been jointly funded by the New South Wales and Commonwealth Governments. The work undertaken within this project has been managed by the joint NSW / Commonwealth CRA/RFA Steering Committee which includes representatives from the NSW and Commonwealth Governments and stakeholder groups.

The project has been overseen and the methodology has been developed through the Environment and Heritage Technical Committee which includes representatives from the NSW and Commonwealth Governments and stakeholder groups.

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EXECUTIVE SUMMARY

This report has been prepared for the joint Commonwealth/State Steering Committee which oversees the comprehensive regional assessments of forests in New South Wales.

The comprehensive regional assessments (CRAs) provide the scientific basis on which the State and Commonwealth governments will sign regional forest agreements (RFAs) for the major forests of New South Wales. These agreements will determine the future of the State's forests, providing a balance between conservation and ecologically sustainable use of forest resources. This report was undertaken to compile and validate all flora data belonging to State Forests of NSW (SFNSW) from the Eden CRA Region. This data was made available for use in other projects identified in the Technical Framework. Flora data is a basic and consistent theme of a number of CRA projects, including vegetation mapping, ecosystem derivation, disturbance modelling, threatened species assessments and the development ecologically sustainable forest management (ESFM) systems.

Flora data was compiled from various State Forests sources, including research plots, District surveys, Environmental Impact Statement (EIS) and forest resource surveys and miscellaneous flora surveys and observations. The relevant methodologies for the field collection of this data are varied and are documented in this project report. Data was subject to spatial validation and species distribution validation.

The project enabled data from fifteen systematic plot based flora surveys to be compiled and validated prior to incorporation into SFNSW' Flora Database. This process resulted in a total of 57 617 validated records of 824 species from 15 surveys - an increase in records of over 1 000%. Prior to the commencement of this project there were no miscellaneous records of flora species in the Eden region available through the SFNSW' Flora Database. This project has assisted in the compilation and validation of nearly 30 000 miscellaneous records of around 940 species. In total this compilation project has resulted in the addition of more than 80 000 records of flora species in the Eden CRA region to SFNSW' Flora Database. These records are available for use in the Eden CRA/RFA process.

The data compiled and validated through this project has been supplied to National Parks and Wildlife Service (NPWS) for use in the Eden Vegetation Mapping Project. This project has made extensive use of this data set, and others, during the analysis and validation phases completed from June-August 1997. Furthermore, data compiled by this project has also been used by the Eden CRA Response to Disturbance flora project to establish the spatial database and guide the application of the reservation and management targets.

1 INTRODUCTION

This project has been undertaken in order to enter, compile and validate all State Forests of NSW (SFNSW) flora data for use in the Comprehensive Regional Assessment (CRA) of the Eden CRA Region, in accordance with the Project Specifications (Attachment 1).

The objectives of this project were to:

1. develop a directory of all flora data collected by SFNSW, or consultants to SFNSW for the Eden CRA region;
2. develop a priority list, based on the above data directory, of data sets to be entered, compiled and validated according to the Eden CRA region timetable;
3. develop a program to achieve the above; and
4. progressively enter (where necessary), compile, validate and document the above datasets according to the standards prescribed for SFNSW' Flora Database, which has been modelled on the National Parks and Wildlife Service (NPWS) Atlas of NSW Wildlife.

The following report details the steps which have been taken to achieve these objectives and a summary of the outputs of the project.

2 DEVELOPMENT OF STATE FORESTS DATA DIRECTORY - OBJECTIVE 1

A preliminary list of the data available for the Eden CRA region was generated for this project's proposal to the NSW CRA/RFA Environment and Heritage Technical Committee on January 28, 1997, this list is shown in Appendix 1 of the Project Specifications (Attachment 1). This list is reproduced in the table below with additional data sets found to occur within the Eden CRA region. In addition to the data set name this table also indicates where (if at all) the data has been published, the ID codes used to identify each data set in the final data set and the type of data contained in each data set.

The fields used in this table are as follows:

✦ **Ref No** - number by which the data set is identified and cross-referenced within this report.

- ✦ **Project** - informal name of data set.
- ✦ **Publication** - indicates the name of the publication in which the methodology of data collection for each dataset is explained.
- ✦ **Id Code** - data set records are tagged with these values to indicate to which data set they belong.
- ✦ **Data Type** - indicates whether the data was collected as part of a formal plot based flora survey (P) or whether the records were collected incidentally or as part of an informal survey.

TABLE 1: DIRECTORY OF FLORA DATA HELD BY SFNSW FOR THE EDEN CRA REGION.

Ref No.	PROJECT	PUBLICATION	Id Codes for Data	Data Type
1	Burning Study Area	Not yet published See Appendix A for project documentation	BSA_MUS BSA_VEG	P
2	Yambulla Catchment Experiment	Not yet published See Appendix B for project documentation	YAMBULLA	P
3	Rockton Section, Bondi SF	Fanning, F.D. and Mills, K. (1989) Natural Resource Survey of the Southern Portion of Rockton Section, Bondi State Forest. Forest Resources Series No. 6. Forestry Commission of NSW.	FRS_6	P
4	Rockton Section, Bondi SF	Fanning, F.D. and Rice, B. (1989) Natural Resource Survey of the Northern Portion of Rockton Section, Bondi State Forest. Forest Resources Series No. 7. Forestry Commission of NSW.	FRS_7	P

Ref No.	PROJECT	PUBLICATION	Id Codes for Data	Data Type
5	Nullica SF	Binns, D.L. and Kavanagh, R.P. (1990). Flora and fauna survey of Nullica State Forest (part), Eden District, Eden Region, south-eastern New South Wales. Forest Resources Series No. 10. Forestry Commission of New South Wales.	EEDENUL	P
6	Nullica SF	Fanning, F.D. and Clark, S.S. (1991) Flora and Fauna Survey of Jingo Creek Catchment, Nullica State Forest, Eden Region. Forest Resources Series No. 14. Forestry Commission of NSW.	FRS_14	P
7	Nalbaugh SF	Binns, D.L. and Kavanagh, R.P. (1990). Flora and fauna survey of Nalbaugh State Forest (part), Bombala District, Eden Region, south-eastern New South Wales. Forest Resources Series No. 9. Forestry Commission of New South Wales.	EEDENAL	P
8	Tantawangalo SF	Dodson, J.R., Kodela, P.G. and Myers, C.A. (1988) Vegetation Survey of the Tantawangalo Research Catchments in the Eden Forestry Region, New South Wales. Forest Resources Series No. 4. Forestry Commission of NSW.	FRS_4	P
9	Coolangubra SF - Myanba Creek	Fanning, F.D. and Mills, K. (1990) Flora and Fauna of the Myanba Creek Catchment, Coolangubra State Forest, Eden Region. Forest Resources Series No. 11. Forestry Commission of NSW	FRS_11	P
10	Coolangubra SF - Wog Wog River	Fanning, F.D. and Fatchen, T.J. (1990) The Upper Wog Wog River Catchment of Coolangubra and Nalbaugh State Forest, (Mines Road Area) New South Wales. Forest Resources Series No. 12. Forestry Commission of NSW.	FRS_12	P
11	Waratah Creek monitoring study	Unpublished PhD thesis: Shields, J.M. (1990). The effects of Logging on Bird Populations in Southeastern New South Wales. University of Washington. Data collection methodology outlined in Appendix C	WARAT_CK	M
12	Eden Management Area rapid coupe surveys (including pre-logging ROTAP surveys) - (Eden MA occurs in both Eden and Narooma districts)	Data not published Methodology outlined in Eden EIS SFNSW (1994) Proposed Forestry Operations in the Eden Management Area. Volume A. Environmental Impact Statement. Main Report. SFNSW (1994) Proposed Forestry Operations in the Eden Management Area. Volume B. Environmental Impact Statement. Appendix 1 (Fauna Impact Statement).	DIST_DATA	M
13	Permanent Growth Plots	Unpublished Data collection methodology outlined in Appendix C	PGP_DATA	M
Additional Data not previously listed or detailed in Appendix 1 of Schedule 1.				
14	Coolangubra SF - Stockyard Creek	Fanning, F.D. and Mills, K. (1990) The Stockyard Creek Catchment of Coolangubra State Forest, New South Wales, A Fauna and Flora Survey. Forest Resources Series No. 13. Forestry Commission of NSW.	FRS_13	P
15	Coolangubra Escarpment Flora Reserve	Unpublished. Data collected according to York et al. (1991) guidelines York, A., Binns, D. & Shields, J. (1991) Flora and fauna assessment in NSW State forests. Survey Guidelines. Procedures for sampling flora and fauna for Environmental Impact Statements. Version 1.1a.	CENP	P
16	Illawambra Flora Reserve	Unpublished. Data collected according to York et al. (1991) guidelines York, A., Binns, D. & Shields, J. (1991) Flora and fauna assessment in NSW State forests. Survey Guidelines. Procedures for sampling flora and fauna for Environmental Impact Statements. Version 1.1a.	IBFR	P

Ref No.	PROJECT	PUBLICATION	Id Codes for Data	Data Type
17	Mt Poole Flora Reserve	Unpublished. Data collected according to York et al. (1991) guidelines York, A., Binns, D. & Shields, J. (1991) Flora and fauna assessment in NSW State forests. Survey Guidelines. Procedures for sampling flora and fauna for Environmental Impact Statements. Version 1.1a.	MPFR	P
18	Mt Waalimma Flora Reserve	Unpublished. Data collected according to York et al. (1991) guidelines York, A., Binns, D. & Shields, J. (1991) Flora and fauna assessment in NSW State forests. Survey Guidelines. Procedures for sampling flora and fauna for Environmental Impact Statements. Version 1.1a.	WAALFR	P
19	Miscellaneous records	Binns, D.L. (1988) A preliminary list of vascular plant species for far south-eastern NSW. Research Paper No. 4. Forestry Commission of New South Wales.	BINNSLIST	M
20	Miscellaneous records	Unpublished	MISC_SRES	M

33. DEVELOP PRIORITY LIST AND PROGRAM - OBJECTIVES 2 AND 3

The priority list developed for the entry, compilation and validation of the individual data sets, identified in Table 1, was based on the requirement of preparing and making data available as required for the Eden CRA region timetable. Data compiled as a result of this project contributes directly to the CRA/RFA process through its input to the forest ecosystems project area -Vegetation classification/mapping (see Attachment 2). At the time of commencement of this data compilation project, the Eden CRA region Vegetation Mapping Project, to be co-ordinated by NSW NPWS had not yet been approved by the NSW CRA/RFA Steering Committee. Assuming that the NPWS co-ordinated Vegetation Mapping Project would be

approved, the priority list and program for the entry, compilation and validation of State Forests flora data was developed to coincide with expected data and validation requirements and the timing of the NPWS co-ordinated Vegetation Mapping Project. As such, all systematically collected full floristic plot based flora data (eg York *et al.*, 1991) was required initially by the NPWS co-ordinated Vegetation Mapping Project, followed by other miscellaneous flora records used in model validation and threatened species analyses. The data requirement deadlines were reflected within the milestones timetable of the original Project Specifications (Attachment 1, page 4).

4 COMPILATION, VALIDATION AND DOCUMENTATION OF DATASETS - OBJECTIVE 4

4.1 4.1 DATA COMPILATION

The following table indicates the format in which data from the identified sources was available prior to the commencement of the compilation project. It also shows what action was necessary

to convert these data sets into a format that could be integrated into SFNSW' Flora Database and would meet the data and model validation requirements of the NPWS co-ordinated Vegetation Mapping Project.

TABLE 2: AVAILABILITY AND FORMAT OF DATA SETS PRIOR TO COMMENCEMENT OF THE COMPILATION PROJECT AND THE NECESSARY ACTION REQUIRED TO PREPARE DATA SETS FOR USE IN THE CRA/RFA PROCESS.

Ref No.	Survey	Status Pre-project	Action
1	Burning Study Area	Data available digitally (recently entered by Research Division).	Reformat and add to Flora Database. GIS to attach some spatial attributes.
2	Yambulla catchment experiments	Data available digitally (recently entered by Research Division).	Reformat and add to Flora Database. GIS to attach some spatial attributes.
3	Natural Resource Survey of the Southern Portion of Rockton Section, Bondi SF	70% of data was available in a formatted word document. The remaining 30% was available only in hard copy.	Electronic data had to be reformatted, added to the Flora Database. Hard copy data was entered to template files and added to the Flora Database.
4	Natural Resource Survey of the Northern Portion of Rockton Section, Bondi SF	90% of data was available in a formatted word document. The remaining 10% was available only in hard copy.	Electronic data had to be reformatted, added to the Flora Database. Hard copy data was entered to template files and added to the Flora Database.
5	Nullica SF Flora Survey	Data had been added to SFNSW' central database as a part of an IAP project	Data previously compiled for the IAP. Data had only to be extracted from the Flora Database to be re-supplied.
6	Flora and Fauna Survey of Jingo Creek Catchment	Data available only in hard copy format.	Data was entered to template files and added to the Flora Database.
7	Nalbaugh SF Flora Survey	Data had been added to SFNSW' central database as a part of an IAP project	Data previously compiled for the IAP. Data had only to be extracted from the Flora Database to be re-supplied.
8	Vegetation Survey of the Tantawangalo Research Catchments	Data available only in hard copy format.	Data was entered to template files and added to the Flora Database.

Ref No.	Survey	Status Pre-project	Action
9	Flora and Fauna Survey of the Myanba Creek Catchment	95% of data was available in a formatted word document. The remaining 5% was available only in hard copy.	Electronic data had to be reformatted, added to the Flora Database. Hard copy data was entered to template files and added to the Flora Database.
10	Fauna and Flora Survey of the Upper Wog Wog River Catchment	95% of data was available in a formatted word document. The remaining 5% was available only in hard copy.	Electronic data had to be reformatted, added to the Flora Database. Hard copy data was entered to template files and added to the Flora Database.
11	Waratah Creek monitoring study	Data available variously in electronic format	Electronic data had to be reformatted, added to the Flora Database. Hard copy data was entered to template files and added to the Flora Database.
12	District compartment harvesting plans	90% of data available as hard copy only.	Data was entered to suit Flora Database format.
13	Floristic data from State Forests Permanent Growth Plots	Data available digitally though a large amount of re-coding necessary.	Recode and reformat data for addition to the Flora Database. GIS to attach some spatial attributes.
14	Fauna and Flora Survey of the Stockyard Creek Catchment	95% of data was available in a formatted word document. The remaining 5% was available only in hard copy.	Electronic data had to be reformatted, added to the Flora Database. Hard copy data was entered to template files and added to the Flora Database.
15	Flora Survey of Coolangubra Escarpment Flora Reserve	Data available digitally.	Reformat and add to Flora Database. GIS to attach some spatial attributes.
16	Illawambra Flora Reserve Flora Survey	Data available digitally.	Reformat and add to Flora Database. GIS to attach some spatial attributes.
17	Mt Poole Flora Reserve Flora Survey	Data available digitally.	Reformat and add to Flora Database. GIS to attach some spatial attributes.
18	Mt Waalimma Flora Reserve Flora Survey	Data available digitally.	Reformat and add to Flora Database. GIS to attach some spatial attributes.
19	Miscellaneous records held by Southern Research	Data available digitally.	Reformat and add to Flora Database. GIS to attach some spatial attributes.
20	Other miscellaneous records held by Southern Research	Up to 90% of data available only as hard copy.	Data was entered to suit Flora Database format.

4.2 4.2 VALIDATION OF DATA

SFNSW' flora data undergoes two processes of validation, these are spatial validation and species distribution validation.

Spatial validation is conducted by SFNSW' Geographic Information Systems (GIS) Branch using the point co-ordinates of a record. Each flora record must be spatially referenced by either Australian Map Grid (AMG) co-ordinates or latitude and longitude co-ordinates (which must be converted to AMG co-ordinates). Where flora data has been collected with other State forests location codes (such as District Id, Management Area Id etc) the AMG is used to cross-reference the record location. Where no other location information is recorded, the AMGs are used to assign State forests location codes to a record. The AMG co-ordinates are also used to determine the 1:25 000 topographic mapsheet on which the

species was recorded, which is used for the species distribution validation.

Species distribution validation is used to determine whether the recorded species has been found within its accepted limits of distribution. At present, the most accurate information on the accepted limits of distribution of flora species in New South Wales available from Harden's Flora of NSW (1990 to 1993). This source describes the distribution of all flora species in New South Wales in terms of botanical zones. As such, the only available information on the distribution of flora species is their occurrence by botanical zone. Distribution by botanical zone is also used by NPWS for validation of flora records in the Atlas of NSW Wildlife.

Using the AMGs to determine the 1:25 000 topographic mapsheet on which the species was recorded, and with reference to a botanical zone by mapsheet table created by SFNSW, it can be

determined whether the species recorded is within its accepted limits of distribution. Where the species recorded is considered to be outside its accepted distribution, its level of identification is reduced to genus level. If the genus is found also to be outside its normal accepted distribution, the record is removed from the data set and archived, together with a record history. Archived data will be checked periodically in the event that the record becomes valid with increasing knowledge and extension of the range of known distributions of individual species.

For example, if a record for *Dennstaedtia davallioides* (accepted to occur in Botanical Zones NC, CC and CT) has been recorded in the South Coast Botanical Division, it is considered

likely to be a misidentified species of the *Dennstaedtia* genus, the record is therefore reduced to indicate the presence of a *Dennstaedtia* species. The likelihood of any species of the *Dennstaedtia* genus occurring in the South Coast Botanical Zone is then assessed. As no member of this genus is accepted as occurring within the South Coast Zone, the record must be removed from the dataset.

The statistics associated with the outcomes of species distribution validation of each of the datasets are indicated in Table 3 below. This table also indicates the final number of species recorded and the number of records contained in the final validated dataset sent to NPWS.

TABLE 3: STATISTICS OF DATASETS FOLLOWING VALIDATION

Ref No.	Survey	No. plots	No. records	Action required to validate records			Final number of species recorded
				Number of species Re-identified	Number of species reduced to genus level	Number of species archived	
1	Burning Study Area	216	12626	-	1	4	261
2	Yambulla Catchment Experiment	448	22826	3	12	2	302
3	Rockton Section, Bondi SF	71	1372	-	1	-	192
4	Rockton Section, Bondi SF	50	1505	-	2	-	182
5	Nullica SF	91	3303	-	-	-	367
6	Nullica SF	66	1778	-	2	-	223
7	Nalbaugh SF	62	2364	-	-	1	262
8	Tantawangalo SF	30	949	-	-	-	110
9	Coolangubra SF - Myanba Creek	107	2574	1	-	-	263
10	Coolangubra SF - Wog Wog R.	113	3526	1	2	3	274
11	Waratah Creek monitoring study	123	1347	-	4	-	85
12	District cmpt harvesting plans	436	19133	-	16	1	634
13	Permanent Growth Plots	23	185	-	5	1	62
14	Coolangubra SF - Stockyard Ck	66	1822	1	12	2	208
15	Coolangubra Escarpment FR	23	697	-	18	11	177
16	Illawambra Flora Reserve	22	811	1	3	-	165
17	Mt Poole Flora Reserve	25	845	2	7	2	203
18	Mt Waalimma Flora Reserve	23	669	1	6	-	178
19	Miscellaneous records held by Southern Research		6198	2	32	7	641
20	Other miscellaneous records held by Southern Research		3078	3	22	6	537

4.3 4.3 DATA DOCUMENTATION

Documentation on the methods of data collection has been provided for data sets of projects which have not yet been published. Documentation has been provided for data from the following sources:

✦ Burning Study Area (Appendix A)

✦ Yambulla Catchment Experiment (Appendix B)

✦ Permanent Growth Plots (Appendix C)

✦ Waratah Creek Monitoring Study (Appendix C)

The methods used for collection of data for the other unpublished projects have been cited in Table 1.

4.4 4.4 DATA OUTPUTS

Following the completion of a Data Licence Agreement for use of SFNSW flora data for the NPWS co-ordinated Vegetation Mapping Project (Attachment 3), data was sent via e-mail to the NPWS Southern Zone in Queanbeyan. The files to be created from this compilation project and the fields they contain are detailed in Annexure A of the Data Licence Agreement with NPWS (Attachment 3).

The initial dataset set sent successfully on March 18, 1997, contained invalidated plot based flora

data from 14 of the 15 plot based data sets. The remaining invalidated plot based data was successfully sent to NPWS by March 25, 1997. These datasets were then validated, with the final complete validated dataset being e-mailed successfully to NPWS Southern Zone office in Queanbeyan on May 9, 1997. Details of the compilation and validation procedure followed to create these files may be found in Sections 4.1 and 4.2 of this report.

Datasets containing miscellaneous records were validated prior to being sent to NPWS Southern Zone office in Queanbeyan on May 14, 1997. Details of the compilation and validation procedure followed to create these files may be found in Sections 4.1 and 4.2 of this report.

55. CONCLUSION

The main aim of this project was to compile and validate all flora data belonging to SFNSW from the Eden CRA region, and to make this data available for use in the Eden CRA.

Prior to the commencement of this project the SFNSW Flora Database contained records from two plot based flora surveys. This project has assisted in the addition of data from a further 13 plot based surveys to the database. This results in a total of 57 617 validated records of 824 species from 15 surveys - an increase in records of over 1 000%.

Prior to the commencement of this project there were no miscellaneous records of flora species in the Eden region available through the SFNSW'

Flora Database. This project has assisted in the compilation and validation of nearly 30 000 miscellaneous records of around 940 species.

In total this compilation project has resulted in the addition of more than 80 000 records of flora species in the Eden CRA region to SFNSW' Flora Database. These records are all now available for use in the Eden CRA/RFA process. The attached map shows the location of the newly compiled records, as well as the location of those records available prior to this compilation project.

The data compiled and validated through this project has been supplied to NPWS for use in the Eden Vegetation Mapping Project.

66. REFERENCES

Harden, G.H.(Ed) (1990) *Flora of New South Wales*. Volume 1. University of New South Wales Press; Kensington Sydney.

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Harden, G.H.(Ed) (1993) *Flora of New South Wales*. Volume 4. University of New South Wales Press; Kensington Sydney.

Shields, J.M. (1990). *The effects of Logging on Bird Populations in Southeastern New South Wales*. Unpublished PhD thesis, University of Washington.

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APPENDIX A

EDEN BURNING STUDY

AREA - VEGETATION DATA

INTRODUCTION

The Eden Burning Study Area (EBSA) was established in the years leading up to and during 1987/88. The intention was “to establish a burning study area capable of being maintained for a period greater than 50 years.” The EBSA which is located in the Faulkner section of Yambulla State Forest, 29 km south west of Eden, provides a secure location for such a long term project to be successfully completed. The study area is bounded on the north-east by Imlay Road and on the south-west by the Wallagaraugh River. The study area covers 1 080 ha and comprises seven compartments numbered from 417 to 423 inclusive. The actual treatment area consists of five compartments, being 417 to 421, covering 835 ha. Compartments 422 and 423 are untreated and form a protective buffer on the north west side of the study.

The EBSA aims to examine the effects of integrated harvesting and fuel reduction burning regimes on dry sclerophyll forests (Silvertop Ash - Stringybark forest type). The objectives of the understorey vegetation component are:

- ✎ To describe pre-treatment patterns of floristic variation in relation to broad habitat parameters;
- ✎ To investigate impact of treatments on understorey floristic patterns;
- ✎ To investigate response of individual species to treatments, e.g. changes in abundance, response mechanisms, patterns of recovery and reproduction.

EXPERIMENTAL TREATMENT AND DESIGN

Two logging treatments and three burning treatments are being investigated by the EBSA

experiment. The combination of logging and burning regimes produces six treatments (Table 1).

TABLE 1: LOGGING AND BURNING TREATMENTS APPLIED TO EBSA

Abbr	Description	Fire Regime
UU	Unlogged, Unburnt	No planned burning
UR	Unlogged, Routine burn	Burning at year 4, then 4 year intervals.
UF	Unlogged, Frequent burn	Burning at year 2, then 2 year intervals.
LU	Logged, Unburnt	No planned burning
LR	Logged, Routine burn	Burning at about year 12, then 4 year intervals
LF	Logged, Frequent burn	Burning at year 0 (immediately post-logging), then at 2 year intervals

Year 0 is taken as 1988, the year of completion of logging treatment.

Each treatment has been replicated three times requiring eighteen distinct treatment areas. The treatment areas were defined according to logical segregation by tracks and drainage lines and treatments were allocated randomly. The treatment areas are herein referred to as “blocks” to avoid confusion with measurement plots, even though they are not blocks in the statistical sense of a randomised block design. Table 2 shows the allocation of block by treatment and replicate. All treatment blocks in the EBSA are of coupe size, while not necessarily retaining original coupe boundaries. This allows treatments to be applied at an operational scale. The average coupe size was 40-50 ha in the Eden management area at the time the experiment was established. The treatment blocks in the EBSA range from approximately 11 ha to 56 ha. This approach incorporates the variability and scale of forest operations into the study.

TABLE 2: BLOCK ALLOCATION BY TREATMENT AND REPLICATE

TREATMENT		BLOCK NUMBER		
		REP 1	REP 2	REP 3
Unlogged Unburnt	UU	14	15	16
Logged Unburnt	LN	1	12	17
Unlogged Frequent Burn	UF	7	5	20
Logged Frequent Burn	LF	3	2	9
Unlogged Routine Burn	UR	19	10	13
Logged Routine Burn	LR	11	4	6

The logged blocks were logged according to the Eden District's then current planning procedure and logging practice. The only difference was that the alternate coupe logging pattern was modified due to the random allocation of the treatments. All logging treatments were carried out between the 7/11/87 and 1/4/88, with sawlogs and pulpwood being extracted in an integrated operation. The average size of logging coupes was 37 ha. All logging treatments were conducted in accordance with harvesting plans prepared by the Eden district of NSW State Forests.

Routine burning according to the Fire Management Policy for Eden Region (Appendix 26 of the Eden Native Forest Management Plan, 1982) consists of post log burning of logged coupes in the autumn following logging; and fuel reduction burning in logged and unlogged coupes, commencing when regrowth is large enough to tolerate fire. The routine burning applied to the EBSA varied from this in that burning was applied to unlogged blocks in year four, but is planned for logged blocks in about year 12, when regrowth reaches sufficient size. Subsequent fires in both logged and unlogged blocks are planned at four year intervals. Frequent burning was applied experimentally as post-log burning of logged coupes in the autumn following logging (1988) and fuel reduction burning in logged and unlogged coupes at two year intervals. Unlogged blocks were first burnt in 1990. The aim of frequent burning is to maintain fine fuel weights at low levels, particularly during the early phase of development in regrowth stands.

DATA COLLECTION

Data for understorey species is collected from plots at 12 points in each block, a total of 216

sample points. Each block is divided into four approximately equal sized regions, and three plot points are randomly located in each of these regions giving 12 plots per block. To minimise trampling effects from intensive measurement these sample points were located to be mutually exclusive from the overstorey datum points. If a plot point fell within areas being used for other assessment or on a track or log dump then the point was moved along the bearing at 10 m intervals until free of interference. The intention was that plots could be stratified by floristic composition following the initial measurement. These plots are permanently marked in the field with steel fence droppers and their position is recorded on study area maps. Two reference trees were blazed at ground level and marked with orange paint. Bearings and distances have been recorded to these reference trees.

Understorey vegetation is assessed at the twelve sample points per block as three separate components:

- ✧ Large shrubs/small trees - Woody vegetation greater than 3 m tall and less than 10 cm dbh.
- ✧ Small shrubs - Woody vegetation greater than 1 m tall and less than 3 m tall.
- ✧ Ground cover - All vegetation less than 1 m tall and all herbaceous vegetation regardless of height, of vascular plant species only. Arborescent ferns and monocotyledons over 1 m are excluded and foliage of woody plants is excluded unless the maximum height of the plant is below 1 m.

Large shrub plots are circular, with a variable radius up to a maximum of 5.64 m. The radius is determined as the average distance to the plot centre from the tenth and eleventh shrub. For the initial assessment, a maximum of ten shrubs were measured at each plot, according to a variable radius plot using radii of 0.56 m, 1.26 m, 1.78 m, 2.52 m, 3.99 m or 5.64 m. The 10 (or less) individuals measured for each plot are tagged and numbered. Each individual is given a unique number for the plot, sequentially beginning at one. The number is impressed on a stainless steel tag and attached to a stainless steel peg inserted in the ground at the base of the shrub. Multi-stemmed individuals are regarded as a single unit. A plant is considered to be within a plot if >50% of its stem cross sectional area at ground level is within the plot. Height is measured as the straight

line distance from the base of a plant to the highest point of its live foliage.

Details recorded in large shrub plots are height, distance from plot centre, bearing from plot centre (magnetic compass bearing) and appropriate plot radius for the measured individual. Additional parameters recorded following initial treatment were: treatment affect and post treatment response. For second and subsequent assessments, the only modification to the measurement method was the use of variable radius plots recording the plot radius as the mean of the distance to the 10th and 11th plants, for each plot where there were more than 10 individuals of a species within the radius of 5.64 m. Any plants which have died since previous measurement are recorded as a mortality and subsequently not measured. All plants remaining alive will continue to be measured, regardless of total height.

Small shrub plots were assessed in a similar manner to large shrubs plots, but with a maximum radius of 3.99 m.

Ground cover plots are 5.64 m radius circles. Eight square quadrats are located within each plot according to a random bearing and distance. Location of the square quadrat plots at each understorey plot adhered to the following procedure: one corner of the quadrat to be located at the random bearing and distance, the quadrat aligned diagonally outwards along bearing, the near corner is marked with a pigtail pin and orange flagging tape, the side pins are marked with small stainless steel pegs. The quadrats are 0.5×0.5 m therefore 0.25 m^2 and are divided into 16 subdivisions. For each subdivision every

ground cover species with living parts intersecting the perpendicular (i.e. not always vertical) projection of the subdivision is recorded as present and identified to species level. A plant does not need to be rooted within the quadrat to be recorded. Data is recorded as either present or filling (projected cover > 80%) a subdivision. Exposed rock, logs and lichen and moss are also recorded in this way.

Field measurement procedures are detailed in Appendix 1.

Immediately after logging, plots were measured, logging effect recorded and the following assessments made:

- ✘ visual estimate of 5.64 m plot disturbance as a proportion to nearest 10%,
- ✘ major type of logging disturbance coded for each of the 16 ground cover quadrat subdivisions,
- ✘ for each tagged plant the type and extent of logging damage was recorded in one of nine categories.

Fire effect was assessed as for logging effect: for the 5.64 m radius, for each quadrat and for individual tagged plants.

VEGETATION ASSESSMENT

There have been three complete assessments of large shrubs, small shrubs and ground cover vegetation, to end 1996 (Table 3).

About 250 vascular plant species were recorded during the initial assessment.

TABLE 3: UNDERSTOREY VEGETATION ASSESSMENTS COMPLETED FOR THE EBSA.

Treatment	Block	A1	A2	A3
UN	14	Dec 1988 - Jan 1989	NA	Mar 1995
	15	Oct - Dec 1988	NA	Mar - Apr 1995
	16	Jan - Oct 1988	NA	Apr 1995
UR	10	Feb - Apr 1987	NA	Jan - Feb 1994
	13	Nov - Dec 1987	NA	May - Jun 1994
	19	Sep - Oct 1987	NA	Feb - Mar 1993
UF	5	May - Aug 1987	NA	Sep - Oct 1993
	7	Aug - Sep 1987	NA	Jan - Feb 1993
	20	Oct - Nov 1987	NA	Feb - Mar 1994
LU	1	Jul 1985, Feb 1986	Jul - Aug 1990	Jun - Jul 1994
	12	Mar - Apr 1986	Feb - Apr 1989	Jul - Dec 1996
	17	Feb - Dec 1986	Mar - Apr 1990	Oct - Dec 1996
LR	4	Mar - Nov 1986	Apr - Jun 1989	Jul 1995 - Jul 1996
	6	Jul - Aug 1986	Apr - Jun 1990	Aug - Sep 1995

Treatment	Block	A1	A2	A3
	11	Jan - Nov 1986	Feb - Mar 1989	Aug - Oct 1996
LF	2	Jul 1985 - Mar 1986	Aug - Nov 1989	Jul - Aug 1993
	3	Jun 1986, Jan 1987	Nov - Dec 1989	Mar - Apr 1994
	9	Jun - Oct 1986	Feb - Mar 1990	Aug - Sep 1993

NA = no assessment scheduled

APPENDIX 1: FIELD PROCEDURES FOR MEASURING UNDERSTOREY VEGETATION

6.1.1.1 Woody vegetation, > 1 m tall.

1. For data recording use “listings” of previous measurements.
2. Ensure that an entry is made for all previously recorded individuals.
3. (Initial assessment only) LOG TR = Logging treatment. Enter 0 for unlogged, 1 for logged. This refers to block treatment not plot treatment, therefore an unlogged plot in a logged block would have LOG TR recorded as 1.
4. (Initial assessment only) B TR = Burning Treatment. Enter 0 for unburnt, 1 for routine burn, 2 for frequent burn. Again this applies to block treatment not plot treatment.
5. PLOT RAD = Plot radius appropriate to particular species and size classes. Leave blank if no change from previously recorded radius or if no radius needs to be recorded (e.g. for status M or A plants (see point 12) or those reduced below the minimum height). Originally a set radius was used to accommodate about 10 individuals but when more than 10 individuals were present in the maximum radius, this caused practical difficulties during the initial measurement. In future measurements these will be changed to a variable radius based on 10 individuals. The radius will be recorded as the mean distance to the 10th and 11th closest individual of a species/size category. However, the previous radii should not be changed unless necessary. Ensure that a radius is recorded for every individual of a species/size category which is affected by a change in radius. The following guidelines also apply:
 - If a plot radius is changed, it is only necessary to record the new radius for any

- one individual in a size/species class. This is then automatically applied to all in that class.
 - If there are more than five individuals in a species/height class, tag and number ingrowth only to a maximum of five plants in total in that class. All previously tagged plants are continued to be measured.
 - If it is necessary to tag ingrowth for a class, and there is a choice, the individuals may be chosen regardless of distance, subject to the maximum radius. It isn't necessary to choose the closest plant(s).
 - If there are >5 plants, and not all are tagged, ensure to record either the maximum plot radius and the total number within that radius (BTR column), or record the average distance to the fifth and sixth plants and enter “5” in the BTR column, whichever is most convenient.
 - If desired, it is acceptable to tag ingrowth using numbered tags removed from plants recorded as M.
6. NEW HT = Height to nearest 0.1 m. Leave blank for plants which have died or been destroyed. Prior to 1993 height was recorded as vertical height. It is more usual to record height as the straight line distance from the plant base to the highest living foliage. The height of previously measured stems should be recorded consistent with the previous method however all ingrowth should be measured by the latter standard measure.
 7. LD = Logging Effect. Record 2 digit code, according to the attached sheet. Leave blank if LOG TR = 0. otherwise enter code for every plant.
 8. GS = Ground Surface Characteristics. Record code for extent of burning around plant, as described on “Fire Effect Codes Sheet”. Blank if B TR = 0.

9. FD = Fire Damage. Record 2 digit code according to the “Fire Effect Codes Sheet”. Blank if B TR = 0, otherwise enter a code for every plant. Following January 1993 fire damage is assessed separately within three months of treatment. At this assessment, if it is evident that a plant has died since the last measure, but prior to the fire, leave the fire damage column blank and record “N” in the status column.

10.SC = Scorch Height. Record scorch height to the nearest decimetre. Use 99 for full scorch where potential scorch was greater than plant height. Blank if unscorched. Scorch height is defined as the maximum height of foliage scorch. If there is no foliage scorch but the ground surface is burnt, record scorch height as either lowest living foliage, or maximum bark scorch height whichever is lower. Scorch height was inconsistently recorded prior to January 1993.

11.REC = Recovery. Use 2 character alphanumeric code as follows:

- First Character
 - A = Crown regrowth or branch epicormics
 - B = Stem epicormics
 - C = Coppice from stem base at ground level
 - D = Root Suckers
- Second Character
 - 1 = Weak growth
 - 2 = Moderate growth
 - 3 = Strong growth

Recovery is regarded as new growth which occurs as a result of damage and does not include new growth which is expected to occur normally in an undamaged plant, such as extension of apical shoots. Leave blank if no evidence of recovery.

Root suckers are defined as all growth from below ground level, including shoots which arise close to the stem or which appear to have arisen from the underground part of the stem.

12.ST = Status.

Single or multiple letter code, as follows:

A = plants which have grown beyond the maximum size limit (> 10 cm dbh)

E = ingrowth plants added by increase in plot radius

F = evidence that the plant has fruited

G = previously measured plants which are outside a new plot perimeter because of decrease in variable plot radius.

I = ingrowth, i.e. plants which have grown into a size class.

M = mortality

N = damage or mortality from natural (unspecified) causes; if mortality record MN

R = evidence that the plant has flowered

S = seedling in ground cover quadrat, > 0.1 m but < 1 m tall

Leave the column blank if none of the above applies. Note that plants with status recorded as M or A are not subsequently measured and will be omitted from future “listings”, but G plants will continue to be measured.

13.General comments may be entered in the heading space, above the dashed line. Situations which deserve comment include plots in a logged or burnt block which have remained unaffected; plots seriously affected by natural tree falls.

6.1.1.2 Ground cover vegetation

1. Use “Ground Cover” sheets as for pre-treatment assessment.
2. Immediate post-treatment assessment only. Record ground disturbance codes in the SPECIES column to indicate extent and type of disturbance. For each division record only the major type of disturbance, as “full”(i.e. 2) for logging and fire separately as appropriate. If one type of disturbance covers the whole quadrat, 16 may be recorded in the NF column, leaving all the division columns blank. Otherwise, divisions will need to be assessed individually.

Ground disturbance codes are as follows:

- *Logging*:
 - LGD = Light general disturbance, with little damage to vegetation and negligible soil or litter disturbance; includes deposition of scattered logging debris.

- MGB = Moderate general disturbance, with some vegetation damage and some litter or soil disturbance, but including a range of disturbances not easily categorised separately.
 - LS = Moderate to heavy deposition of logging debris such as crowns, branches, logs and bark essentially smothering vegetation.
 - BARKH = Bark heaps where ground surface is covered to reasonable depth by heap pushed from log dump.
 - SB = Bare soil, litter mostly removed, some soil disturbance.
 - SC = Severe soil disturbance, including removal of topsoil, subsoil disturbance or obvious soil compaction, (e.g. snig tracks).
 - LDUMP = Log dump.
 - *Burning:*
 - LBURN = Light burn, litter only partially burnt.
 - MBURN = Medium burn, litter and light fuel (< 6 mm dia) mostly consumed, some 6.25 mm fuel burnt.
 - HBURN = Heavy burn, large fuel burnt, 6.25 mm fuel consumed.
3. Immediate Post-treatment assessment only. A subjective visual estimate of ground surface characteristics should be made for each 5.64 m radius plot. These may be recorded in the space above the quadrat orientation box. The following should be assessed as approximate % cover (to nearest 10%):
- total cover of vegetation < 1 m high (GC)
 - total cover of vegetation 1-3 m high (SC)
 - litter cover (L)
 - proportion of plot disturbed by logging (L)
 - proportion burnt (B)
 - rock cover (RC)
 - proportion of bare ground (BG).
2. For this project seedlings are woody plants < 1m tall which appear to have germinated since the previous assessment, and include cotyledon stage seedlings. Only seedlings of woody plant species likely to grow > 1m high are to be included. Seedlings of other species should generally be ignored, though if numerous or conspicuous, an appropriate comment may be recorded on the sheet. Seedlings are to be recorded only if they are rooted within the quadrat.
3. For each species, enter S in the right hand space of the MPH column, and record number of seedlings in each division. Leave blank for 0 and record 9 for 9 or more.
4. Note that recording of seedlings is separate to ground cover, even though both are recorded on the same sheet. Thus any species for which seedlings are recorded should also have a separate entry for ground cover assessment.
5. Following 1993 the following amendments were also made:
- If a species occurs in a quadrat as both seedlings and established plants, it should be recorded twice (once for seedlings, once for cover), as described in 3 above, but the divisions where only seedlings of the species exist may be left blank for the cover record.
 - Where other species (not likely to exceed 1m) occur in a quadrat predominantly as seedlings established since the last measure, record H in the rightmost NF column.
 - Tag and number seedlings which exceed 0.1 m height, to a maximum of one of each species in each quadrat. Record these on the major understorey species sheets.

6.1.1.3 Seedlings

1. Record on “Ground Cover” sheets.

APPENDIX B: YAMBULLA CATCHMENTS VEGETATION PROJECT

INTRODUCTION

The Yambulla catchments study was originally established in 1977 as an hydrology experiment to investigate the effects of integrated logging on water quantity and quality. The study area is located south-west of Eden in south-eastern NSW, on east-flowing tributaries of the Wallagaraugh River, at approximately 37° 29' S, 149° 35' E. The original intention was to investigate a range of logging intensities, but this was made impractical by a high intensity wildfire in January 1979 which burnt four of the six catchments and required additional control catchments to be selected.

Following the fire and re-design of the experiment, the objective of the vegetation component was to examine the effects of integrated harvesting and unplanned fire on floristic composition.

METHODS

Six catchments were used for hydrological studies, varying from 50-200 ha in area. Five of these were used for vegetation studies. The sixth was not used because it was severely burnt by the wildfire soon after the initial assessment began and was subsequently salvage logged. The treatments were as follows:

- 1 Control (unburnt, unlogged)
- 2 Routine, alternate coup logging in 1987, followed by post-log burning
- 3 Routine logging only, in 1987
- 4 Not logged, but burnt by wildfire in 1979
- 5 Logged in 1978, then burnt by wildfire in early 1979

Assessments were based on a series of about 100 plots for each catchment. These were located

systematically throughout each catchment on a regular square grid with a random starting point. The grid interval was varied to produce the required 100 points, but was approximately 100 m in most catchments. Four site variables were recorded at the time of establishment at each point: aspect (in 45° classes, beginning 0-45), slope (in classes of degrees, 1=0-5°, 2=6-10°, 3=11-15°, 4=16-20°, 5=21-25°, 6=over 25°), position on slope (1=ridge, 2=upper slope, 3=midslope, 4=lower slope, 5=alluvial flat or gully, 6=creek) and altitude (to nearest 10 m from topographic map).

At each point, vegetation was assessed in three size strata:

1. less than 2 m tall
2. over 2 m tall but less than 20 cm dbhob
3. over 20 cm dbhob.

Nested circular plots centred on the plot points were used. Plot sizes were 10 m², 100 m², and 1000 m² respectively for each of the three size classes. Measures of abundance varied from the initial to subsequent assessments. Initial measurements of catchments Three, Four and Five were completed in 1977. For these measurements, at each plot the distance to the nearest individual and crown diameter was recorded for each species of each size class, within the maximum search area defined by the relevant plot size.

Additional sites (Catchments One and Two) were chosen in 1980 following the unplanned fire of 1979. Initial measures in these were completed in 1980, and Catchments Three, Four and Five were remeasured at this time. The 1980 measurement used a coded projected foliage cover for the smallest size stratum (< 2m tall) and a density count for the larger strata. The projected foliage codes were 1 = <5%, 2 = 5-25%, 3 = 25-50%,

4 = 50-75%, 5 = >75%. All catchments were remeasured in 1984, using the 1980 measures of abundance. At this measure, estimated percentage cover of total vegetation < 2 m tall, litter, bare ground, rock and logs were additionally recorded, based on the 10 m² plots. Catchments Two and Three were remeasured in 1988 following logging. No other catchments were measured at this time, and there have been no subsequent measures.

APPENDIX C. DESCRIPTION OF DATA COLLECTION METHODOLOGIES FOR PROJECT WHICH HAVE NOT YET BEEN PUBLISHED

PERMANENT GROWTH PLOTS

The overall purpose of permanent growth plots (PGPs) is to obtain accurate and reliable growth data for productive forest types which are to be managed on a long-term basis for wood production.

Three types of parameters are measured within the circular plots, these are the permanent plot parameters, tree parameters and the changeable parameters. The permanent plot parameters are recorded only once when the plot is established; tree and changeable parameters are recorded once every five years if no operations take place, or up to six months prior to and following scheduled operations. The parameters measured for each PGP are listed below, those parameters which were used to create species records to be provided for the CRA process are shown in bold.

☞ Permanent plot parameters include:

- *Plot number*
- State Forest number
- Compartment number
- Establishment date
- *Co-ordinates* (AMG)
- *Slope*
- *Aspect* (class)
- *Terrain* (class)
- *Altitude*
- Rainfall

- *Species/forest type* (R.N. 17)
- Site height
- Geology
- Soils
- Rock Cover
- Logging history
- Treatment history
- Fire history

☞ Tree parameters include:

- *Plot number*
- Tree number
- *Species* (commercial spp of dbhob >10cm only)
- Usefulness (categories)
- Vigour
- Crown
- DBHOB
- Log length
- Bole height
- Damage
- Tree status code
- Tree location (distance from plot centre)

☞ Changeable parameters include:

- *Plot number*
- Measurement number
- *Measurement date*
- Stand Description
- Stand dominant height
- Events since last measurement

- *Understorey species* (record % ground cover and dominant species for the following categories - grasses, ferns, palms and other trees and shrubs <10cm dbhob; also record dominant vine species and estimate abundance)

WARATAH CREEK MONITORING STUDY

The Waratah Creek monitoring study was set up as part a of PhD thesis by Jim Shields (Shields, 1990). The main aim of this study was to determine the effect of logging on birds at Eden NSW. Three different logging intensities were studied at the site (normal, removal of 75%

canopy removed in normal logging and removal of 50% canopy removed in normal logging treatments) which together with a control made up four treatments. The vegetation in each of these treatments was measured at two levels, the trees and other vegetation.

Trees were measured using a point to plant method. Through this method the ten trees closest to each point and greater than 30 cm in diameter were recorded. Each treatment contained 20 points, 10 each on two 1 km transects. Related to these points were 10x10 m plots in which the species of non-tree vegetation was recorded.