Wildfire Chronosequence Project

Establishment Report

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August 2007

TABLE OF CONTENTS

SUMMARY **5**

1. INTRODUCTION **6**

1.1 PROJECT RATIONALE 6

1.2 PROJECT AIMS 8

1.3 THE WARRA LTER SITE 9

2. SITE SELECTION AND ESTABLISHMENT **11**

2.1 FILE LOCATION 11

2.2 PROJECT BACKGROUND 12

2.3 SITE SELECTION 16

2.4 SITE LOCATION 23

Descriptions of individual sites *29*

Oldgrowth north (OGN) *29*

Oldgrowth south (OGS) *30*

1898 wildfire north (98N) *32*

1898 wildfire south (98S) *33*

1934 wildfire north (34N) *34*

1934 wildfire south (34S) *35*

1967 wildfire north (67N) *36*

1966 wildfire south (66S) *37*

1966 clearfell burn and sow north (66CN) *38*

1966 clearfell burn and sow south (66CS) *40*

2003 clearfell burn and sow north (03CN) *41*

2001 clearfell burn and sow south (01CS) *42*

2.5 SITE DESIGN AND CODING SYSTEM FOR PLOTS AND SUBPLOTS 43

Plot layout maps 46

3 STRUCTURAL AND FLORISTIC SURVEYS **49**

3.1 ENVIRONMENTAL VARIABLES 49

3.2 VERTICAL STRUCTURE – DEFINITIONS AND METHODOLOGY 50

3.3 HORIZONTAL STRUCTURE - DEFINITIONS AND METHODOLOGY 55

3.4 ADDITIONAL METHODS FOR MEASUREMENT OF VARIABLES 57

4. FURTHER WORK **57**

4.1 MAINTENANCE 57

5. ACKNOWLEDGEMENTS **58**

6. REFERENCES **59**

7. APPENDIX **63**

TABLE OF TABLES

TABLE 1. *List of files and file location for Wildfire Chronosequence Project* 11

TABLE 2. *Site list from original project proposal* 12

TABLE 3. *Forty-two sites found by contractor* 17

TABLE 4. *Fourteen sites selected by contractor* 21

TABLE 5. *Core features of twelve Wildfire Chronosequence Project sites.* 25

TABLE 6. *Additional features of twelve Wildfire Chronosequence Project sites.* 26

TABLE 7. *Environmental variables to be measured for each site* 49

TABLE 8. *Vertical structural attributes proposed for measurement* 52

TABLE 9. *Horizontal structural attributes proposed for measurement* 56

TABLE OF FIGURES

FIGURE 1. *Tasmania and location of Warra LTER site.* *10*

FIGURE 2. *Aspect groups* 16

FIGURE 3. *Distribution of twelve Wildfire Chronosequence Sites* 24

FIGURE 4. *Legend for Figures 5 to 14* 28

FIGURE 5. *Location of site OGN* 29

FIGURE 6. *Location of sites OGS, 98S and 34S.* 31

FIGURE 7. *Location of site 98N* 32

FIGURE 8. *Location of site 34N.* 34

FIGURE 8. *Location of site 67N.* 36

FIGURE 8. *Location of site 67S.* 37

FIGURE 8. *Location of site 66CN.* 39

FIGURE 8. *Location of site 66CS.* 40

FIGURE 8. *Location of site 03CN.* 41

FIGURE 8. *Location of site 01CS.* 42

FIGURE 15. *Site design.* 43

FIGURE 16. *Core plot design and coding* 44

FIGURE 17. *Subplot coding* 46

FIGURE 18. *Maps showing 50 m x 50 m plot layout and position of access track* 47

FIGURE 19. *Vertical attributes* 51

TABLE OF APPENDICES

APPENDIX 1. Stand structure and floristic variables proposed for measurement 63

APPENDIX 2. Data recording sheet for vertical structure. 70

APPENDIX 3. Data recording sheet for horizontal structure 71

Summary

The Wildfire Chronosequence Project is a joint initiative of the Bushfire CRC, the University of Tasmania (School of Plant Science) and Forestry Tasmania. The overall aim of the project is to investigate successional processes in the fire-adapted wet eucalypt forest landscape of southern Tasmania, to enable the development of methods for managing structural complexity and fire-dependent biodiversity in the production forest landscape and adjacent protected areas. The project incorporates a set of permanent research plots in forest regrowing following past stand-replacing disturbance events (wildfire or timber harvesting). There are six disturbance treatments in total, each represented by a 50 x 50 m plot (with 100 m external buffer) on a northerly to westerly aspect and another on a southerly to easterly aspect. These encompass regrowth forest following wildfire's in 1898, 1934 and 1966/67, as well as equivalent plots in forest that has not experienced wildfire for over 150 years (old-growth) and forest regenerating following clearfell, burn and sow silviculture in 1966 and 2000. Six of the sites are within the Warra Long Term Ecological Research (LTER) site with the remaining six sites within an adjacent area of State Forest recently designated as an Experimental Forest Landscape. For each of these twelve sites, stand structural, coarse woody debris and biodiversity surveys are being undertaken. Methodology used in the collection of this data is documented in this report. This report makes recommendations pertaining to future surveys, maintenance of plots and the administration of electronic and paper files.

The research aims to inform forestry and conservation by developing better methods for managing structural complexity and fire-dependent biodiversity in the landscape. The establishment of permanent research sites in the landscape will facilitate research on a range of components of biodiversity and ecological processes in wet eucalypt forests.

1. Introduction

1.1 Project Rationale

Wildfire is a natural or anthropogenic disturbance that plays a fundamental role in the establishment and survival of wet eucalypt forests. Whether the occurrence of wildfire is through fire-stick farming or lightning strikes, wildfire has occurred in the landscape for millennia over a range of spatial and temporal scales.

Forests in Tasmania are of three main types, temperate rainforest, wet eucalypt forest and dry sclerophyll forests (Wells and Hickey 1999). The term 'wet eucalypt forest' includes both mixed forest and forests with broad-leaved shrubs and/or ferns dominant in the understorey (Kirkpatrick *et al.* 1988). Tasmanian mixed forest is defined as vegetation with a rainforest understorey and eucalypt overstorey (Gilbert 1959). Wildfire is the principle agent of disturbance in the mixed forests of Tasmania. In wet eucalypt forest, wildfire frequency may range from once in every 20 to once in 100 - 400 years (Mount 1979). The eucalypt overstorey of mixed forest requires fire at intervals of 100 – 400 years to regenerate; thus, in the absence of fires for more than approximately 400 years, the eucalypt overstorey dies out and rainforest will persist (Gilbert 1959; Jackson 1968). In classical successional terms, in the absence of disturbance, sedgelands progress to shrublands, then to a wet eucalypt forest community, to mixed forest and if there is still an absence of disturbance (i.e. fire after approximately more than 400 years) eucalypts die out, leaving rainforest (Jackson, 1968). The impact of fire on wet eucalypt forest is determined by a number of factors, such as past disturbance, fuel levels and climate (Ashton 1981). A substantial amount of fuel is produced via growth and litter accumulation, especially where forests exist on fertile soils and in areas of higher rainfall.

Current conservation management of these forests consists generally of either active management (which includes extinguishing/suppression of wildfire) or what has been described by Brown (1996) as 'benign neglect'. With time, suppression of wildfire may lead to less heterogeneity in forest age and stand structure across the landscape. A consequence of a broad scale wildfire may include a loss of late successional forest stages and a more simplified forest structure across large areas. Current silvicultural practices in

wet eucalypt forest may also be simplifying forest structure through short rotation times (eg 90 years, Whiteley 1999) and clearfelling. Clearly these management approaches do not entirely replicate the natural ecological processes that determine the structure and function of wet eucalypt forests and carry the possibility of a loss in biodiversity.

The sites will build upon current silviculture research in the Warra LTER site; six of the Wildfire Chronosequence Project sites are situated within Warra and one of these is situated within a silvicultural systems trial site. Clearfell burn and sow harvesting is currently the most commonly used silvicultural method in Tasmania (Hickey *et al.* 2001). Clearfell burn and sow harvesting involves completely felling all trees in an area usually less than 100 ha (Forest Practices Board 2000), in a single operation. The remaining litter (slash, unsaleable timber, remnant understorey etc.) is burnt to create a seedbed in which regeneration of both overstorey and understorey vascular plants can occur. Revegetation of *Eucalyptus* is undertaken by sowing seed by hand, by aerial sowing or naturally via seedfall from remaining or fringing/nearby live trees. At present the primary method is aerial sowing Florence 1996). This form of silviculture is intended to mimic some aspects of a natural wildfire event (Attiwill 1994). However, the view that this form of silviculture reduces the structural complexity of the forest, particularly rotations of less than 100 years, is becoming increasingly more widespread (Lindenmayer and Franklin 1997). With the inclusion of sites regenerating after clearfelling and sites regenerating after wildfire from similar time frames (eg 1966-or-1967), the Wildfire Chronosequence Project sites will further enhance current silvicultural research in the southern forests through the addition of comparative post-fire and post-logging successional study sites.

The Wildfire Chronosequence Project aims to establish a set of permanent, baseline sites along a wildfire chronosequence in order to better understand biodiversity, physical responses and ecosystem processes following wildfire. The sites span wildfire years (1898, 1934, 1966 – or – 1967), old growth mixed forest or forest subject to silvicultural management (clearfell burn and sow sites from 1966 and 2000's +).

The research is based in wet eucalypt forest of southern Tasmania. Included in the study area is the Warra Long Term Ecological Research (LTER) site. The southern forests consist of a mosaic of forest ages resulting from past disturbance due to wildfire (eg

1898, 1934 and 1967) and logging practices since early European settlement. The inclusion of the Warra LTER site provides the project with a wealth of data including silvicultural trials (Hickey *et al.* 2001), biodiversity monitoring (eg. Bashford *et al.* 2001, Kantvilas & Jarman, 2004), and stand age and history research (eg Alcorn *et al.*2001, Hickey *et al.* 1999). With the inception of the Warra LTER site has come an increased understanding of wet eucalypt forest ecology and management (eg. see *Tasforests* volume 13).

Despite substantial research into wet eucalypt forest ecology, very few projects have utilised the same research sites, which makes comparisons between projects difficult. The permanent set of benchmark sites established through the Wildfire Chronosequence Project will provide a platform upon which comparative studies can begin, continue and be compared. In addition, because of the space – for – time approach, the project will also provide a deeper insight into successional processes in wet eucalypt forest particularly pertaining to biodiversity conservation and management.

1.2 Project aims

The Wildfire Chronosequence Project is a joint project established by Forestry Tasmania, the Bushfire CRC and the School of Plant Science, University of Tasmania. The project aims to establish a set of permanent, baseline sites along a wildfire chronosequence in order to better understand biodiversity, physical responses and ecosystem processes following wildfire. The sites span wildfire years (1898, 1934, 1966 – or – 1967), old growth mixed forest and forest subject to silvicultural management (clearfell burn and sow sites from 1966 and 2000's +).

The research aims to inform forestry and conservation by developing better methods for managing structural complexity and fire-dependent biodiversity in the landscape. The establishment of permanent research sites in the landscape will facilitate research on a range of components of biodiversity and ecological processes in wet eucalypt forests.

The overall project considers the following questions:

1. How does a single catastrophic wildfire affect structural diversity, physical processes (eg. biomass accumulation, and nutrient cycling) and succession of

biodiversity in wet eucalypt forest over a time-scale measured in decades or centuries?

2. How do these effects and processes differ from those brought about by clearfell, burn and sow silviculture?

Within these aims, the present report focuses on two main initial goals of the project

1. Establishment of permanent baseline sites along a wildfire chronosequence
2. An investigation of stand structural attributes in wet eucalypt forest over time, using the permanent plots

Section 2 of this report outlines the first of these goals, outlining site selection criteria, location and design. Section 3 discusses methodology to be used for measurement of some stand structural attributes (beginning December 2006). Through these and additional, future, measurements, the following research questions will be investigated:

1. Does species composition and species richness of vascular plants differ between/among treatments?
2. Does stand structure differ between/among treatments?
3. Do stand structure and/or environmental variation explain dissimilarity/similarity in vascular plant species composition and/or species richness?

The final section of this report (Section 4) discusses plot maintenance with some suggestions.

1.3 The Warra LTER site

The Wildfire Chronosequence Project incorporates the Warra Long Term Ecological Research (LTER) site. The Warra LTER site is situated in southern Tasmania between the Huon and Weld Rivers, approximately 60 km west south west of Hobart (Brown *et al* 2001) (Figure 1). The Warra LTER site area spans 15,900 ha of which approximately half is State Forest (managed by Forestry Tasmania), with the remaining half within the Tasmanian World Heritage Area (WHA), managed by the Department of Tourism, Arts and Environment (DTAE). The altitudinal range in Warra is from ~ 30 m to 1200 m ASL. Jurassic dolerite is the major rock within Warra; it also is extensive in large areas outside of Warra (Laffan 2001).

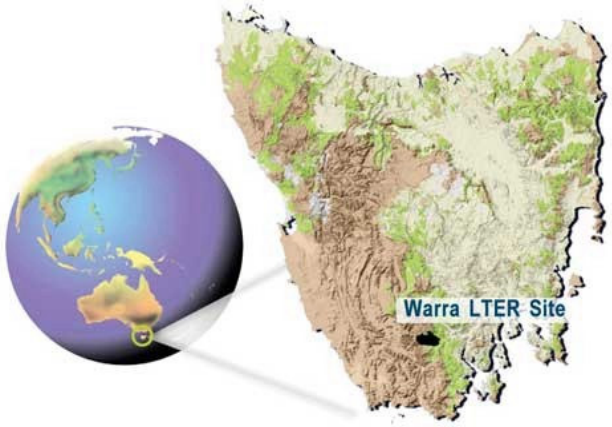

Figure 1. Tasmania and location of Warra LTER site.

Hydrology and climate data are obtained from a range of sources. Sampling from instrumented weirs began in 1998. A weather station is positioned on Manuka Rd and elsewhere on this road 16 river sites are sampled fortnightly. Another weather station is positioned near the headwaters of the Warra Creek catchment.

The site is accessible via several major roads from the eastern side, with the main route being via the Arve Rd from the nearby town of Geeveston (~ 40 minutes drive). There are currently no on-site accommodation or laboratory facilities. However, the Tahune Airwalk at the end of the Arve Rd on the Huon River houses toilet, café, bbq, shelter and toilet facilities. A helipad is also nearby.

Most of the Warra LTER area is forested, dominated by wet *Eucalyptus obliqua* forest. Temperate rainforests, buttongrass moorlands and some alpine moors and scrub are also present. Species lists for vascular plants, bryophytes, lichens, invertebrates and vertebrate fauna are available (www.warra.com/warra/docs/species_list/species_list_home.html).

The Warra LTER and surrounding forest area has a well documented history of forest use including occurrences of wildfire, logging practices, exploration and mapping. There is a well documented history of data collection for forestry use since the late 1960's. This includes logging history, recent fire history and vegetation survey data from Continuous Forest Inventory plots (now called Permanent Inventory Plots), which were first established from the late 1960's to early 1970's.

For more information on Warra LTER, see *Tasforests* Volume 13.

2. Site selection and establishment

2.1 File location

Printed information, including correspondence and contracts relating to the Wildfire Chronosequence Project can be found in Forestry Tasmania's 'Fire Management Collaboration - Bushfire Cooperative Research Centre Application' F62607/3 file and the 'Forest Research Silviculture - Warra Reference Sites' F62426 file. All GIS files which include reference points for the twelve chronosequence plots as well as other plot reference points are stored on the Forestry Tasmania GIS area G:\silv\Biology & Conserv\CRC Bushfire\Chronosequence permanent plots\GIS files. Forestry Tasmania Division of Forests Research and Development hold original hardcopies of collected data (eg. plot sheets). Electronic files, including databases, digital photographs and other data files are held in the project folders on the CRC Bushfire data area of the G drive at Forestry Tasmania (G:\silv\Biology & Conserv\CRC Bushfire). A list of important files is shown in Table 1.

Table 1. List of files and file location for Wildfire Chronosequence Project

File	File location	Details
All information pertaining to the Bushfire CRC	G:\silv\Biology & Conserv\CRC Bushfire	Various folders with information relating to all Bushfire CRC folders.
All information on the permanent plots	G:\silv\Biology & Conserv\CRC Bushfire\Chronosequence permanent plots	Includes information for each site, plus additional sites. Includes folders such as site data, site history, site information, maps and aerial photos
Reports	G:\silv\Biology & Conserv\CRC Bushfire\Reports	All quarterly performance reports and Wildfire Chronosequence Establishment Report (with maps)

2.2 Project background

A proposal for a wildfire chronosequence project was first put forward to the Bushfire CRC and University of Tasmania by Dr Simon Grove, Conservation Biologist, Forestry Tasmania in 2004 (Establishment of a wildfire chronosequence benchmark set in wet eucalypt forest). The project forms part of Bushfire CRC Project B3.1 Impacts of fire on ecological processes and biodiversity (http://www.bushfirecrc.com/research/b31/b31.html). The successful application sought to establish a set of permanent benchmark sites (Table 2) along a wildfire chronosequence in the Warra LTER site and surrounding forest in southern Tasmania.

Table 2. Site list from original project proposal

Treatments	North to westerly aspect	South to easterly aspect
Pre-1898 old growth	√	√
1898 wildfire regeneration	√	√
1934 wildfire regeneration	√	√
1967 wildfire regeneration	√	√
1934 + 1967 wildfire regeneration	√	√
1898 wildfire regeneration	√	√
1967 clearfell burn and sow regeneration	√	√
1990's+ clearfell burn and sow regeneration	√	√

Since the conception of the project, the only significant changes have been to the list of treatments for inclusion and the criteria under which sites would be selected for. After extensive field surveys, wildfire regeneration resulting from multiple fires (eg 1934-and-1967) was considered to vary considerably from site to site. It was understood that this variation could no be sufficiently assessed using only one replicate from each aspect, so the treatment was dropped. However, sites identified which fit this treatment, aspect and other site criteria have been documented as they may be utilised in future projects associated with the wildfire chronosequence project. Clear fell burn and sow regeneration

from 1990's+ was changed to 2000's +. One reason for this change was the potential for a recently logged site to be compared to a recent fire, should the latter eventuate.

The original site selection criteria were as follows:

Site criteria- version 1.

- Meeting the fire history and aspect criteria outlined in Table 1
- Location (preferably within the Warra, Picton or Arve forest blocks, and preferably as tight a cluster of sites as possible)
- Site management agency (State Forest preferred)
- Altitude (within the range 0 – 400 m)
- Site potential (E2 preferred but E1 and E+3 sites can be included)
- Dominant tree species (*Eucalyptus obliqua*)
- Underlying bedrock (dolerite preferred)
- Position on slope (midslope preferred)
- Exclusion from timber harvesting schedules (preferably outside provcoupes)
- Ease of access (the easier the better)
- Former research history (consider current or dropped CFI plots /PIPs; consider sites already included in trials (SST, BAMPs) at Warra; consider sites used in other ecological studies such as by John Hickey or Sue Baker).

After ground surveys and subsequent discussion, this list of criteria was changed slightly (see below). These changes included: extending the altitude range from 0 - 400 m to 0 - 500m; including the World Heritage Area in site selection; expanding the dominant eucalypt from 100% *Eucalyptus obliqua* to accepting up to 50% of *E. regnans* as a co-dominant; and relaxing the ease of access criteria to enable sites to be located further from a hard edge (ie road).

Also added was the criterion regarding cut stumps: sites were still open for consideration if any stumps only had evidence of axe and saw cutting and the presence of 'shoes' (the area where boards/planks were inserted for logging). However, if evidence of stumps cut with chainsaws existed, the site was not considered. This criterion was added for two reasons:

1. extensive areas were salvage logged (by chainsaw) post wildfire (particularly the 1967 wildfire) and therefore much potential downed woody material was removed, and
2. it was assumed that logging using axe and saw (i.e. pre-chainsaw) left more wood behind than where chainsaws were used .

Site criteria- Final version.

- Meeting the fire history. (1898-or-1906 wildfire, 1934 wildfire, 1966-or-67 wildfire
- Clearfell burn and sow (1966-or-1967, post 2000)
- Old growth mixed forest - containing at least 5% eucalypt old growth
- Aspect: north to westerly is defined as between WSW (247˚) and NNE (22.5˚). South to easterly aspect is defined as between ENE (67˚) and SSW (202.5˚) (Figure 2).
- Located preferably within the Warra, Picton, Weld or Arve Forest Blocks.
- On State forest or within the World Heritage Area
- Altitude within the range 0 – 500 m
- Site potential (E2 preferred but E1 and E+3 sites can be included)
- *Eucalyptus obliqua* is the dominant tree species but up to 50% of the stocking of co-dominant strata by *E .regnans* is acceptable.
- Underlying bedrock (dolerite is preferred). Disregard sites on sandstone, quartzite and conglomerates.
- Position on slope: midslope preferred
- Exclusion from timber harvesting schedules (preferably outside provcoupes)
- Ease of access (the easier the better). but least 100 m and preferably no more than 1km from a road edge.
- Former research history. Consider current or dropped Continuous Forest Inventory (CFI) plots /Permanent Inventory Plots (PIP's); sites already included in trials (Silvicultural Systems Trial (SST), Baseline Altitudinal Monitoring Project plots (BAMP's)) at Warra; and sites used in other ecological studies such as by John Hickey, Sue Baker, Perpetua Turner, Gemma Woldendorp).
- At least 100 m from hard edges (main roads, buttongrass plain). Each 50m X 50 m plot will have a 100 m buffer, therefore the site will be 250m X 250m = 6.25 ha.
- Any site(s) found which meet all the criteria **and** have cut stumps with the evidence of 'shoes' (the area where boards/planks were inserted for logging) will be included in a short-list. Sites with cut stumps but no evidence of shoes should be disregarded.

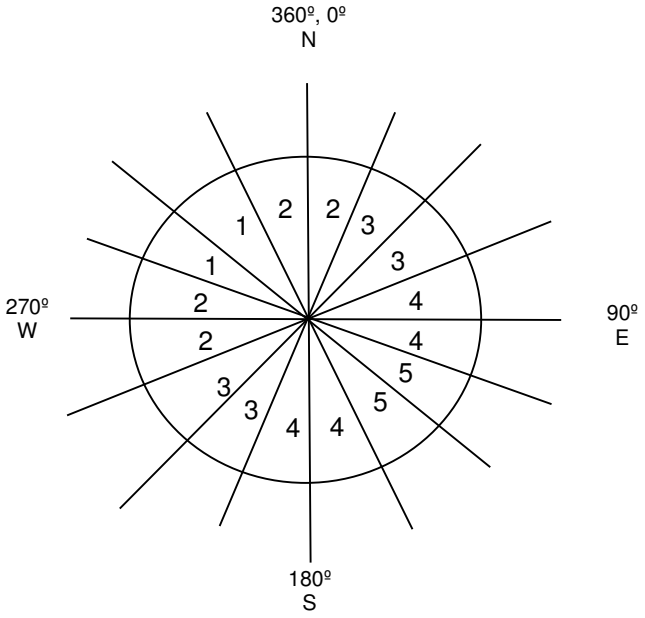

Figure 2. Aspect was recorded in degrees and grouped into classes; 1 = northwest, 2 = north or west, 3 = northeast of southwest, 4 = east or south, 5 = southeast).

2.3 Site selection

An initial survey for sites began in November - December 2004, when Forestry Tasmania contracted Chris Barry to undertake a search for sites adhering to the treatments outlined in Table 2 and the selection criteria (version 1) listed above.

The contractor collated and presented to FT a shortlist of potential study sites (up to three, and no fewer than two, per fire history/aspect combination) available for ground-truthing (Table 3).

From these forty-two sites, the contractor identified fourteen for inclusion in the wildfire chronosequence project (Table 4). Although these sites are the same as those that appear in Table 3, the locations (co-ordinates) of some sites differ slightly due to re-location.

Table 3. Forty-two sites found by contractor for potential inclusion in the wildfire chronosequence project

Fire Year[a]	Site No	GDA Easting	GDA Northing	PI Type[b]	MDC[c]	Geology[d]	Altitude (m)	Aspect	Species[e]	Position on Slope	Management. Agency	Pre. Use[f]	Distance (m)	Remarks
OG	01	475250	5228770	E2d.S.	PRT	Qpt	130	SE	OBL	Mid/Lowslope	Forestry Tasmania	Nil	150	
OG	02	471775	5229190	E1c.S.	PRT	Qpt	185	SSW	OBL	Midslope	Forestry Tasmania	Nil	140	
OG	03	472280	5236540	E2c.S.	PRT	Qpt	345	ENE	DEL	Midslope	Forestry Tasmania	Nil	40	
OG	04	474010	5235300	E2c.S.	PRT	Jd	490	WNW	DEL	Upper Midslope	Forestry Tasmania	Nil	250	
OG	05	474920	5235470	E+3b.S.ER	PRD (Edge PRT)	Jd	310	ENE	DEL	Upper Midslope	Forestry Tasmania	PIP(01177-FIN)	350	
OG	06	476200	5223100	E2B	PRT	Jd	75	W	OBL	Lower Slope	Forestry Tasmania	Nil	70	
OG	43	470980	5229260	E2B.S.ER	PRD (Edge PRT)	Qpt	190	S	OBL	Midslope	Forestry Tasmania	PIP(01086-ACT)	780	
1898/06	07	473050	5227280	ER4a/2	PRT	Qpt	240	NE	OBL	Midslope	Forestry Tasmania	Nil	60	
1898/06	08	479440	5227780	ER4b/1	PRT	Qpt	240	W	REG	Midslope	Forestry Tasmania	Nil	90	
1898/06	09	473120	5226800	ER4b/2	PRT	Qpt	260	W	REG/OBL	Midslope	Forestry Tasmania	Nil	230	May be 1934 regrowth
1898/06	10	473320	5229540	ER4b/1	PRD (Adj. STR)	Qpt	290	S	OBL	Midslope	Forestry Tasmania	Nil	380	Adjacent STR - streamside reserve.
1898/06	11	473650	5228900	ER4d.S.E2F	PRT	Qpt	190	S	OBL	Mid/Lowslope	Forestry Tasmania	Nil	380	
1898/06	12	474010	5228780	ER3C/2	PRD	Qpt	210	SW	OBL	Mid/Lowslope	Forestry Tasmania	PIP(01106-ACT)	270	
1934	13	478710	5223920	E2d.ER4C	PRT	Jd	560	NW	REG/DEL?	Upperslope	Forestry Tasmania	PIP(01114-INA)	610	
1934	14	479180	5234320	ER4d/1.S	PRT	Jd	65	NE	REG/OBL	Lower Slope	Forestry Tasmania	Nil	100	

Fire Year[a]	Site No	GDA Easting	GDA Northing	PI Type[b]	MDC[c]	Geology[d]	Altitude (m)	Aspect	Species[e]	Position on Slope	Management. Agency	Pre. Use[f]	Distance (m)	Remarks
1934	15	475310	5225640	ER3b.E2f	PRD	Pu	160	E	OBL	Mid/Lowslope	Forestry Tasmania	Nil	480	Isolated regrowth patch between 2 creeks
1934	16	493400	5233050	ER3b/2	PRD(STP ?)	Jd	430	W	REG	Upperslope	Forestry Tasmania	Nil	390	Adj. new plantation
1934	17	492790	5233180	ER3d/2.T(W)	PRT	Rq	340	N	REG	Midslope	Forestry Tasmania	Nil	225	
1934	18	491335	5226660	ER4b/1.S	PRT	Pu	280	SE	REG/OBL	Midslope	Forestry Tasmania	Nil	280	
1934/67	19	489170	5230880	E(67)2d.ER4 d/1.S	PRT	Rq	360	W	REG	Upperslope	Forestry Tasmania	Nil	300	
1934/67	20	486950	5229710	E(67)2d.ER4 d/1	PRD (SSR)	Rq	120	W	REG/OBL	Mid/Lowslope	Forestry Tasmania	Nil	210	
1934/67	21	487550	5231115	E(67)2d.T(W).ER3f/1	PRD (NCM)	Rq	130	S	REG	Mid/Lowslope	Forestry Tasmania	Nil	130	
1934/67	22	487460	5231250	E(67)2d.T(W).ER3f/1	PRD (NCM)	Rq	130	W	REG	Mid/Lowslope	Forestry Tasmania	Nil	130	
1934/67	23	488190	5229460	E(67)2b.ER3 f/2	PRD(ADJ. NCM)	Jd	320	E	REG/OBL	Upperslope	Forestry Tasmania	Nil	130	Adjacent NCM - non commercial forest
1934/67	24	490100	5229420	E(67)2d.ER3 d/1.S	PRD(ADJ. PRT)	Jd	440	S	REG/OBL	Midslope	Forestry Tasmania	Nil	200	Adjacent PRT - MDC protection forest
1967 W	25	487290	5231200	E(67)2c/1.T(W)	PRD (NCM)	Rq	105	W	REG	Mid/Lowslope	Forestry Tasmania	Nil	85	These 2 will require ground truthing to determine whether age class(es) are 1934/67 or pure 1967.

Fire Year[a]	Site No	GDA Easting	GDA Northing	PI Type[b]	MDC[c]	Geology[d]	Altitude (m)	Aspect	Species[e]	Position on Slope	Management. Agency	Pre. Use[f]	Distance (m)	Remarks
1967 W	26	487130	5231250	E(67)2c/1.T(W)	PRD (NCM)	Rq	100	S	REG	Mid/Lowslope	Forestry Tasmania	Nil	70	
1967 W	27	482290	5229280	E(66)1c.dd.E2D.S.	PRT	Jd	400	E	REG	Upperslope	Forestry Tasmania	Nil	150	
1967 W	28	484060	5226280	E(67)2c.E1f & dd(D).S	PRT	Rq	85	E	REG	Lowslope	Forestry Tasmania	Nil	190	
1967 W	29	486840	5227080	E(67)2c.S.dd E1F	PRT	Jd	140	W	REG	Lowslope	Forestry Tasmania	Nil	40	
1967 W	30	487330	5227280	E(67)2d/1.S.T.	PRD/PRT	Jd	190	S	REG	Midslope	Forestry Tasmania	PIP(01139-INA)	10	
1967CBS	31	481430	5221590	E(66)2b.dd E1D	PRT	Jd	270	SE	REG/OBL	Midslope	Forestry Tasmania	Nil	80	
1967CBS	32	484375	5221425	E(66)2b/1.S.T.	PRT	Jd	160	N	REG	Mid/Lowslope	Forestry Tasmania	Nil	95	
1967CBS	33	481325	5221520	E(66)2b.dd E1D	PRT	Jd	280	N	REG	Midslope	Forestry Tasmania	NIL	150	
1967CBS	34	484185	5229035	E(67)2c.S.dd EiF	PRT	Rq	80	E	REG	Lowslope	Forestry Tasmania	Nil	40	
1967CBS	35	483610	5227640	E(67)2c.S.T.dd EiF	PRD(STR)	Jd	160	E	REG	Mid/Lowslope	Forestry Tasmania	Nil	60	
1967CBS	36	484770	5221640	E(66)2a/1	PRT	Jd	200	W	REG	Midslope	Forestry Tasmania	Nil	70	

Fire Year[a]	Site No	GDA Easting	GDA Northing	PI Type[b]	MDC[c]	Geology[d]	Altitude (m)	Aspect	Species[e]	Position on Slope	Management. Agency	Pre. Use[f]	Distance (m)	Remarks
1990+	37	471770	5237120	E(94)A/2	PRD(STR)	Qpt	360	NE	OBL	Midslope	Forestry Tasmania	Nil	50	
1990+	38	475215	5233145	E(98)A/2	PRD(ADJ. PRT)	Jd	500	NE	OBL/DEL	Mid/Upperslope	Forestry Tasmania	Nil	90	
1990+	39	475710	5232020	E(98)A/2	PRD(ADJ. PRT)	Jd	485	SW	OBL/DEL	Midslope	Forestry Tasmania	Nil	465	90 m in from fireline.
1990+	40	475528	5228500	E(98)N.E2F	PRD(ADJ. STR)	Qpt	100	SE	OBL	Lowslope	Forestry Tasmania	Nil	95	
1990+	41	473150	5229370	E(90)A/1	PRD(ADJ. PRT)	Qpt	230	SW	OBL	Midslope	Forestry Tasmania	Nil	120	
1990+	42	475665	5225580	E(99)A/2	PRD(ADJ. STR)	Pu	120	S	OBL	Mid/Lowslope	Forestry Tasmania	Nil	160	

[a]Fire year: OG = Old growth mixed forest, 1898/1906 = wildfire in 1898-or-1906, 1934 = wildfire in 1934, 1934/1967 = wildfire in 1934-and-1967, 1966/67 W = wildfire in 1966 -or-1967, 1966/67 CBS = clearfell burn and sow in 1966-or-1967, 1990+ = clearfell burn and sow post 1990.
[b]PI Type = Photo Interpretation Type from 1984 photography. See Forestry Tasmania Photo Interpretation Type codes.
[c]MDC = PRT, PRD, ADJ, STR, NCM – see Forestry Tasmania land classification codes.
[d]Geology: Qpt = sedimentary talus, Pu = limestone, Jd = dolerite, Rq = sandstone
[e]Species: OBL = *Eucalyptus obliqua*, REG = *E. regnans*, DEL = *E. delegatensis ssp. tasmaniensis*
[f]Preuse: PIP = Permanent Inventory Plot.

Table 4. Fourteen sites selected by contractor for inclusion in the wildfire chronosequence project

Site No	Fire Year[a]	GDA Easting	GDA Northing	PI Type[b]	MDC[c]	Geology[d]	Altitude (m)	Aspect	Species[e]	Position on Slope	Management Agency	Pre. Use[f]	Distance (m)	Remarks
01	OG	475265	5228827	E2d.S.	PRT	Qpt	130	ESE	OBL	Midslope	Forestry Tasmania	Nil	240	OG and scattered RG
04	OG	473482	5235856	E2b.S.	PRD*	Jd	320	N	OBL	Midslope	Forestry Tasmania	Nil	80	Moved location from DEL to OBL (770 m NW). Remnant OG and scattered regrowth between SSR and spur road.
08	1898/06	479381	5227784	ER4b/1	PRT	Qpt	240	WNW	OBL	Midslope	Forestry Tasmania	Nil	140	Convenient access from Arve Road
11	1898/06	473600	5228943	ER4d.S.E 2F	PRT	Qpt	190	SW	OBL	Midslope	Forestry Tasmania	Nil	30	Access from "Top Coupe Loop Track"
14	1934	478925	5234087	E2d.ER4c	PRD	Jd	90	W	OBL	Midslope	Forestry Tasmania	Nil	145	Moved from REG.. Regrowth dominant. Some scattered OG. Requires extension to PRT on Weld River.
15	1934	475278	5224838	ER3b/2	PRD	Pu	160	SE	OBL	Midslope	Forestry Tasmania	Nil	160	Moved due to poor access. Same PI type. PRD but very narrow ridge between creeks
19	1934/67	489178	5230949	E(67)2d.E R4d/1.S	PRT*	Rq	360	SW	OBL	Midslope	Forestry Tasmania	Nil	280	Requires extension of PRT (WHS) for buffer
23	1934/67	488525	5229271	f/d ER3d/2.S*	PRD (NCM)	Rq	320	N	OBL	Midslope	Forestry Tasmania	Nil	20*	PIType is actually E(67)2d.ER3d. Very

Site No	Fire Year[a]	GDA Easting	GDA Northing	PI Type[b]	MDC[c]	Geology[d]	Altitude (m)	Aspect	Species[e]	Position on Slope	Management Agency	Pre. Use[f]	Distance (m)	Remarks
														easy access off old fire trail.
28	1966/67 W	482279	5225954	E(66)2b/1. T.S.	PRD*	Jd	150	S	OBL	Midslope	Forestry Tasmania	Nil	140	Moved location 1.4 k WSW due to species. Requires extension to Arve Road PRT.
29	1966/67 W	486677	5227006	E(67)2c.S. dd E1F	PRT*	Jd	140	N	OBL	Midslope	Forestry Tasmania	Nil	215	Requires Extended PRT
31	1966/67 CBS	481415	5221628	E(66)2b.d d E1D	PRT	Jd	280	SE	OBL	Upperslope	Forestry Tasmania	Nil	100*	Access off old track. May need to move south 50m
33	1966/67 CBS	481327	5221618	E(66)2b.d d E1D	PRT	Jd	280	N	OBL	Midslope	Forestry Tasmania	NIL	200*	Access off old track. May need to move south 50m
37	1990+	471648	5237129	E(94)A/2	PRD(STR)	Qpt	360	NE	OBL/DEL	Midslope	Forestry Tasmania	Nil	135	Requires extended buffer on SSR
40	1990+	475087	5228641	E(000)A/2	PRD	Qpt	135	SE	OBL	Midslope	Forestry Tasmania	Nil	50	

[a]Fire year: OG = Old growth mixed forest, 1898/1906 = wildfire in 1898-or-1906, 1934 = wildfire in 1934, 1934/1967 = wildfire in 1934-and-1967, 1966/67 W = wildfire in 1966 -or-1967, 1966/67 CBS = clearfell burn and sow in 1966-or-1967, 1990+ = clearfell burn and sow post 1990.
[b]PI Type = Photo Interpretation Type from 1984 photography. See Forestry Tasmania Photo Interpretation Type codes.
[c]MDC = PRT, PRD, ADJ, STR, NCM – see Forestry Tasmania land classification codes.
[d]Geology: Qpt = sedimentary talus, Pu = limestone, Jd = dolerite, Rq = sandstone
[e]Species: OBL = *Eucalyptus obliqua*, REG = *E. regnans*, DEL = *E. delegatensis ssp. tasmaniensis*
[f]Preuse: PIP = Permanent Inventory Plot.

Ground-truthing of these fourteen sites by P. Turner found that some sites had anomalies. Even though the sites fitted all of the criteria initially (i.e. version 1), they did not fit the final criteria. For example, site 28 had been cutover using chainsaws post 1967 wildfire; an additional disturbance effect was prevalent and the site no longer fitted the selection criteria. Sites 8, 14, 29, 31 and 33 were deemed suitable. Of these, only site 31 was later dropped due to a better alternative being found using former studies.

Alternative sites were investigated through the use of previous studies, discussion with Forestry Tasmania staff and field surveying. Previous studies included Hickey (1994), Hickey *et al.* (1999), Baker (2000), Alcorn et al (2001), Turner (2003) and Woldendorp (2005). A total of approximately 150 potential sites were investigated, in the office and/or in the field. Not all of these sites fitted all of the selection criteria. From this large number, twelve sites were considered suitable. All information pertaining to these investigated sites is being added into a database and will be published.

2.4 Site location

The location of each site is shown in Figure 3, with specific site details listed in Tables 5 and 6. All twelve sites are in the Huon forest district; six of these are within the boundaries of the Warra LTER site. Three sites are in Blakes forest block, 2 sites in Picton block, 4 within Arve block and 3 sites within Warra block. All sites are within State Forest.

In this section, information regarding access to individual sites is described under a sub-heading for that site. A general location map for each site is provided (Figures 5 to 14) with Figure 4 being the legend applicable to all these maps. Sites are generally accessible via cut tracks of approximately one metre wide marked with yellow flagging tape and/or blazing on trees.

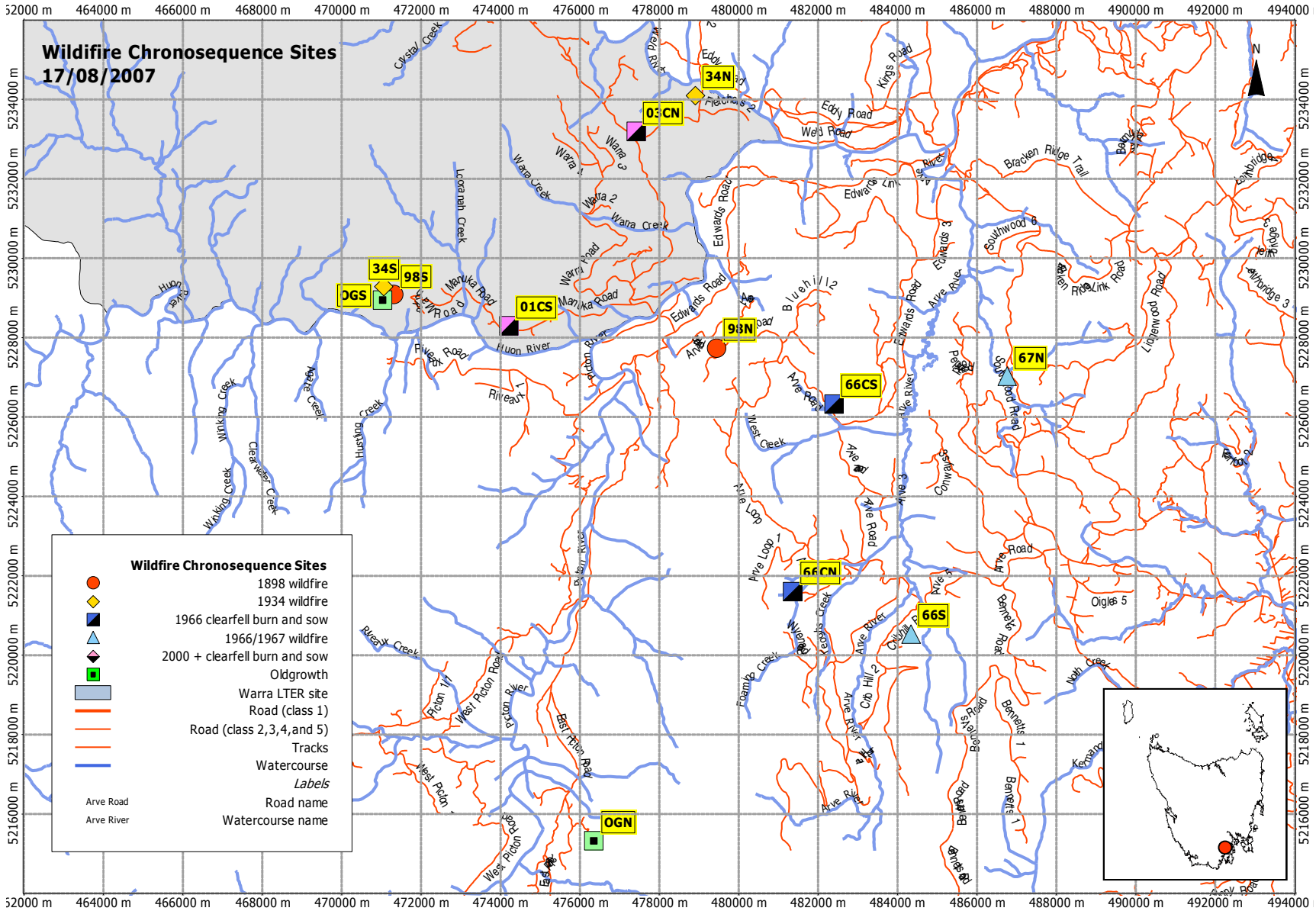

Figure 3. Distribution of twelve Wildfire Chronosequence Sites in the southern forests landscape. See Table 5 for site codes and details. The position of 34N is tentative (at the writing of this report). Inset: Map of Tasmania showing position of southern forest landscape.

Table 5. Core features of twelve Wildfire Chronosequence Project sites.

Site code	Treatment (CBS = Clearfell burn and sow)	Eucalypt spp.dominant	Mapsheet (1:25,000)	Approx Easting (MGA:m)*	Approx Northing (MGA:m)*	ProvCoupe[a]	PIP[b]	Altitude (m) (to nearest 20m)	Aspect	Geology[d]	Nearest road
OGN	old growth mixed forest	*Eucalyptus obliqua*	Picton	476355	5215330	PC072B	n/a	380	NW	Jd	East Picton Spur 5/3
OGS	old growth mixed forest	*Eucalyptus obliqua*	Picton	471029	5228932	BK002A	n/a	120	S	Qpt	Bird Track, Manuka Rd
98N	1898 wildfire	*Eucalyptus obliqua*/ occ. *E. regnans*	Picton	479437	5227732	Zig Zag Track reserve	n/a	240	NW	Qpt	Arve Rd
98S	1898 wildfire	*Eucalyptus obliqua*	Picton	471309	5229072	BK002A	n/a	160	S	Qpt	Bird Track, Manuka Rd
34N	1934 wildfire	*Eucalyptus obliqua*	Weld	478900	5234100	WR013B	n/a	80	W	Jd	Fletchers Rd
34S	1934 wildfire	*Eucalyptus obliqua*	Picton	471051	5229272	BK002A	near 1086	180	S	Qpt	Bird Track, Manuka Rd
67N	1967 wildfire	*Eucalyptus obliqua*	Geeveston	486762	5227021	AR054I	n/a	120	N-NE	Jd	Southwood Rd,
66S	1966 wildfire	*Eucalyptus obliqua*	Geeveston	484330	5220544	AR015D	n/a	280	SE	Jd	Crib Hill Spur 1/2,
66CN	1966 CBS	*Eucalyptus obliqua*	Geeveston	481367	5221609	Keoghs Rd Conservation reserve	n/a	260	NW	Jd	Keoghs Rd
66CS	1966 CBS	*Eucalyptus obliqua*/ occ. *E. regnans*	Geeveston	482394	5226325	AR051F	1227	200	S -SW	Jd	Arve Rd, Blue Hill
03CN	2003 CBS	*Eucalyptus obliqua*	Weld	477405	5233189	WR003C	n/a	160	NW	Jd	Sth Weld Rd
01CS	2001 CBS	*Eucalyptus obliqua*	Picton	474217	5228294	WR008H	n/a	120	S	Qpt	Manuka Spur 8

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Table 6. Additional features of twelve Wildfire Chronosequence Project sites.

Site code	Exclcode[a]	Total plot area (approx)	Current PI type[c] (and year of photography)	Former PI type[c] (from ~1947 photography)	PRIZONE[a]	SMZTYPE[a]	PSMZ1[a]	PSMZ2[a]	OSMZ1[a]	OSMZ2[a]	Site included in other studies
OGN	MDC/NON	6.25ha (of this ~4ha in reserve)	E1c.S. (1984)	E1d. MM.	PTI	M	FlCom	Ls	Ap	GeG	n/a
OGS	NON	6.25ha (in coupe)	S.T. (1984)	MM.	n/a	n/a	n/a	n/a	n/a	n/a	SST
98N	MDC	6.25 ha in reserve	ER4b/1. (1984)	ERp.T.E1F	PTI	M	Ls	FaWhs	Rc	GeG	n/a
98S	NON	6.25 ha (in coupe)	E1c. S. (1984)	f/d.E1B.S.ERp. Or ERp/1	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34N	NON	6.25 ha in coupe	E2d.ER4c./E2d.ER 3d. (1984)	S.f/d. E1	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34S	MDC/NON	6.25 ha (of this ~3.1ha in current reserve)	E1c. S./E1d.ER4d.S. (1984)	f/d.E1B.S.ERp.	PTI	M	Hzl	Ap	Geg	RsTR	CFI 1086, Turner 2003
67N	MDC/NON	6.25 ha (of this ~3.1 ha in reserve)	E(67)2c.S.dd E1F. (1995)	ERg.S.	PTI	M	FaWhs	ZZ	ZZ	ZZ	n/a
66S	NON	3.5 ha (of this ~1.7 ha in reserve)	E(66)2b.dd E1D. (1995)	S.C/o	PTI	M	FaWhs	Ap	ZZ	ZZ	n/a
66CN	MDC	6.25 ha in reserve	E(66)2b.d (1995)d E1D.	E1B	PTI	M	FaWhs	ZZ	ZZ	ZZ	n/a
66CS	NON	6.25 ha (of this ~2.08 ha in reserve)	E(66)2b/1.T.S.	E1B.-O/m.MM.S.	PTI	M	FlCom	Rc	Fa	Ls	Hickey 1994, Turner 2003, CFI 1227

Site code	Exclcode[a]	Total plot area (approx)	Current PI type[c] (and year of photography)	Former PI type[c] (from ~1947 photography)	PRIZONE[a]	SMZTYPE[a]	PSMZ1[a]	PSMZ2[a]	OSMZ1[a]	OSMZ2[a]	Site included in other studies
03CN	NON	6.25 ha in coupe	ER3d/2.S.	ERg.E1F	n/a	n/a	n/a	n/a	n/a	n/a	n/a
01CS	NON	6.25 ha in coupe	E(001)A/2.	f/d. ERp/x	n/a	n/a	n/a	n/a	n/a	n/a	SST

[a]MDC = Exclcode, ProvCoupe, PRIZONE, SMZTYPE, PSMZ1, PSMZ2, OSMZ1, OSMZ2PRT, PRD, ADJ, STR, NCM – see Forestry Tasmania land classification codes.
[b]Preuse: PIP = Permanent Inventory Plot.
[c]PI Type = Photo Interpretation Type from 1984 photography. See Forestry Tasmania Photo Interpretation Type codes.
[d]Geology: Qpt = sedimentary talus, Pu = limestone, Jd = dolerite, Rq = sandstone

* Easting and Northing co-ordinates will direct you to within the 50 m X 50 m core plot area. The co-ordinates given are not to any particular position within this area

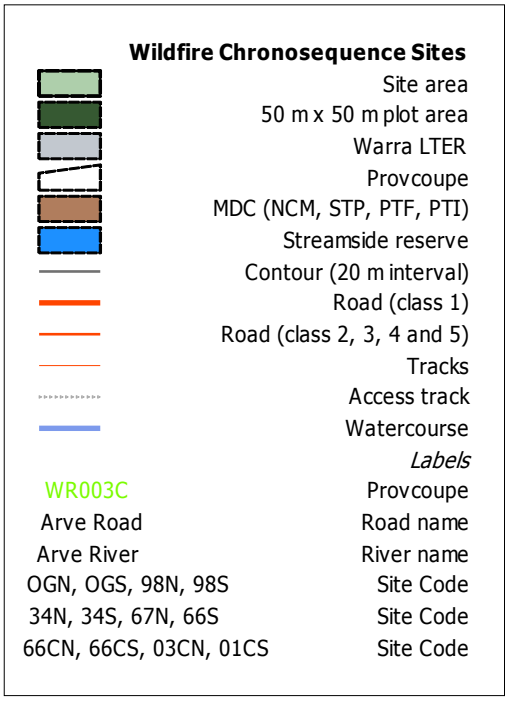


Figure 4. Legend for Figures 5 to 14

Descriptions of individual sites

Oldgrowth north (OGN)

Access

This site is serviced by a single cut track (cut in Nov 2006) which begins within forestry coupe PC071C. The take off point (TOP) is at the end of East Picton Spur 5/3. The access track travels toward the southern coupe edge for 120 m along a snig track, and then turns east (uphill) for 70 m along the fire trail southern boundary between PC071C and PC072B. The track then turns south and southwest into PC072B for 125 m along a cut track. This ends at the bottom northwest corner of the 50 X 50 m plot (Figure 4).

The coupe PC072B is unlogged. However, PC071B and PC072A have been logged in the past decade and lie either side of PC072B. The 50 m X 50 m plot is itself located within a reserved zone yet the southern buffer area is partially within PC072B. Given that PC072B is approximately 98% old growth forest, it is highly likely that future harvest will include aggregated retention. The buffer area within PC072B will therefore become part of an aggregate.

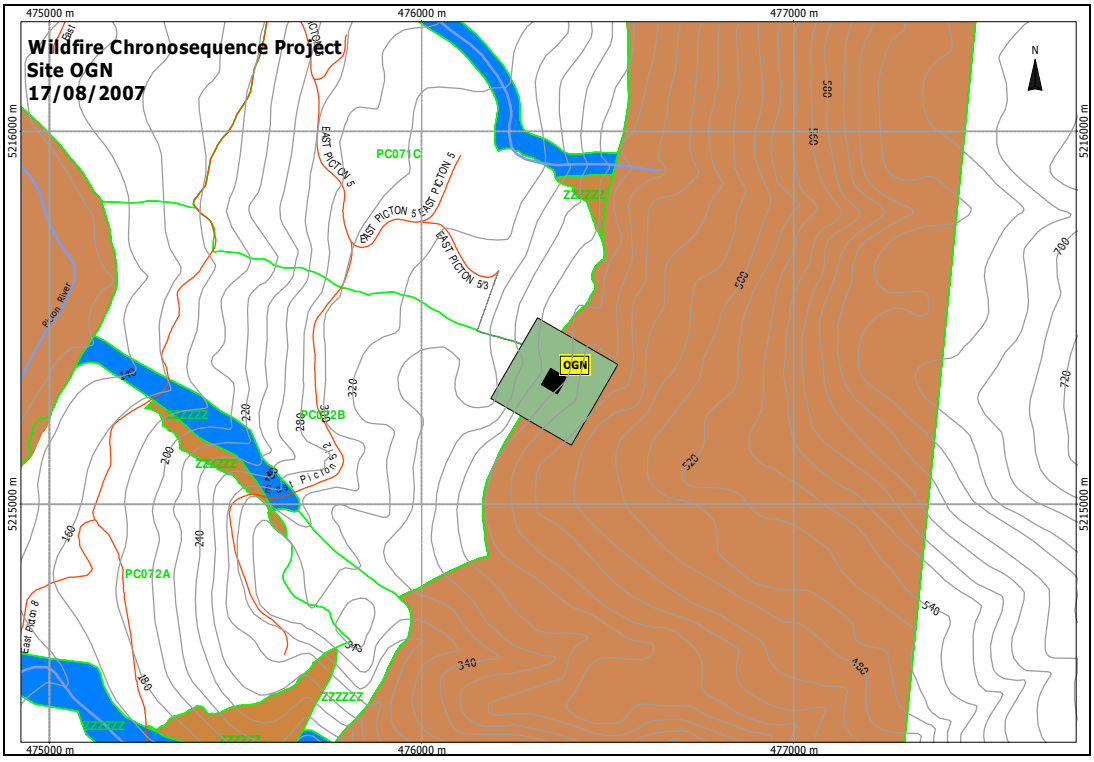


Figure 5. Location of site OGN.

Oldgrowth south (OGS)

Access

Oldgrowth south is accessed along the Bird Track in the Warra LTER site (Figure 6). Bird Track is a blazed and cut loop track with the TOP on the uphill side of a hairpin turn located approximately 7.1 km from the junction of Manuka Rd and South Weld Rd. Access to OGS is either via the northern or southern branches of Bird Track. The TOP for northern and southern branches is not from the same place. The main access route is the northern branch (here called TOP). The southern branch entrance is also on Manuka Rd at the hairpin turn, approximately 5 m south of the northern branch TOP. Junction track links both northern and southern branches of the track.

Northern Branch – Take Bird Track 450 m from TOP to the northern intersection with junction track. Turn south and take Junction track 250 m to the intersection with the southern branch of Bird Track. Turn west, and go 250 m. The OGS site is to the right of the track on a slope facing south.

Southern Branch – take Bird track southern branch for 720 m (the southern intersection with Junction track is at 470 m). The OGS site is to the right of the track on a slope facing south. Although the passage to OGS by the southern branch of Bird Track is shorter than that via the northern branch, the former is muddier and the gullies are steeper.

Both the northern and southern branches of Bird Track ford gullies. The gullies between Manuka Rd and the Junction track along the Bird Track northern branch have 'footsteps' dug out along the sides, and where necessary, rope and star pickets have been used to guide walkers on either side. There are only two major gullies between Manuka Rd and the Junction track along the Bird Track southern branch. The first is steep and may be very slippery in the wet. The second is not so slippery. Neither of these have rope/star picket guides.

The Wildfire chronosequence project plots OGS, 98S and 34S, along with other research plots associated with Bird Track, have been incorporated into a new exclusion zone set-aside for scientific research. This exclusion zone includes Woldendorp (2002) Plot TAS2_1087 (a plot in which coarse woody debris has been measured) at its western end. At the time of writing this report, the exclusion zone area had been surveyed and was in

the process of being finalised. The area boundary shown in Figure 6 is drawn from unsurveyed data and is therefore an approximate of the final area position. The boundary shown should only be taken as a guide.

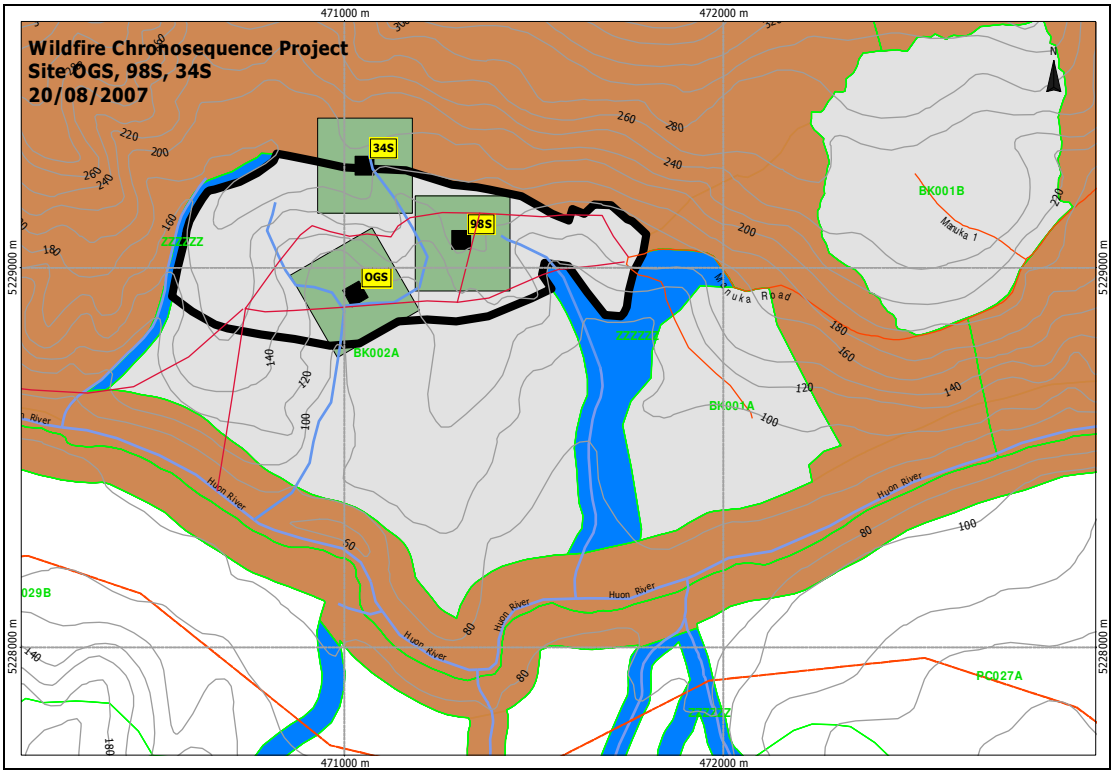


Figure 6. Location of sites OGS, 98S and 34S. The exclusion zone (indicated by black line) is an approximate position only.

1898 wildfire north (98N)

Access

1898 wildfire north (98N) is situated within the reserved area of the Zig Zag Track (Figure 6). The distance from the Arve Rd-Southwood Rd intersection to the Arve Rd-Arve Spur 2 intersection is approximately 17 km. The closest parking is at the intersection of Arve Rd and Arve Spur 2 (hairpin turn). Walk north towards the Zig Zag track along Arve Rd for 150 m from this intersection. On the left (downhill side of road) a tree is blazed with the blazed area sprayed yellow. This is the TOP to the plot.

Walk for ~ 80 m along a blazed and cut track which takes you to the east corner of the 50 x 50 m plot.

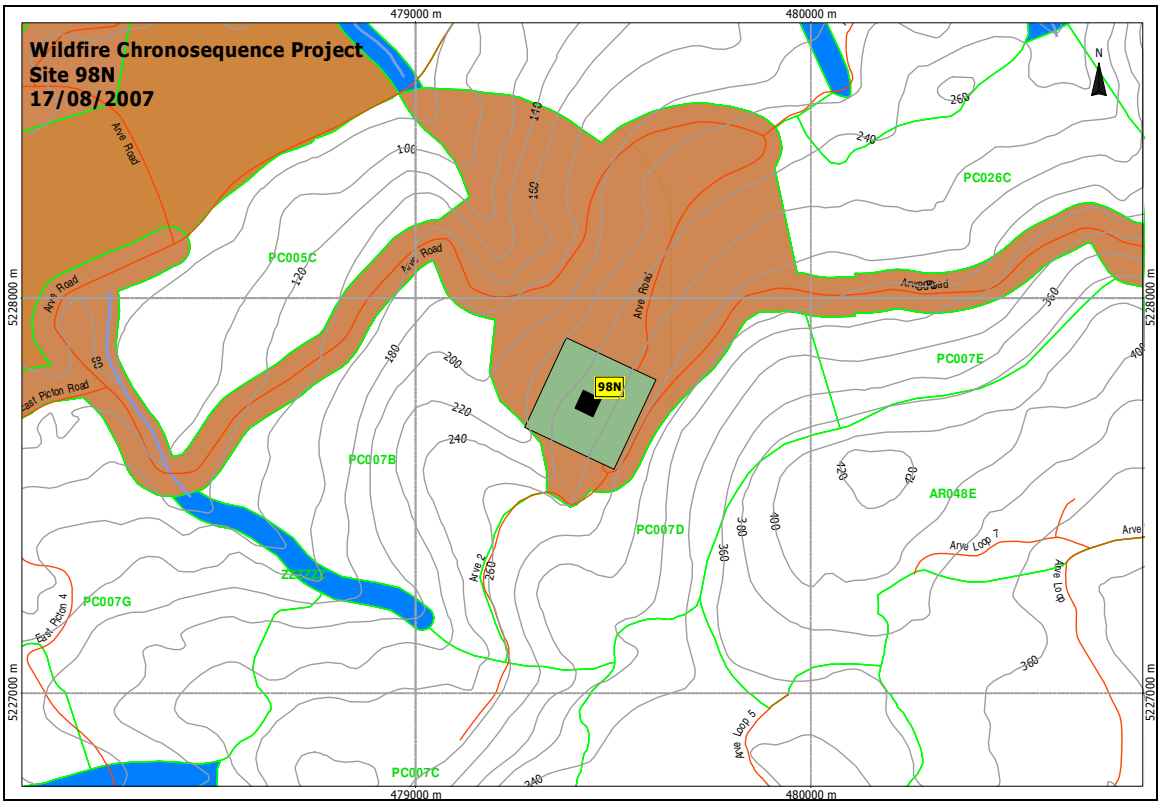


Figure 7. Location of site 98N.

1898 wildfire south (98S)

Access

1898 wildfire south is accessed along Bird Track, Warra LTER site (see Figure 6). Bird Track is a blazed and cut loop track with the TOP on the uphill side of a hairpin turn located approximately 7.1 km from the junction of Manuka Rd and South Weld Rd. Access to 98S is easiest either via the northern branch of Bird Track (see OGS for TOP details). Junction track links both northern and southern branches of the track.

Take the northern branch of Bird Track 450 m to the northern intersection with Junction track. Turn south down Junction track and walk for ~ 80 m. There are two plots either side of this section of Junction track. The plot to the east of the track is [#]Genevieve Gates' 50 X 50 m plot. The plot to the west is the Wildfire Chronosequence 50 X 50 m plot, 98S. At the 80 m mark is the north east corner of the 98S plot.

[#]Genevieve Gates is a PhD candidate at the University of Tasmania, School of Plant Science (enrolled 2006). Her PhD is entitled 'Macrofungal biodiversity as a tool for the sustainable management of coarse woody debris in the forest landscape'. The project utilises four research plots, three of which are positioned in close proximity to, but not overlapping, the wildfire chronosequence plots OGS, 98S and 34S. The fourth plot is a multi-aged plot (1934 and 1898 wildfire) and is positioned near Manuka Rd at the entrance to Bird Track north branch. Her project involves mapping coarse woody debris on each of the four plots and subsequent surveying for epixylic macrofungi. Surveys span 2-3 years and the resulting data will be analysed to assess long term monitoring and landscape management decisions.

1934 wildfire north (34N)

(NB: site established but not yet confirmed permanent. PAMT 7/12/2006)

Access

1934 wildfire north is situated within WR013B (Figure 8). Access is gained from Fletchers Rd. The TOP is on the western side of Fletchers Rd. The TOP can be found at either a distance of 400 m south along Fletchers Rd from the intersection of the Weld River and Fletchers Rd, or 2.6 km north along Fletchers Rd from the intersection of Fletchers Rd and South Weld Rd. From TOP follow some old roading westward for ~ 60 m until you meet a cut track flagged with yellow tape. From here take the track a further ~60 m until you come to the northeast corner of the 50 x 50 m plot.

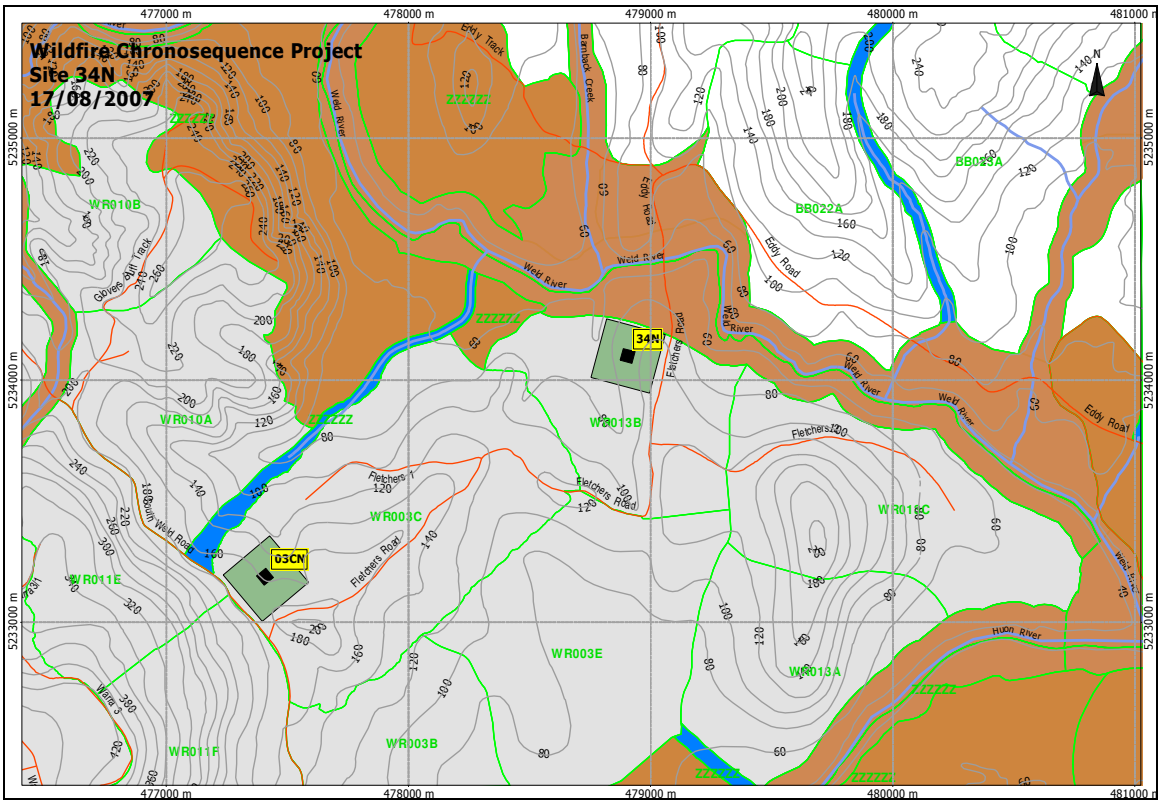


Figure 8. Location of site 34N.

1934 wildfire south (34S)

Access

1934 south is accessed along Bird Track, Warra LTER (Figure 6). Bird Track is a blazed and cut loop track with the TOP on the uphill side of a hairpin turn located approximately 7.1 km from the junction of Manuka Rd and South Weld Rd. Access to 34S is via the northern branch of Bird Track (see OGS for TOP details). Take Bird Track 450 m to the northern intersection with junction track. Continue east for ~500 m. At this point you turn north along a blazed and cut track for ~100 m. This takes you to the southwest corner of the 50 X 50 m plot.

1967 wildfire north (67N)

Access

1967 wildfire north is situated west of Billy Creek, upstream ~100 m from the confluence with Lidgerwood Creek (Figure 9). Access is gained from Southwood Rd. The TOP is on the western side of Southwood Rd. The TOP can be found at either a distance of 420 m south along Southwood Rd from the intersection of Southwood Rd and Lidgerwood Spur 2. Parking is possible beside a dirt mound on the western side of the road. From this western side of Southwood Rd a ~ 150 m cut track with yellow flagging tape heads west towards the north corner of the 50 x 50 m plot.

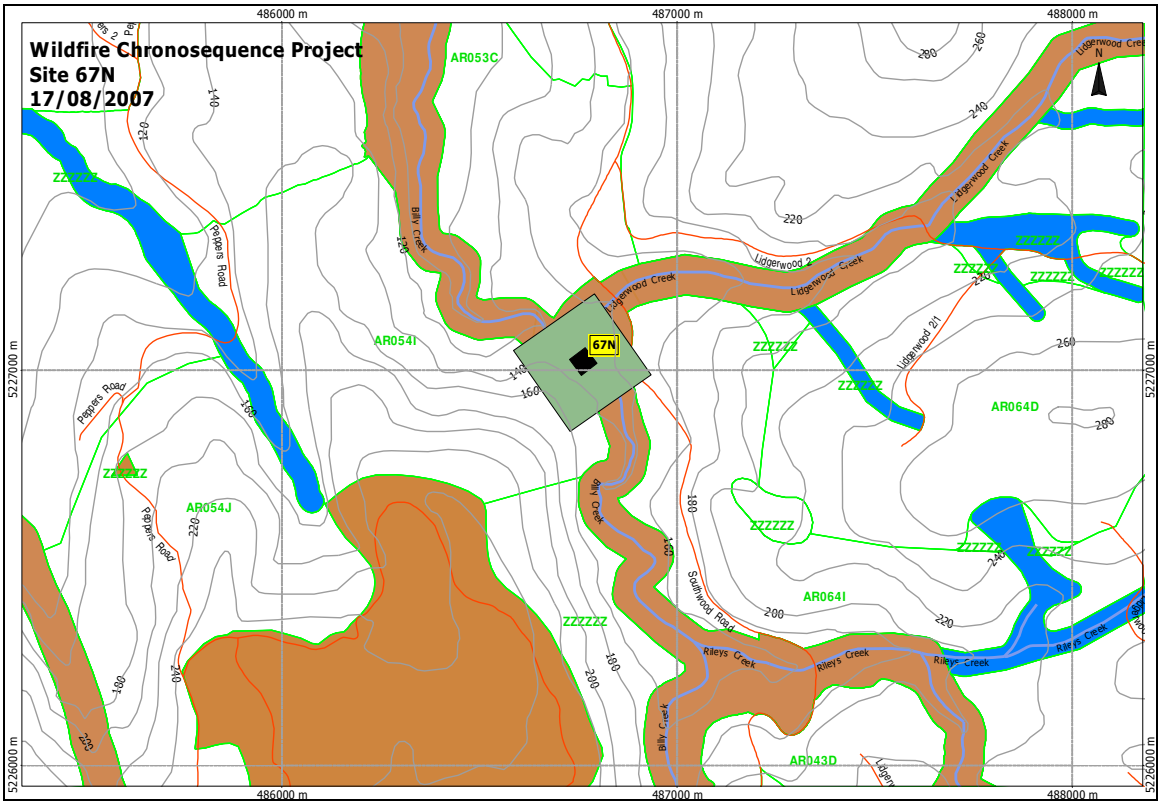


Figure 9. Location of site 67N.

1966 wildfire south (66S)

Access

1966 wildfire south (Figure 10) is within an unthinned section of forestry coupe AR015D; the remaining coupe area was thinned during October - November 2006. The TOP to the plot is found on the southeast side of Crib Hill Spur 1/2 at a distance of 400 m northeast along Crib Hill Spur 1/2 from its junction with Crib Hill Spur 1. Follow a cut track for 70 m where it comes to the northwest corner of the 50 X 50 m plot.

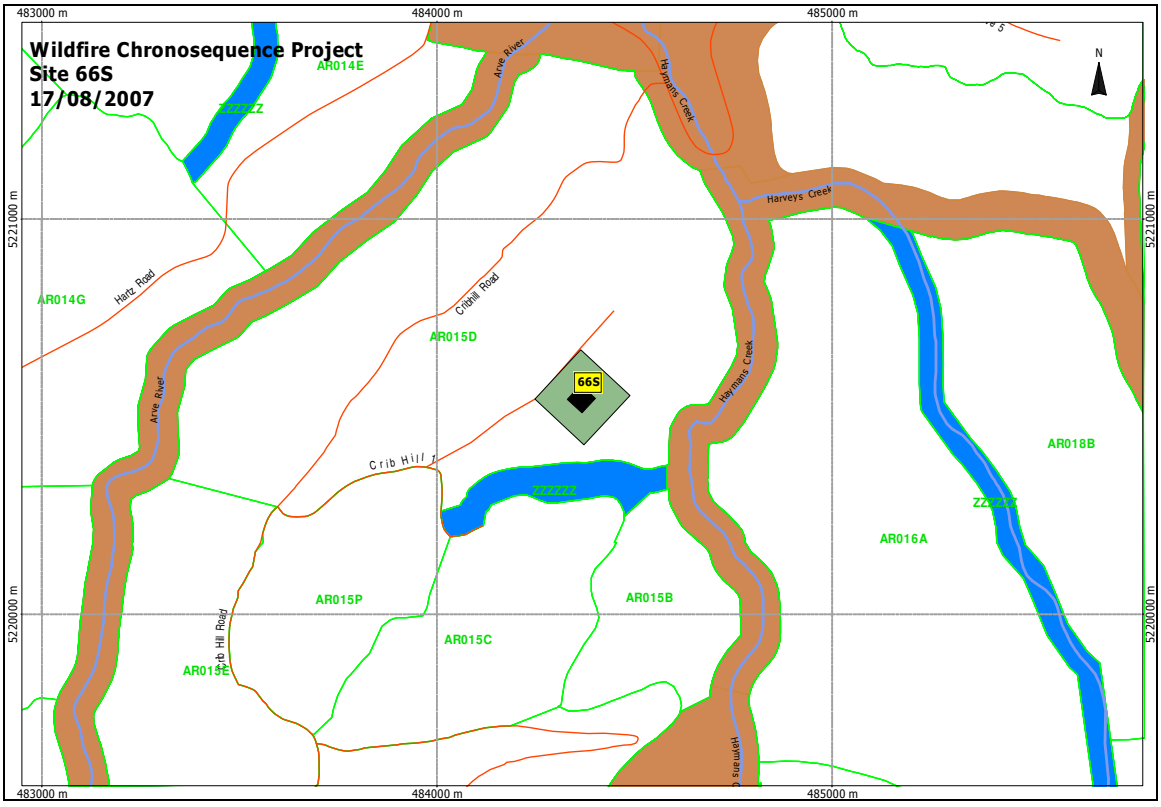


Figure 10. Location of site 66S.

1966 clearfell burn and sow north (66CN)

Access

1966 clearfell burn and sow north is located within a conservation reserve on Keoghs Rd (Figure 11). Keoghs Rd is on the left hand side of Arve Rd approximately 7.45 km from the Arve Rd - Southwood Rd intersection. Take Keoghs Rd for 2.1 km where you meet an intersection. Take the right hand side branch for 450 m which will take you to the end of the road. A turning circle is available at the roads end. Just off the turning circle is Foaming Creek and an old bridge which leads to a road. This bridge and road are impassable by vehicle but are walkable. A few planks have been laid to assist passage over the bridge. Continue from the bridge along the disused road for ~500 m. The road skirts around the middle of a hill and is not on current maps. However, sections are visible on aerial photography. After ~ 500 m a short track heads ~20 m uphill (east) to the northwest corner of the 50 X 50 m plot. The plot bottom (western) boundary is parallel with, and close to, the disused road.

The plot is within an area assigned as a conservation reserve. At the time of writing this report, it is unclear why this area is a conservation reserve. Plot 66CN is 'paired' with 66CS. There may be a requirement, for future research, that one of the plots' be rezoned so that they share the same management zoning. That is, either change the reservation status of 66CN to non-reserve (so it can potentially be harvested), or change the reservation status of 66CS so that it is not harvested.

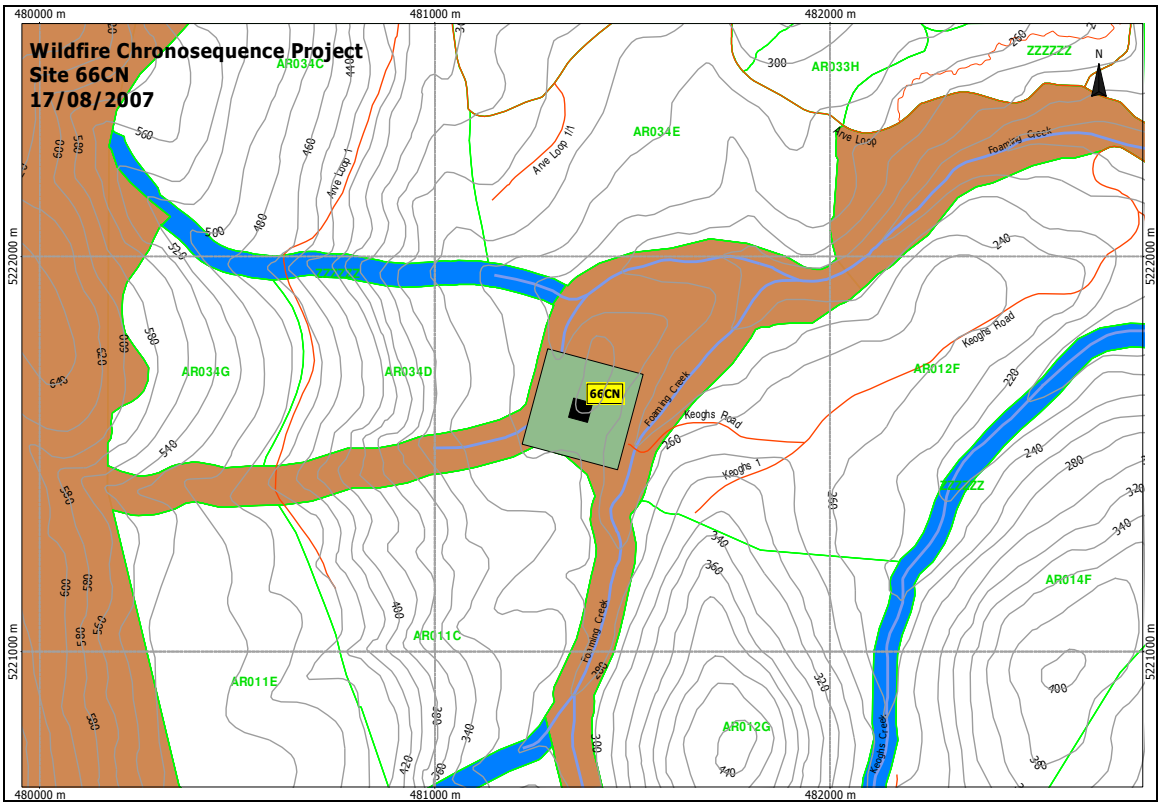


Figure 11. Location of site 66CN

1966 clearfell burn and sow south (66CS)

Access

1966 clearfell burn and sow south plot is located on Blue Hill and incorporates Forestry Tasmania's Permanent Inventory Plot (PIP) 1227 along the northwestern boundary of the 50 X 50 m plot (Figure 12). The wildfire chronosequence plot area also incorporates one quarter of a 1 ha coarse woody debris plot area (TAS1_1227) surveyed by Woldendorp (2002).

The TOP is located on the eastern side of Arve Rd, at a distance of 600 m north of the Arve Rd and Edwards Rd junction. The marker is an oldgrowth log of approximately 120 cm diameter, with a sawn-off end. This is the PIP plot reference mark and it is marked by blazing and orange paint. The access track is not visible from the road edge. An access line can be gained from the plot reference mark by a true bearing of 309˚ for 9 m then a true bearing of 84.5˚ for 80 m. This will end at the western corner of the 50 X 50 m wildfire chronosequence plot.

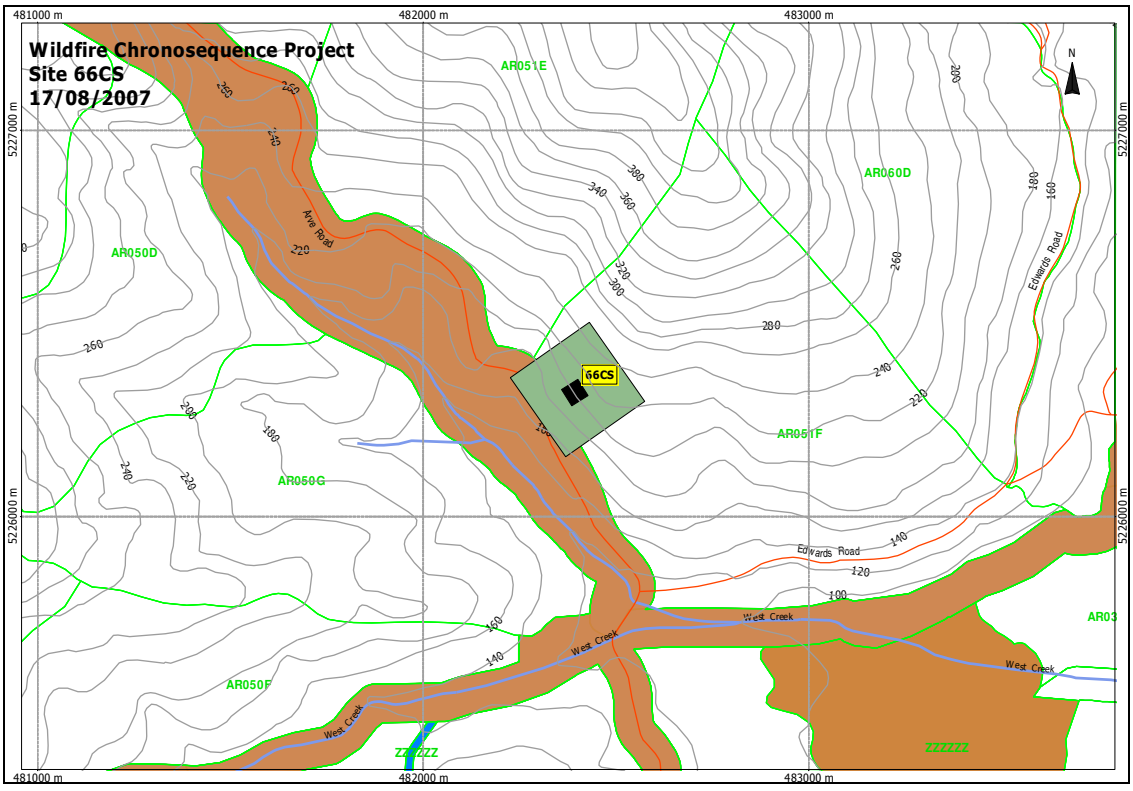


Figure 12. Location of site 66CS

2003 clearfell burn and sow north (03CN)

Access

The 2003 clearfell burn and sow north plot TOP is located on South Weld Rd, at a distance of 140 m northwest of the intersection with Fletchers Rd (Figure 13). The track is not visible from the road. From the TOP head on a true bearing of 50˚ for ~10 m and a cut track will become visible. Follow this track for ~140 m. The latter 100 m of the track follows a snig track. The track ends at the southern corner of the 50 X 50 m plot.

Only the outer perimeter star-pickets/fence posts have been joined by string. The inner star-pickets/fence posts are not joined by string. This is because much of the vegetation at this site at this age is between 0 m and ~ 3 m above ground level and there is the risk of the inner posts being lifted out of the ground with vegetation growth.

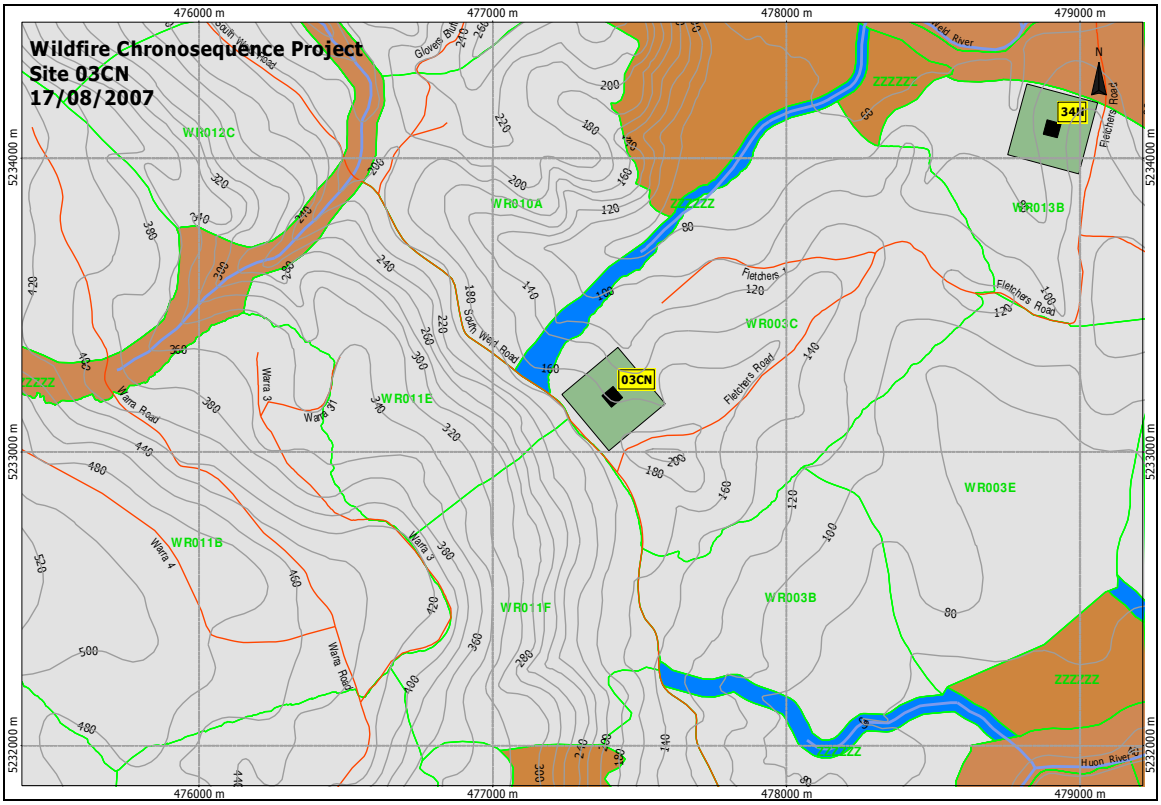


Figure 13. Location of site 03CN

2001 clearfell burn and sow south (01CS)

Access

2001 clearfell burn and sow south is located within the Warra Silvicultural Systems Trial. It is in Big Coupe (WR008H) on the west side of Manuka Rd. The plot is uphill from the coupe's most southwesterly understorey island. From the Manuka Rd – South Weld Rd intersection travel 3.2 km where you turn right into Manuka Spur 8. The TOP is at the end of Manuka Spur 8. At the spur end is a pile of charred logs. The cut track heads over these and continues for ~ 60 m to the northeast 50 X 50 m plot corner (Figure 14).

Only the outer perimeter star-pickets/fence posts have been joined by string. The inner star-pickets/fence posts are not joined by string. This is because much of the vegetation at this site at this age is between 0 m and ~ 3 m above ground level and there is the risk of the inner posts being lifted out of the ground with vegetation growth.

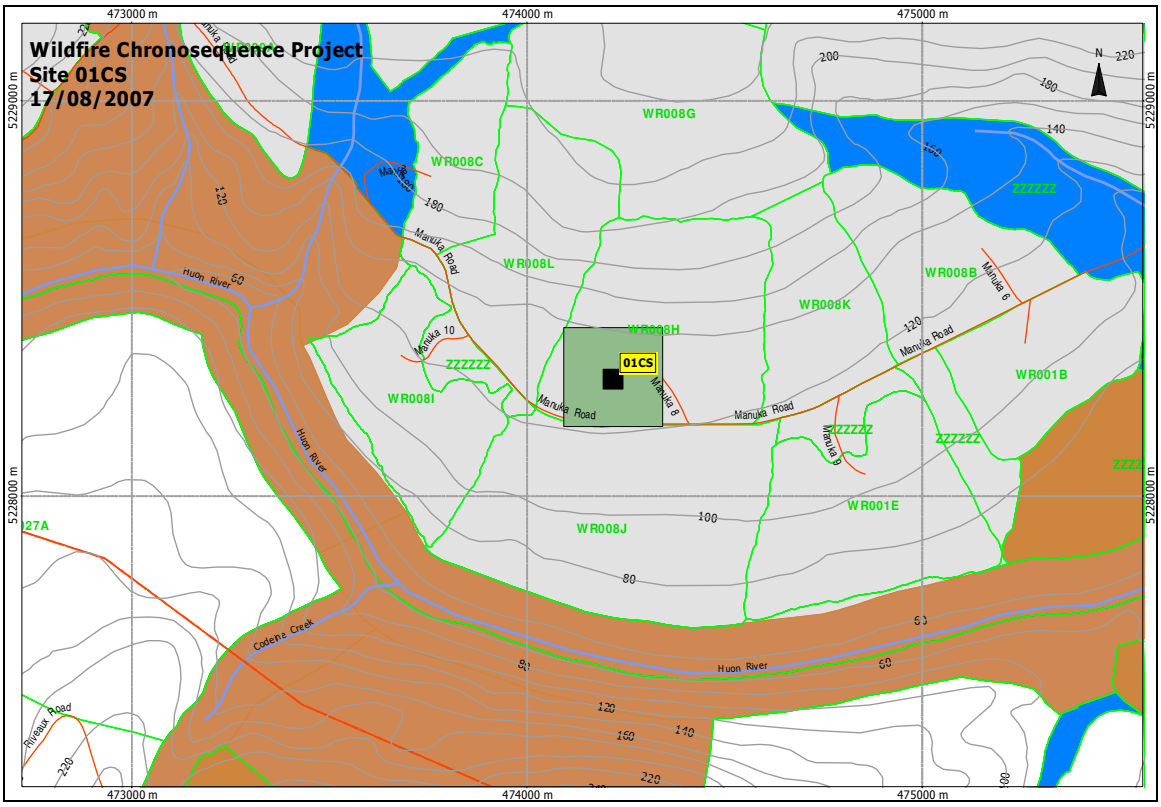


Figure 14. Location of site 01CS.

2.5 Site design and coding system for plots and subplots

Each of the twelve sites consists of a 50 m X 50 m core plot area surrounded by a buffer zone which extends 100 m either side of the core plot; the total site area is 6.25 ha (Figure 15). Each site is positioned so that the top and bottom boundaries of the site are parallel with the predominant contour.

For 1966 wildfire south plot the buffer zone is reduced from 100 m to 70 m from the road on the northwest side of the core plot only. Finding a 1966-or-1967 south facing wildfire site that was consistent with all the site criteria proved to be difficult. After much searching a site was found; however due to roading, streamside reserve vegetation, adjacent fire regimes, and previous site history, an adjustment was made on the buffer area. This change is considered acceptable given the landscape surrounding the core plot.

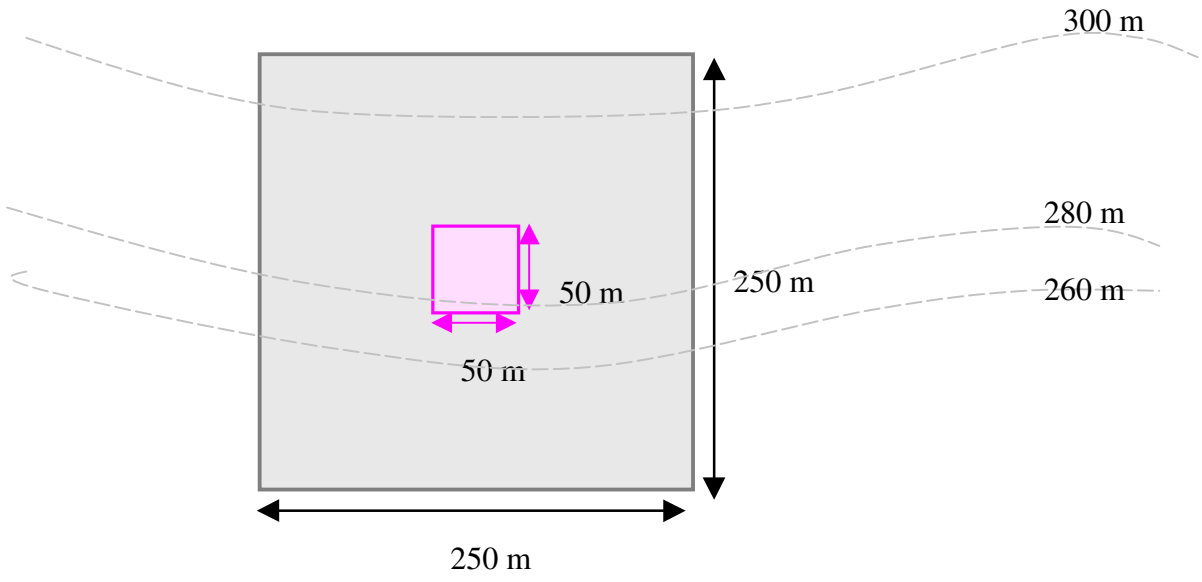


Figure 15. Site design. Core plot is 50 m X 50 m (shown in pink) with surrounding buffer area (shown in grey). Site layout is shown in relation to example contours (dashed line).

Each site is coded as listed in Table 6, eg. OGN = Oldgrowth north facing site. Each 50 m X 50 m core plot is divided into 25 subplots, each of 10 m X 10 m (Figure 166).

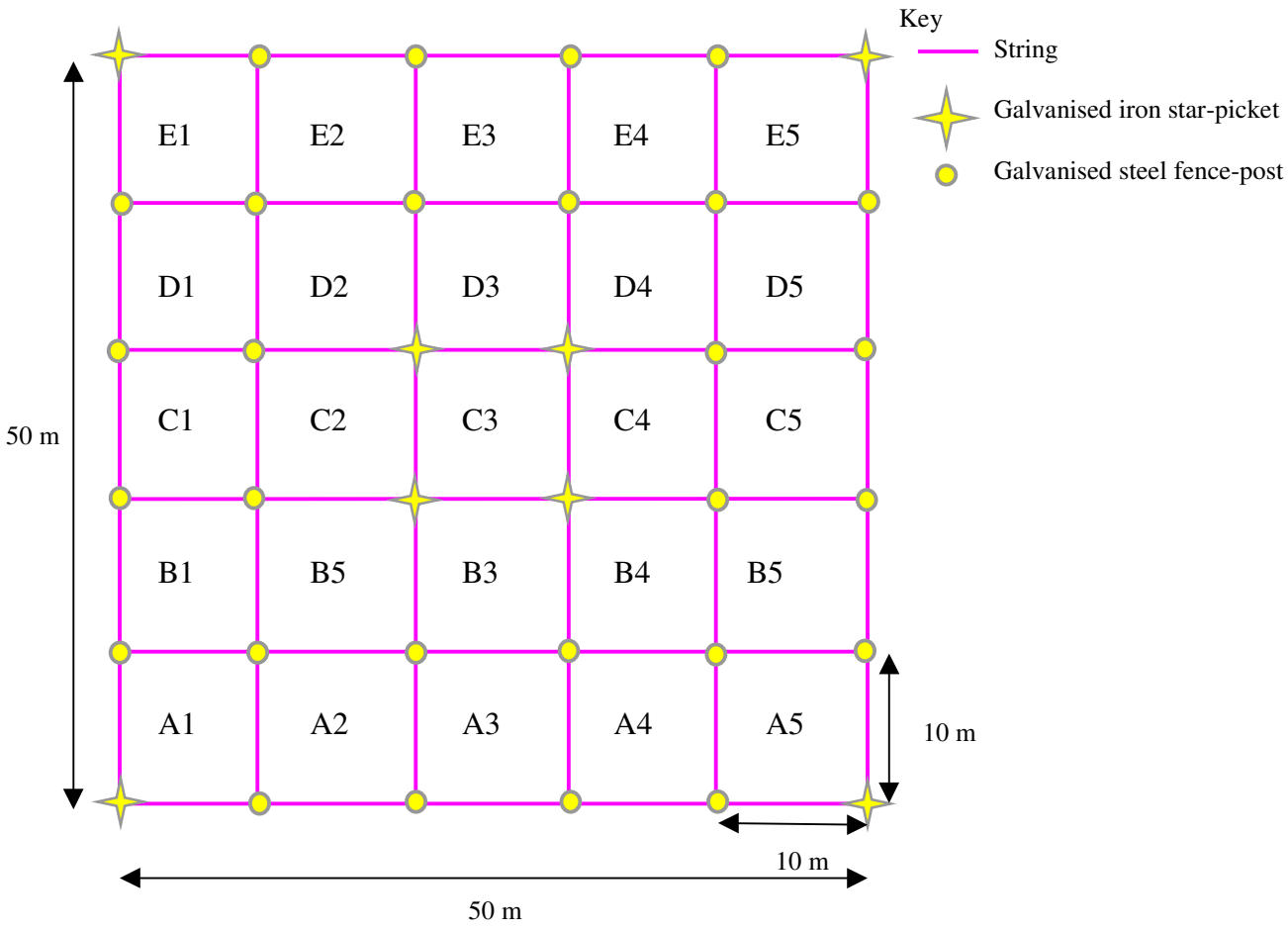


Figure 16. Core plot design and coding. Each core plot is 50 m X 50 m divided into 25 subplots each measuring 10 m X 10 m.

The centre 10 m X 10 m subplot corners, and 50 m X 50 m plot corners, are each marked with a galvanised iron star-picket. All other subplot corners are each marked with a galvanised steel fence-post. The star-pickets have been used in this way so that if the plot is disturbed, eg by wildfire, there is a strong potential that some of these pickets will still be standing and therefore relocating the plot will be possible. String (pink/yellow/white) has run between each post and picket. However, for the 2000 + clearfell burn and sow

plots (03CN and 01CS), only the outer 50 m X 50 m plot area has been outlined with string. The inner plot area has not been strung for two reasons:

- the fast growing vegetation was thought likely to catch on the string as it grew and therefore there is the potential that some posts may be pulled from the ground and/or the string would break;
- the ultraviolet radiation on the string is greater in these plots compared to other plots and the string disintegrates faster, therefore increasing maintenance.

In these plots, relocating the inner posts/pickets has been aided by using yellow flagging tape on a tree near to the post.

Much of the terrain covered by each plot is hilly. Therefore each plot has been corrected for slope so that area estimations refer to a horizontal map plane. Slope correction was achieved by taking percentage slope inclination readings along each 50 m line length and correcting either in sections if the slope changed (eg. 10 m lengths if slope changed) or correcting over the whole 50 m line length (if slope was relatively uniform).

By slope correcting, the perimeter of each site and the 10 m X 10 m subplots may not be 50 m X 50 m, or 10 m x 10 m on the ground. For example, a subplot within the core plot may have a perimeter of 10.3 m x 10.3 m x 10.5 m x 10.5 m. In addition, although a slope correction factor may have dictated placement of a star-picket/fence post at 10.3 m, features such as a log, or rock have at times prevented placement at this point. Kleinn *et al.* (2002) suggest that an overall correction of plot size, such as that undertaken in the present study. is not sufficient for precise stand measurements. However, they suggest that for plot sizes such as that used in the present study and for ecological studies in general, perhaps what is of more concern to biodiversity is 'the actual habitat in the field, its size, shape, and conditions, and not so much the fairly artificial concept of a projected area'. Despite a few minor errors due to post placement, by using slope correction, each of the core plots are comparable in area – a factor that would not be possible had all plots been established based solely on the ground measurements.

Subplots are alpha numerically labelled as A1, A2…A5 through to E1, E2….E5. Subplots labelled with an 'A' are situated down slope, and those beginning with 'E' are up-

slope. The subplot A1 is therefore always positioned down slope in the far bottom left hand corner of the plot. The X axis is always parallel to the contour, therefore the Y axis is always perpendicular to the contour. Measurements of subplots should always begin in the bottom left hand corner of each subplot. That is, the zero of both X and Y axes begins at the position marked '0 m' in Figure 18. Labelling and measurement of sub-subplots (say 5m X 5m within a 10 m X 10 m plot) should also begin at each bottom left-hand corner and move right eg. A1a, A1b (Figure 17).

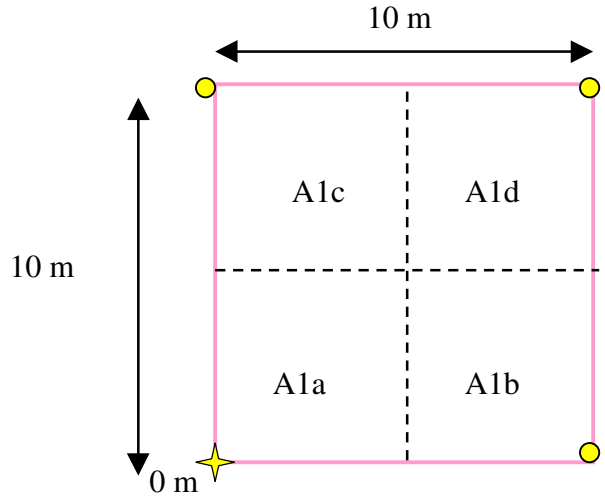


Figure 17. Subplot coding

Plot layout maps

Plot layout maps (not to scale) are shown in Figure 18. Each map details where the access track is in relation to the 50 X 50 m plot area. Rest/equipment areas are designated and compass bearings indicate the direction each grid is positioned on the slope. An approximate slope is given in degrees to the horizontal.

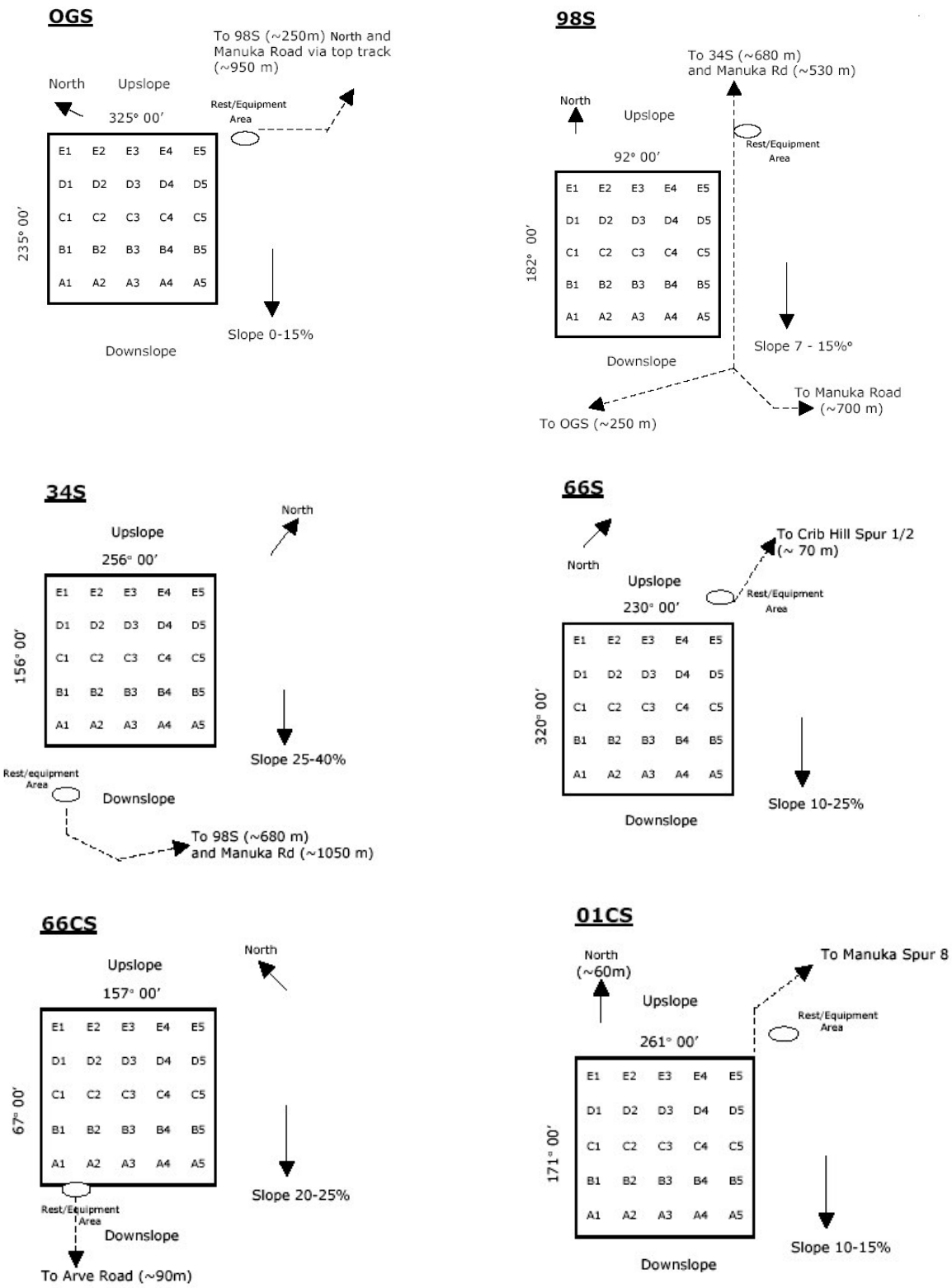


Figure 18. Maps showing 50 m x 50 m plot layout and position of access track in relation to plot setup

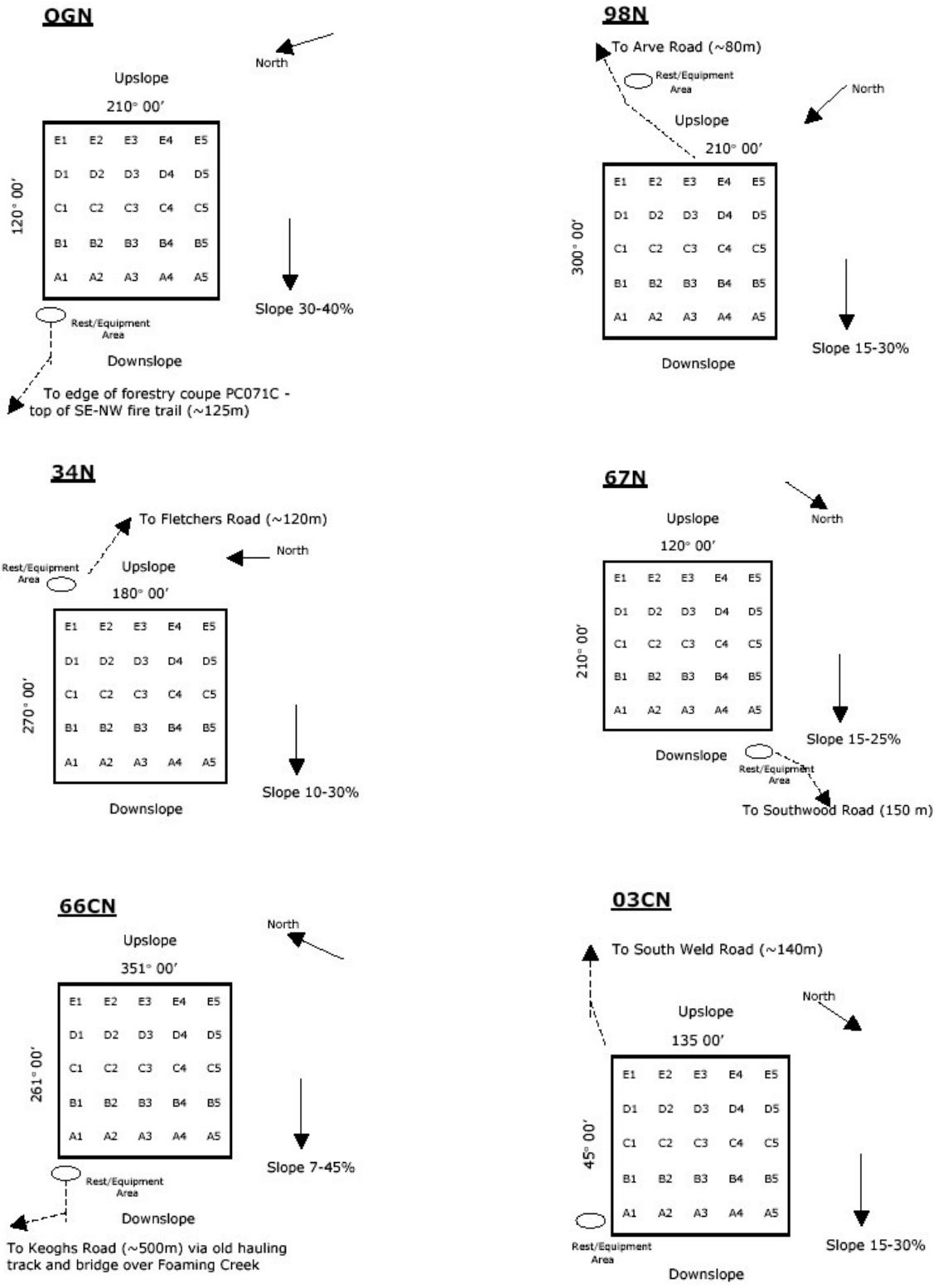


Figure 18 (continued). Maps showing 50 m x 50 m plot layout and position of access track in relation to plot setup.

3 Structural and floristic surveys

Each 50 X 50 m plot will be used to measure environmental, floristic and stand structural attributes (see Tables 8 and 9). Measurements which can be derived at a later date from a main attribute (eg. plant diameter) are mentioned in Appendix 1.

3.1 Environmental variables

Table 7 details environmental variables that are measured for each site. These are general variables, some of which have already been collected, such as latitude and longitude/GDA, geology, altitude, aspect and slope (see Table 6). Climate data are available for Warra via the Bureau of Meteorology and/or the Warra LTER website.

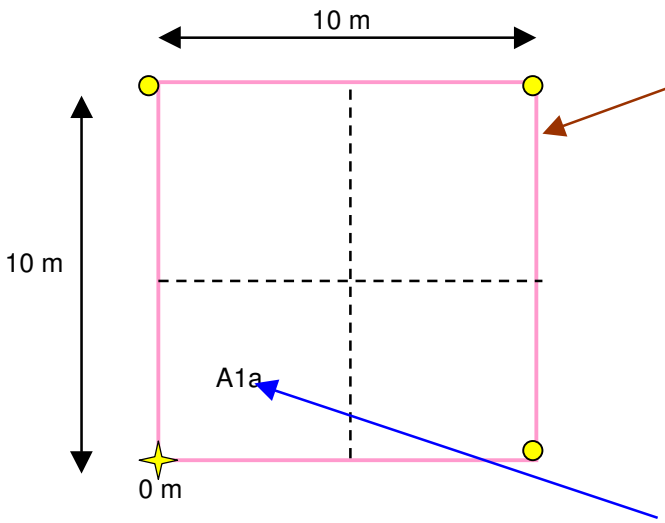
Table 7. Environmental variables to be measured for each site

Attribute	Description
Latitude and longitude/ GDA	Recorded from GIS/GPS
Geology	Recorded from GIS
Altitude (m)	Recorded from GIS/GPS
Temperature (˚), rainfall (mm) and other climatic variables	To be predicted by the BIOCLIM, part of the ANUCLIM package or from actual data (Bureau of Meteorology, Warra LTER)
Aspect (˚)	Recorded in degrees and grouped into 5 classes (1 = northwest, 2 = north or west, 3 = northeast of southwest, 4 = east or south, 5 = southeast).
Slope (˚)	Measured in degrees from the horizontal using a clinometer from the centre of each 50 X 50 m plot and/or each 10 X 10 m plot.

3.2 Vertical structure – definitions and methodology

Initial measurements of structural attributes will focus on vertical structural measurements of vascular plants, dead trees (stags) and stumps (Table 8). Measurements collected from these vertical attributes include diameter at breast height, height to top of crown, height to lowest green growth, position (on a Cartesian plane ie. X and Y axis), and vascular plant species. Measurements of these attributes are taken over the whole 50 m X 50 m plot area, based within each 10 m X 10 m subplot and/or 5m x 5 m sub-subplot. Ten-metre long measuring tapes are placed along each outer edge of the 10 x 10 m subplot with the zero-metre point positioned at the bottom left hand corner of each plot (see Figure 17). Within each 10 m X 10 m subplot, the use of a few 2.5 m measuring poles assist in measurements from vertical attributes to each X and Y axes. Tree chalk is used to mark vascular plants/stags/stumps as they are measured. A plot data sheet (Appendix 2) lists attributes recorded and includes space in which to draw a mud map of the 10 m x 10 m plot including length of X and Y axes (ie the axes may be more than 10 m in length) and any other features. A diagram of plot layout with lists of attributes in each subplot is shown in Figure 19. Table 8 gives definitions and instructions on the measurement of each attribute.

More detail of these and additional vertical structural measurements are given in Appendix 1 This appendix lists alternative/additional measurements for attributes and floristic variables listed in Table 8. These alternative measurements are not required for the present study; instead they are included as suggestions for future studies.



10 m x 10 m subplot eg. A1:

- *For all stems > 10 cm dbh measure:*
  - dbh
  - Height to top of crown
  - Height to lower green foliage
  - Diameter of crown
  - Position in subplot

5 m x 5 m subplot: eg. A1a:

- *For all stems between 5 - 9.9 cm dbh measure:*
  - dbh
  - Height to top of crown
  - Height to lower green foliage
  - Diameter of crown
  - Position in subplot
- *For all stems < 4.9 cm dbh*
  - Height in visual 0.5 m bands
  - Percentage cover per species

Figure 19. Vertical attributes to be measured in each 10 m x 10 m and 5 m x 5 m subplot per 50 m x 50 m core plot

Table 8. Vertical structural attributes proposed for measurement (December 2006 - June 2007)

Attribute	Description and definition
Vascular plant/stag/stump diameter at breast height	Definition: A measure of vascular plant/stag/stump size defined as diameter at breast height (dbh). Breast height is 1.3 m above ground level. Method: Within the 50 X 50 m area 1. within each 10 m X 10 m subplot, measure and record the dbh (1.3 m above ground level, upslope side of stem on sloped sites) of all vascular plant species/stags/stumps > 10 cm in diameter at breast height (and then may be later assigned to a diameter class (see Appendix 1). 2. within each 10 m X 10 m subplot, divide this area into four 5 m x 5 m sub-subplots and in one 5 m x 5 m sub-subplot measure and record the dbh (1.3 m above ground level, upslope side of stem on sloped sites) of all vascular plant species/stags/stumps Multi-stemmed plants: In the 10 m x 10 m subplot measure stem(s) with dbh > 10 cm. In the 5 m x 5 m sub-sub-plot measure stem(s) with dbh > 5 cm and < 9.9 cm. If relocating stem using X and Y co-ordinates is unclear, or defining between stems is unclear use spaghetti tubing to label a single measurement, or spaghetti tubing and pre-labelled metal tag for multiple measurements. Note on recording sheet: a). the labelled stem and its dbh, and b). total number of stems above ground level.
Vascular plant/stag/stump height to top of crown and vascular plant crown diameter	Definition: The height from base to top of a vascular plant species/stag/stump and width of vascular plant species crown at its widest point. Three measurements are taken: 1. height from ground-level of top of vascular plant crown/stag/stump 2. height from ground-level to lower level of vascular plant green growth 3. diameter of vascular plant species crown at widest point Method: 1. Using a vertex (and tape measure) and, stopping at ~ 20 stems per species/stag/stump: 1. within each 10 m X 10 m subplot and the 5 m x 5 m sub-subplot, take all three measurements for all vascular plant species/stag/stump with dbh greater than 5 cm 2. within the 5 m x 5 m sub-subplot record the height only (in either approx m or height bands of ~ 0.5 m) and number of stems for

Attribute	Description and definition
	vascular plant species with dbh < 4.99 cm. Use stopping rules if a large number of stems (eg > 20). These measurements may be later assigned to a height class (see Appendix 1). Multi-stemmed plants: take the height to top of crown and crown diameter measurements as for a single-stemmed plant.. Method 2. remotely sensed data eg LIDAR
Vascular plant/stag/stump species position	Definition: the location of vascular plant species/stag/stump within the 50 m X 50 m plot area Method: Using 10 m tape measures for X and Y axes and 2.5 m poles for facilitating measurements, 1. record the position of each vascular plant species/stag/stump > 10 cm dbh relative to each X and Y (or X or Y +/- 5 m) axis for the 10 m x 10 m subplot and record the position of each vascular plant species/stag/stump > 5 cm <9.99 cm dbh for all stems in the 5 m X 5 m sub-subplot. Mapping can then be done by giving each vertical attribute an X and Y coordinate, and recording this on a form/spreadsheet without the need to produce a mud-map The X axis is always located parallel with the contour. Take note on the recording sheet the position *on the ground* for the location of zero for each X and Y axis.
Vascular plant/stag/stump species	Definition: the identity of a vascular plant species as determined through taxonomic literature. Method: In all measurements above, record the species of vascular plant. Note if the species is dead or alive. This allows for the potential later allocation of vascular plants to one of the following lifeform groups after recording exact height: • tree T (greater than 6 m tall, single stemmed) • tall shrub TS (between 2 m and 6 m tall, can be single/multi stemmed) • short shrub SS (less than 2 m tall, multi stemmed from base, woody species) • non-woody angiosperm NW • treeferns TF; ground fern GF; epiphytic fern EF

Attribute	Description and definition
Standing dead trees (stags) and stumps	Standing dead trees (stags) definition: dead trees greater than 45° to the horizontal and greater than 2 m in height. Stumps definition: dead trees less than 2 m in height, with or without cut tops and greater than 45° to the horizontal. If the attribute is > 2 m in height and has evidence of cutting (plank holes, saw marks), classify as 'stump'. Stumps fall into the following three categories; 1. Cut by chainsaw, 2. Cut with evidence of plank holes (shoes) and 3. Not cut (eg. created by natural causes). Method: 1. record dbh and height (where applicable) as stated above 2. Record vascular plant genus and/or species (if able) 3. Classify stumps as 1. cut by chainsaw, 2. cut by saw/axe with evidence of plank holes (shoes) and 3. not cut (eg. created by natural causes). 4. Classify stags following the forms from Smith and Lindenmayer (1988) eg. Form 3 = dead tree with most branches still intact, F4 = .dead tree with 0-25% of the top broken off branches remaining as stubs only, F5 = dead tree with the top 25-50% broken away, 6 = dead tree with the top 50-75% broken away, F7 = A solid dead tree with 75% of the top broken away, F8 = Hollow stump. NB: where stags are < 10 cm dbh a Form class may not apply. *Dicksonia antarctica* stags of any diameter are not given a form class.

3.3 Horizontal structure - definitions and methodology

Horizontal structural attributes include logs and branches - which here are collectively called coarse woody debris. Horizontal structural attributes and associated floristics to be measured (beginning December 2006) are identified, described and discussed below (Table 9). Measurements of these attributes are taken for the whole 50 m X 50 m plot area but are based within each 10 m X 10 m subplot. Ten-metre long measuring tapes placed within each 10 m X 10 m subplot at its midpoint (i.e. starting halfway along each X or Y axis) and the use of a few 2.5 m measuring poles facilitate measurements. A plot data sheet (Appendix 3) lists attributes recorded and any other features.

Table 9. Horizontal structural attributes proposed for measurement (December 2006 - June 2007)

Attribute	Description and definition
Coarse woody debris	Definition: Coarse woody debris (CWD): dead woody material, in various stages of decomposition, located above the soil and is not self- supporting. Standing dead trees (stags) and stumps (intact in ground) are considered self-supporting. Pieces of coarse woody debris may be suspended on nearby live or dead trees, other pieces of coarse woody debris, stumps or other terrain features. Types of CWD include logs, branches and upturned root/tree bases. Methods: Measure CWD within the 50 X 50 m plot by concentrating measurements within each 10 m x 10 m subplot (25 subplots). Only CWD down to 10 cm diameter and > 1 m in length is included in measurements. 1. Measure diameter (cm) at each end and depth 2. Measure length (cm) 3. Record species type (if applicable/able) 4. Assign CWD to a decay class using 5 decay class system as per Woldendorp (2002). Logs may have to be divided into subsections of uniform decay class to achieve this. 5. Record position on using X and Y axes (see vertical structure section for layout) 6. Measure, over the whole log, bryophyte cover, litter cover, using approximate percentage and/or modified Braun-Blanquet scale eg. 1 = <5 %, 2 = 6 - 25%, 3 = 26 - 50% 4 = 50 - 75 % 5 = 75 - 100 % cover. 7. Measure regeneration presence: 1=ephemeral seedling, 2 = established seedling, 3 = saplings, 4 = trees 8. CWD ends defined as follows: N = natural break, A = axe/saw, C = chainsaw, RB = roots or buttress

3.4 Additional methods for measurement of variables

Appendix 1 details additional methods for measurement of stand structural variables that may be considered for future work.

4. Further work

4.1 Maintenance

The following items are suggested for continuing maintenance to extend the life of each permanent plot. Each item will require maintenance at different timescales. Timescales given are suggestions only. Those entering a plot are requested to make reasonable repairs to plot infrastructure and to report any damages to the Conservation Biologist, Forestry Tasmania.

1. Each plot will be identified with a sign (design and establishment currently in progress). Timescale – annual check for readability and repairs.
2. Track cutting and other track maintenance. This will vary among plots. Generally all plots will require annual and opportunistic checking for clearing of downed wood/trees. Some plots in particular will need specific attention in areas eg.
    a) 01CS and 03CN – these plots have access tracks cut around the perimeter of the 50 m x 50 m area which will require annual pruning/cutting/poisoning of stems for at least the first 10 years.
    b) OGS, 98S, 34S (Bird Track) – annual and opportunistic checking is required for: gully ‘steps’, ‘star picket and rope lines’, fallen wood/trees onto tracks, general muddiness of the track.
    c) 66CN – annual checking of bridge crossing.
    d) 67N – annual checking of Billy Creek rope line crossing.
3. String lines. Plots 03CN and 01CS only have the outer perimeter of the 50 x 50 m area outlined with string. Once vegetation has grown, say in 10 – 15 years, the inner 10 x 10 m subplot areas will need to be outlined with string also. All other plots will require annual and opportunistic checking for string breakage/perishability.

4. In the event of wildfire – relocation and repairs to the plot should be made as soon as possible.

5. Acknowledgements

The following people have given their time, advice and patience in facilitating the establishment of these plots:

Forestry Tasmania

Craig Airey

Bronwyn Appleby

Dr Sue Baker

Dick Bashford

Steve Davis

Leigh Edwards

Dr. Simon Grove*

John Hickey*

Mark Neyland*

Zach Pompa

Dr Steve Read*

Don Riddell

Dr Tim Wardlaw*

Amy Ware

Belinda Yaxley

University of Tasmania (UTAS)

Mr Paddy Dalton

Dr. Neil Davidson*

Dr. Anthony Koutloulis

Dr Caroline Mohammed*

Dr Emma Pharo*

Dr David Ratkowsky

University of Melbourne

Dr Alan York*

Volunteers

Craig Airey

Phil McLeod

Paul Smart

Krystyna Wniekowski

Students

Melanie Askew (UTAS)

Belinda Browning (UTAS)

Genevieve Gates (UTAS)

Daniel Hodge (UTAS)

Julian Power (Southern Cross University)

Julia Sohn (University of Frieburg)

Ian Scanlan (Australian National University)

Oliver Strutt (UTAS)

Jamie Toliver (UTAS)

Department of Primary Industries and Water

Jayne Balmer*

Mike Driessen*

Other

Prof. David Lindenmayer (Australian National University)

Dr Chris McElhinny (Australian National University)

Dr Terry Walshe (University of Western Australia/University of Melbourne)

* These people are also on an Advisory Committee for the project.

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7. Appendix

Appendix 1. Stand structure and floristic variables proposed for measurement - detailed descriptions and definitions. This summary is drawn largely from McElhinny *et al.* (2005) and additional sources. It is not specifically intended that all derived measurements be used in future analyses. Where relevant, comments regarding previous studies follow definition/description of attributes. These comments include what other studies found to be significant (or not) structural and floristic attributes.

Variable	Definition and method of measurement to be used
Stand Age/number of age classes	1. Definition: Time (years) since last major disturbance(s) (eg. wildfire, logging). Sites classified as multi-aged if multiple major disturbances occurred. Method: Age determined using forest type maps and previous publications. 2. Definition: As per Lindenmayer et al. (2000): field sites classified as multi-aged if the difference in diameter between distinct cohorts of trees exceeded 80 cm and any given cohort comprised at least 15% of living stems on a given site. Method: This can be derived from plant diameter at breast height data. Indirect methods – radiocarbon dating, tree diameter – tree age relationships, tree size – radial growth relationships Direct methods – counting the number of annual growth rings from the pith to the outer cambium of cross-sections from high wood density species or increment cores from low wood-density species Alcorn et al 2001) Method 1. Ring counts (Alcorn *et al* 2001). By eye – along each disc, along radii with the most distinct growth ring sequence free of knots, bark inclusions and rot. Old growth stump radii are less reliable. Intra-annual bands or 'false-rings' are identifiable when rings are abnormally narrow, faint or fail to be recognised around the entire circumference of the disc. *E. obliqua* – adjustment of ring count can be made for age to stump height by assuming trees grow 0.3-0.5m by age 1. When rot or hollow piths make ring counts impossible, the distance from solid wood to the estimated tree centre was predicted based on the annual ring width closest to the pith. Reliability class: high (up to 5% error), medium (up to 10%error) and low (up to 15% error) The presence of kino within the annual rings can be used to assess fire history. Kino rings can be recorded and the date of occurrence of these estimated based on the tree age estimate. Alcorn *et al*. 2001 found kino rings to have little correlation with fire occurrence. Other stem injuries (insect attack, branch shedding, bark damage) may have influenced the occurrence of kino. Disc sampling height may also have affected the occurrence – ie disc height was between 2 and 110 cm. Method 2. Cross-dating (Allen 2001). The first step in establishing a ring-width chronology is cross dating. The matching of patterns of wide and narrow rings between samples. If cross-dating at a site cannot be achieved, then it is not possible to build a reliable chronology for that site. Cores are initially visually cross-dated using a microscope. For discs, two radii from the outer edge and centre are marked. Rings are checked between these radii. Computer assisted cross dating (a measuring stage attached to a digital display unit and a computer with data quality control software) follows visual methods. Method 3. Determined using forest type maps provided by FT and previous publications. The number of distinct age classes on a defined site
Dominant tree species	Definition: Dominance defined as the most common taxon within a defined area. Method: Determined from fruits and buds following taxonomic literature.

Variable	Definition and method of measurement to be used
Hollow trees	Definition: A tree with hollows is classified as any tree >0.5 m in diameter and greater than 6m in height containing obvious cavities (Smith and Lindenmayer 1988). Method: determined using binoculars using the methodology of Smith and Lindenmayer (1988). The abundance of living and dead trees with hollows is recorded.
Vascular plant species	Vascular plant species definition: the identity of a vascular plant species as determined through taxonomic literature. Vascular plants are described by species richness, abundance, species composition, species diversity Species richness definition: a count of the number of species in a subplot, area or community. Abundance definition: Presence/absence data and abundance (quantitative) measures. Percentage cover of vascular plant species, bryophyte species, lichen species etc.eg. Modified Braun-Blanquet cover values: 1 = +, 2 = <1%, 3 = 1-5%, 4 = 6-25%, 5 = 26-50%, 6 = 51-75%, 8 = 76-100%. Species composition definition: the species found in a particular area Species diversity definition: a combination of species richness and relative abundance of a species within a sample or community. eg. Shannon index: Distance independent algorithm describing species mingling. Shannon index values are higher the more species there are in forest compartment and the more equally they are represented in terms of relative abundances A reliable measurement for tree height or canopy structural diversity, but ignores the horizontal spatial component (x,y) structure Lifeform groups definition = Vascular plant species are assigned to one of the following eight groups: tree (greater than 2 m tall, single stemmed), tall shrub (greater than 2 m tall, multi-stemmed), short shrub (less than 2 m tall, multi stemmed from base, woody species), non-woody angiosperm, all ferns, treeferns, ground fern and epiphytic fern. (Non-vascular = bryophytes classed as moss or liverwort where possible, otherwise collectively as bryophyte; lichen classed as foliose, fruticose or crustose where possible, otherwise as lichen). Understorey vegetation definition: the layer(s) of vegetation beneath the uppermost vegetation layer (the overstorey). A high proportion of plant species richness is held in the understorey of wet eucalypt forest. Method: Cover abundance. Within 10 X 10 m subplots at the corners (subplot 1, 5, 21 and 25) and at the centre (subplot 13) of the 50 X 50 m area record vascular plant species cover abundance using a Braun-Blanquet scale. Vascular plant species less than 1.3 m in height are measured for height (m) and diameter (cm) where possible. Assign each vascular plant species to a lifeform group. Comments: Understorey vegetation is particularly important in differentiating between successional stages (Spies and Franklin 1991) e.g % cover of the herbaceous layer, density of shade tolerant saplings, % cover of deciduous shrubs, density of subcanopy saplings, and % cover of all understorey vegetation, and the coefficient of variation of herbaceous cover. It also reflects the high proportion of plant species richness that is held in the understorey of these ecosystems, and the relative sensitivity of the understorey to modification. Understorey variables can be derived from species data (species abundance, species richness etc.) Plant species - found to be not so important attributes of temperate forests (than tropical forests) in distinguishing between primary and secondary forest than

Variable	Definition and method of measurement to be used
	attributes such as mean diameter or number of trees. For temperate forests it is the relative abundance of key tree species or groups of species which is important, rather than species richness, which distinguishes successional stages. Other variables derived from data include: percentage cover/species richness of lifeform groups; dominant tree species (most common taxon within a site as identified using taxonomic literature, see above).
Vascular plant diameter	See Table 8 for definition and methodology for measurement. Diameter classes:- 0-5, 6-10, 11-20, 21-30, 31-40, 61-80, 81-100, 101-140, 141-180, and >180 cm (as from Lindenmayer et al 2000). Measurements derived from plant diameter at breast height include: 1. Mean dbh (expect increases with stand age). Stand basal area is directly related to mean dbh and is indicative of stand volume and biomass. Old growth and young stands may have the same mean dbh (Franklin et al 1981). 2. The standard deviation of dbh. A measure of the variability in tree size, and is considered indicative of the diversity of micro-habitats within a stand. Can be comparable with more complex attributes and indices eg. height diversity between successional stages (Spies and Franklin 1991). 3. Number of large trees. The number of large trees may be an indicator for a) number of occupied hollow bearing trees, b) dead standing trees, and c) logs. 4. Frequency distribution of dbh classes (tree size diversity). Frequency distribution across a range of diameter classes as an attribute of stand structure, eg. 10 cm diameter classes to characterise the structure of stands. 5. Basal area. Basal area gives limited information on the size and density of trees in a stand. The basal area is the area outline of a plant near the ground surface. In trees it is measured through the diameter ie. At 1.3 m above ground level by the formula πr^2 where r is ½ X dbh. Method a. The diameter of all trees within a 50 m X 50 m plot using diameter tape (as above). Method b. $m^2 ha^{-1}$ Bitterlich wedge method, (Mueller-Dombois and Ellenberg 1974) Method c. Prism wedges. Comments: Large trees have been used to differentiate old and young forests: Franklin *et al.* (1981) identified these as: i) Large living old-growth trees with dbh > 100 cm. ii) Large dead standing trees. iii) Large logs on land and. Iv) Large logs in streams. The threshold diameter needs to be defined eg. > 100cm

Variable	Definition and method of measurement to be used
	dbh). Diameter - may or may not be useful in succession studies. CBS management may influence classes. One drawback is the complexity issues of comparing distributions from different stands, addressed by using the Shannon–Weiner Index to summarise diameter distribution in a single measure called tree size diversity (H0), where H0 = _S(pi ln pi) and pi is the proportion of trees in the ith diameter class This measure permits direct comparisons between diameter distributions, and also provides a simple attribute that can be modeled under different management strategies. Not sure how useful this measure would be.
Vascular plant height	See Table 8 for definition and methodology for measurement. Height classes may be 1.3-2m, 2-5, 6-10, 11-20, 21-30, 31-40, 41-60, and> 60 m. From data height classes of lifeforms can also be derived eg. Vegetation layers assigned to classes - eg. tree overstorey, tree understorey, tall-shrub layer and short-shrub layer. The number of strata recorded. Comment: Height: • can indicate successional stages, strata number and biomass. • can be quantified as structural richness i.e. the number of height classes occupied by trees in a stand. Because height also depends on horizontal arrangement three dimensional models are also possible (using indices). Tree height is defined by qualitative relationships between height and diameter, but the relationship is non-linear. More meaningful to use attributes directly associated with height for vertical elements.
Plant height and diameter combined = Plant Matrix Lindenmayer et al (2000)	Measurement of all species for height and diameter is time consuming. Other options for measurement may include eg. only measuring plant species ≥ 2m in height and ≥ 10 cm (or 20 cm) dbh. Comment: Lindenmayer *et al.* (2000) developed a plant matrix of tree diameter and vegetation layers = A two-way height and diameter matrix for all stems of all species >2 m in height on each plot. The species of stem in the plot is recorded and then assigned to a height and diameter class. Height classes are: 2-5, 6-10, 11-20, 21-30, 31-40, 41-60, and >60 m. Diameter classes:- 0-5, 6-10, 11-20, 21-30, 31-40, 61-80, 81-100, 101-140, 141-180, and >180 cm. Multi-stemmed shrubs are assigned to the class corresponding to stem with the largest diameter and height class for the plant.
Canopy cover	Canopy cover definition: the percentage cover of the vertical projection of tree crowns, where the crowns are considered as opaque objects (Walker and Hopkins, 1990). Canopy gap definition: proportion and average size, distribution (Spies and Frankiln 1991). Associated with the variance in canopy cover. Extent and condition of canopy cover is important eg. the number of trees with dead/broken crowns Method 1: photography (hemispherical, constant height and aperture with rectifying photography). E.g. using a defined number of stratified photo's per plot with immediate obscuring vegetation removed. Each photo taken with the maximum focal length (30 mm – 80 mm) and at a constant height (eg 1.7 m). At a

Variable	Definition and method of measurement to be used
	threshold value for each negative, percentage canopy cover is recorded as the number of dark pixels within a centred circle on the negative. Method 2. Spherical mirror Method 3. Aerial photography (takes into account gaps and sizes) Method 4. Lidar data. Comment: Canopy cover = useful for successional studies as canopy changes over time (Franklin *et al*. 2002). Not meaningful biologically as canopy species have differing levels of opacity and this measure does not reflect these differences (light interception, light penetration).
Tree spacing	Definition: the horizontal distribution of trees. Method 1. The number of trees per hectare as a measure of the average space between trees. Studies which have found this successful in distinguishing between successional stages include Spies and Franklin (1991). Others (in tropical forest systems) have not (Uuttera et al., 2000; Kappelle et al., 1996). Method 2. GIS. Use differential GPS to record the position in the plot of each plant species and other structural attributes such as logs. Can record to sub decimeter provided a stationary GPS receiver (a base station) is simultaneously logging data nearby (say within 5 km). Method 3. Describe tree spacing in terms of its variation rather than its average dimension. Likely to be more meaningful (indicative of the size and distribution of gaps). Variation in spacing is described by an aggregation index, which quantifies the degree of clustering in the horizontal arrangement of trees: Indices reviewed by Pommerening (2002). Aggregation Indices include: a) Clark–Evans Index (R) (Pretzsch, 1997). (Clark and Evans 1954) Most commonly used. This index describes the ratio between the observed average distance of a tree to its nearest neighbour and the expected average distance for a random tree distribution. Aggregation values below 1 are indicative of a tendency towards clustering, values close to 1 indicate a random distribution and values greater than 1 are indicative of an increasingly regular distribution (Clark and Evans, 1954). A major problem with applying this index is that it requires nearest neighbour distances to be determined for each tree in the plot. Summary 1. describes the horizontal spatial arrangement of tree positions, 2. describes aspects of variability of tree locations in forest stands by a single value b) The Cox Index of clumping (Neumann and Starlinger, 2001). Addresses the problem of requiring nearest neighbour distances to be determined for each tree in the plot by quantifying the variance to mean ratio of the number of trees in equal sized sub-plots rather than using nearest neighbour distances. A variance to mean ratio of 1 indicates a random distribution, values less than 1 a regular distribution and values greater than 1 an increasingly clustered distribution. Used by Franklin *et al.* (1981) and Lindenmayer *et al.* (1990). Lindenmayer *et al.* (1990) used the variance to mean ratio to quantify the pattern of hollow-bearing trees in Mountain Ash (Eucalyptus regnans) forests in

Variable	Definition and method of measurement to be used
	south-eastern Australia. They found that the occupancy of hollows was limited when trees were clustered rather than more uniformly spaced. c) Contagion index or neighbourhood pattern (W) Describes the horizontal spatial arrangement of tree positions. Defines the degree of regularity of the spatial distribution of tree positions in a forest. Unlike the Aggregation index, this variable is a single-tree parameter. A single tree based alternative to the aggregation index. Observed contagion distribution also describes the horizontal arrangement of tree locations. Stands of trees with a mean contagion value greater than 0.6 can be considered as clumped, those with values between 0 and 0.5 indicate regular tree distributions and between 0.5 and 0.6 are random. Distinctions may not be sharp. d) Shannon Index (similar to the Simpson index) Distance independent algorithm describing species mingling. Shannon index values are higher the more species there are in forest compartment and the more equally they are represented in terms of relative abundances A reliable measurement for tree height or canopy structural diversity, but ignores the horizontal spatial component (x,y) structure e) Pielous coefficient of segregation The degree of missing of trees of two species A and B in a forest and like the aggregation index, R, it is based on the nearest neighbour tree distances. f) Mingling index The corresponding single tree variable to Pielou's coefficient of segregation, known as mingling (M_i), gives the proportion of n = 3 nearest neighbours j (j = 1…n) of the ith reference tree which do not belong to the same species as the reference tree I For the calculation of the mingling variable for a whole stand, all Mi values are added up and divided by the number of trees The bigger the mean mingling M, the more the different tree species are intermingled. Small values indicate large groups of only one tree species and therefore segregation g) Diameter differentiation index The single tree diameter differentiation variable gives the size difference of neighbouring trees on a continuous scale and describes the spatial distribution of tree sizes Other: Three dimensional structural variables Structural complexity index (Zenner and Hibbs 2000): Incorporates both spatial distribution of neighbouring trees and their vertical complexity. SCI is defined as the sum of the areas of 3-dimensional triangles (with x, y and z coordinates) divided by the sum of the areas of 2-dimensional triangles. Has been strongly associated with conventional structural descriptions such as tree density, density of trees >100cm in dbh, mean dbh, standard deviation of dbh, and basal area.

Variable	Definition and method of measurement to be used
Standing dead trees (stags/snags) and stumps	See Table 8 for definition and methodology for measurement. Comment: There is little agreement in quantification of standing dead trees. Measurements used include: • numbers (per ha) (eg. dbh > 40 cm: to indicate the potential hollow bearing resource (Van Den Meersschaut and Vandekerkhove 1998) • dbh (diameter classes) (e.g. standard deviation: to indicate the variation in size of dead wood and associated hollows, and hence its value to a diversity of fauna (Van Den Meersschaut and Vandekerkhove 1998)). • basal area - can indicate the approximate volume of standing dead wood (can assume that dead trees are of a similar height (Van Den Meersschaut and Vandekerkhove 1998)) • decay (classes) • height (classes) • volume Franklin et al. (1981) suggested using the classification of Cline *et al.* (1980) for classifying standing dead trees into five decay decay classes (different vertebrates utilised trees from different classes (Lindenmayer *et al.*1990) Spies and Franklin (1991) -the volume the number of standing dead trees 5– 15 m tall, explained most of the variation between successional stages unmanaged Douglas-fir forests Tyrrell and Crow (1994) - the most useful of these was the basal area of standing dead trees, which increased linearly with stand age.

Appendix 2. Data recording sheet for vertical structure.

Location/comments:						**Site:**				
						Date: / /				
						Subplot:				**Sub-Subplot:**
						Time start:				**Time Stop:**
						Photos:				
						Collectors:				
Plant no.	**x (m)** ground measure	**y (m)** ground measure	**Species/stag/stump**	**dead/ alive (D/A)**	**DBH (cm)**	**Crown Height (m)**	**Lowgreen Height (m)**	**(1) Crown diameter (m) widest point**	**(2) Crown diameter (m) 90¢ª t (1)**	**Comments**
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Plot details

Comments

Appendix 3. Data recording sheet for horizontal structure

CWD DATA SHEET (Revision A) **Collectors:** **Date:** **Time start/finish:** **Site:** **Subplot:**

CWD No.	CWD Type	Species if known	Decay Class	Dia. 1 cm	Depth 1 cm	Dia. 2 cm	Depth 2 cm	Length cm	CWD ends	B'phyte Cover	Litter Cover	Regeneration presence	Comments

Decay Class:(1) structurally intact or almost so,bark or small branches still attached,few signs of wood decay,wood mostly retains original colour;(2) structurally less intact but still hard when kicked,small branches absent,early signs of decay or discolouration;(3)clearly decaying but still supports its own weight,may be slightly soft when kicked,may be hollow in places,no bark,moss and fungi may be prominent;(4)cannot support its own weight,soft to kick (but may still be hard in places,in which case may be extensively hollow),moss, fungi and invading roots likely; & (5) no longer retains original shape, wood very soft or largely disintergrated, sometimes only outline visible beneath moss and invading roots etc.
CWD Type: Stag; Stump; Log; or Branch. **Bryophyte & Litter Cover:** (1) < 5%; (2) 5-25%; (3) 25-50%; (4) 50-75%; (5) >75%
Regeneration presence: (1) ephemeral seedling, (2) established seedlings, (3) saplings,(4) trees **CWD** Ends: (N) Natural break; (A) Axe/Saw; (C) Chainsaw; (RB) Roots/Buttress
Species Key - (Eo) Eucalypt obliqua, (Er) Eucalypt regnans, (E) Eucalypt species, (Nc) Nothofagus cunninghamii, (Ad) Acacia dealbata, (Am) Acacia melanoxylon, (A) Acacia species, (Ag) Anopterus glandulosus, (Amo) Atherosperma moschatum, (Cq) Coprosma quadrifida, (Cg) Cyathodes glauca, (Da) Dicksonia antarctica, (El) Eucryphia lucida, (Ls) Leptospermum scoparium, (L) Leptospermum species, (Mg) Monotoca glauca, (Ns) Nematolepis squamea, (Oa) Olearia argophylla, (Pa) Phyllocladus aspleniifolius, (Pom) Pomaderris apetala, (Pb) Pittosporum bicolor, (Pg) Pimelia glauca, (Tl) Tasmannia lanceolata, (Za) Zieria arborescens, (Pe) Pteridium esculentum, (Pp) Polystichum proliferum, (Bw) Blechnum wattsii, (Ha) Hymenophyllum australe, (Hf) Hymenophyllum flabellatum, (Hr) Hymenophyllum rarum, (H) Hymenophyllum species, (Gb) Grammitis billardierei, (Gm) Grammitis magellanica, (Gp) Grammitis pseudociliata, (G) Grammiti species, (Gg) Ghania grandis **page __of__**