ESTABLISHMENT OF THE BOX-IRONBARK ECOLOGICAL THINNING TRIAL IN NORTH CENTRAL VICTORIA

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An ecological thinning trial was established in 2003 in north-central Victoria as part of the development of an ecological management strategy to support the newly created Box-Ironbark Parks and Reserves System. The objective of the trial was to restore diversity of habitat structure to declining Box-Ironbark forests and woodlands. Three ecological thinning techniques were designed around several principles: reducing total basal-area of trees and retaining levels of patchiness whilst retaining large trees. Thinning treatments were implemented in 30 ha plots at four conservation reserves south of Bendigo, Victoria. A range of ecosystem components were monitored before and after thinning. A woody-debris removal treatment was also set-up at a 1 ha scale within thinning treatments. Prior to thinning, plots were dominated by high numbers of coppice regenerated trees with few of the trees sampled considered large, resulting in low numbers of tree hollows and low loadings of coarse woody debris. It is anticipated that the establishment of the ecological thinning trial (Phase I), is the beginning of long-term monitoring, as effects of thinning on key habitat values may not be apparent for up to 50 years or more. The vision for restoration of Box-Ironbark forests and woodlands is one of a mosaic landscape with a greater diversity of habitat types including open areas and greater numbers of larger, hollow-bearing trees. This paper summarises the experimental design and the techniques adopted in Phase I of this project during 2003-2008.

Key words: Box-Ironbark forests and woodlands, ecological thinning, habitat restoration, adaptive management

BOX-IRONBARK forests and woodlands are a significant feature of Central Victoria, spread across a varied landscape and containing considerable natural and cultural values. However, at present they are highly fragmented and believed to be quite different to the forests that existed at the time of European settlement. There are fewer large old trees, crucial for habitat, and large areas comprising crowded stands of small multi-stemmed trees. Large old hollow-bearing trees were favoured for timber cutting, which combined with clearing for agriculture and gold mining, dramatically altered Box-Ironbark forests (ECC 1997).

Canopy tree composition varies considerably throughout the Box-Ironbark forests. Forests and woodlands in the central part of its distribution are almost entirely mixed eucalypt stands, and can typically include Grey Box *Eucalyptus microcarpa* and Red Box *E. polyanthemos*, but also Long Leaf Box *E. goniocalyx* and Yellow Box *E. melliodora*, and often ironbarks such as Red Ironbark *E. tricarpa*. Red Stringybark *E. macrorhyncha* and Yellow Gum *E. leucoxylon* may also be important components. Understorey vegetation may be shrubby, heathy, herb-rich, or grassy but may also be absent in disturbed areas. Box-Ironbark forests and woodlands are rich in native wildlife and provide important habitat for many threatened fauna such as Brush-tailed Phascogale *Phascogale tapoatafa*, Powerful Owl *Ninox strenua*, the migratory Regent Honeyeater *Xanthomyza phrygia* and the 'Victorian temperate-woodland bird community' (Tzaros 2005).

In 2002, the Victorian Government endorsed the majority of recommendations made by the Environment Conservation Council (ECC 2001) in its investigation into Box-Ironbark forests and woodlands. This included increased protection of 105 000 ha of Box-Ironbark forests and woodlands on public land in 11 new or expanded national and state parks supported by a further 112 000 ha of conservation reserves in the Box-Ironbark Parks and Reserves System (Parks Victoria 2007).

Central to the Government's initiative to protect Box-Ironbark ecosystems was a recommendation to develop an Ecological Management Strategy (EMS) for Box-Ironbark forests to ensure future management appropriate to goals for ecological sustainability. The EMS is intended to address a broad range of landscape and biodiversity elements as well as the management of issues such as fire, land degradation and pest plants and animals. It would include the use of ecological thinning as part of the management of Box-Ironbark forests and woodlands, one of the ECC recommendations.

AN ECOLOGICAL THINNING TRIAL

Thinning as a silvicultural tool has long been used in forest management worldwide (McEvoy 2004). Its use in Box-Ironbark forests on public land to reduce stem densities, to increase future timber availability and provide secondary benefits of timber fence-posts and firewood is well established (Fagg & Bates 2009). The concept of thinning Box-Ironbark forests based on ecological objectives which was recommended by the ECC (2001), had little precedent in Victoria but has now been adopted by some community and Government organisations (Pigott et al. in press) and subsequently recommended for use in River Red Gum forests (VEAC 2008).

To distinguish ecological thinning from commercial thinning, Cunningham et al. (2009: 5) provided a useful definition:

> 'ecological thinning' is the reduction of stem density to improve the ecological health of a forest, with adequate fallen timber retained to improve habitat and structure for animals and plants.

To properly assess whether ecological thinning is a suitable management technique, it was essential that the concept be investigated scientifically. A field-based experimental program of ecological thinning (*Box-Ironbark Ecological Thinning Trial* – the Trial) was established in 2003, a key requirement for the proposed EMS. The design and establishment of the Trial was developed in an adaptive experimental management (AEM) framework that would also allow for modification of research if required and planning for future implementation of ecological thinning in parks and reserves (see Robley et al. 2008; Alan & Stankey 2009).

The broad aim of the Trial is to investigate whether ecological thinning can be used to restore greater structural diversity of habitat types to the landscape and therefore allow improved functioning and persistence of key communities and species populations. The research project comprised planning, operational and scientific activities including experimental design, implementation (i.e. field operations) and a pre- and post-thinning monitoring program with assessment and reporting.

Aims and Objectives

In establishing the research program Parks Victoria considered ecological outcomes such as improved ecological function and biodiversity to be the underlying drivers of the ecological-thinning trial (Pigott et al. in press). The main objective of the research was 'to determine the response of selected ecological variables to various ecological thinning and related woody-debris removal techniques for implementation under a future EMS.'

The primary objective of the ecological thinning trial was to determine whether ecological thinning can be used to accelerate the development of older growth conditions of ecosystem function, forest structure and habitat diversity.

Further objectives of the research program were to investigate where, when and how often ecological thinning could be applied and if any environmental issues may indirectly enhance its effectiveness.

A number of aims, focusing on the assessment of the potential impacts of ecological thinning, were developed after consultation with Parks Victoria's Research Partners (Pigott *et al.* in press). In the medium term, likely 5-20 years, aims for the Trial were:

- investigate whether the proposed methods of ecological thinning can be used to improve forest structure so that it moves towards developing the conditions associated with older-growth Box–Ironbark forest;
- investigate whether the rates of improvement in ecosystem function, forest structure and habitat diversity are affected by the basal area of trees retained after the proposed methods of ecological thinning; and
- investigate whether there is a difference in rates of improvement in ecosystem function, forest structure and habitat diversity between a 'patchy'

or ‘even’ arrangement of retained trees.

Longer term, likely 20-50 years, aims for the Trial were:

- determine whether the development of older-growth characters is best facilitated by a silvicultural approach or the proposed methods of ecological thinning;
- investigate whether the proposed methods of ecological thinning can be used to improve ecosystem function so that it moves towards developing the conditions associated with older-growth Box–Ironbark forest;
- investigate whether the rates of the development of ‘desirable’ characters are affected by the amount of woody debris that is retained after the proposed methods of ecological thinning;
- investigate whether the proposed methods of ecological thinning can be used to move habitat diversity and distribution in a direction to developing ’desirable characters’;

Prior to implementation several issues were considered in planning the establishment of the Trial:

- the scale of proposed experimental ecological thinning;
- silvicultural treatments and monitoring programs required; and
- feasibility of implementation within given timeframes and resourcing.

Central to the establishment of the Trial was the appointment of an external Scientific Reference Group (SRG) to ensure that it was scientifically robust and able to meet long-term goals (Pigott et al. 2009b). The SRG comprised four ecologists with expertise in aspects of the project as well as a community representative. They contributed to the design and layout of the Trial and provided advice on technical issues within the project as they arose.

METHODS

Trial design

Due to the experimental nature of the proposed trial, it was necessary to implement a hierarchy of silvicultural treatments and monitoring components. Treatment components were: Site (location, shown in Fig. 1; designed as a substitute for Treatment replication); Plot (four Treatments based on percentage tree-area removal combined with tree-patch design); and Sub-plot (three replicated Woody-Debris Removal Sub-treatments). Both permanent and temporary Transects within Sub-plots were used for measurement of small scale monitoring targets (e.g. ants) whereas the larger scale Plot size was more appropriate for some targets (e.g. owls).

Site locations

The Trial is being undertaken at four sites south of the City of Bendigo, in central Victoria (Fig. 1):

- Castlemaine Diggings National Heritage Park (CDNHP) – located 7 km south of Castlemaine via Chewton;
- Pilchers Bridge Nature Conservation Reserve (PBNCR) – located 15 km south-east of Bendigo;
- Spring Plains Nature Conservation Reserve (SPNCR) - 8 km south of Heathcote;
- Paddy’s Ranges State Park (PRSP) – located 1 km south-west of Maryborough.

Selection of sites was based on both ecological and logistic criteria. Factors considered included forest type, sufficient area of forest to accommodate all treatment plots, proximity to Castlemaine and Bendigo work-centres and suitable vehicle access. Plot locations at each Site were governed by factors such as land-use history, local geographical features and tracks as is illustrated for Pilchers Bridge NCR in the following outline (Fig. 2).

Layout of Sub-plots however was made using a grid system across each Plot to space Woody-Debris Removal Sub-treatments replicates apart (e.g. Pilchers Bridge NCR - Fig. 3).

Thinning treatments

The Trial examines three different thinning treatments plus an unthinned control. The Plots, four at each Site, were established at 30 ha, to enable monitoring change across a range of faunal habitat scales (Pigott et al. in press). Thinning treatments are summarised in Table 1.

Tree size and habitat value are the main consideration in selecting trees for retention. Patchy 1 treatment is the most open of the ecological thinning treatments, with a high stem reduction of 75%, but retaining 10% unthinned patches (Table 1). Basal area, a commonly used measurement unit in commercial forestry, is the cross-section of a tree measured in m^3 and calculated from stem diameter at 1.3 m of height (McEvoy 2004).

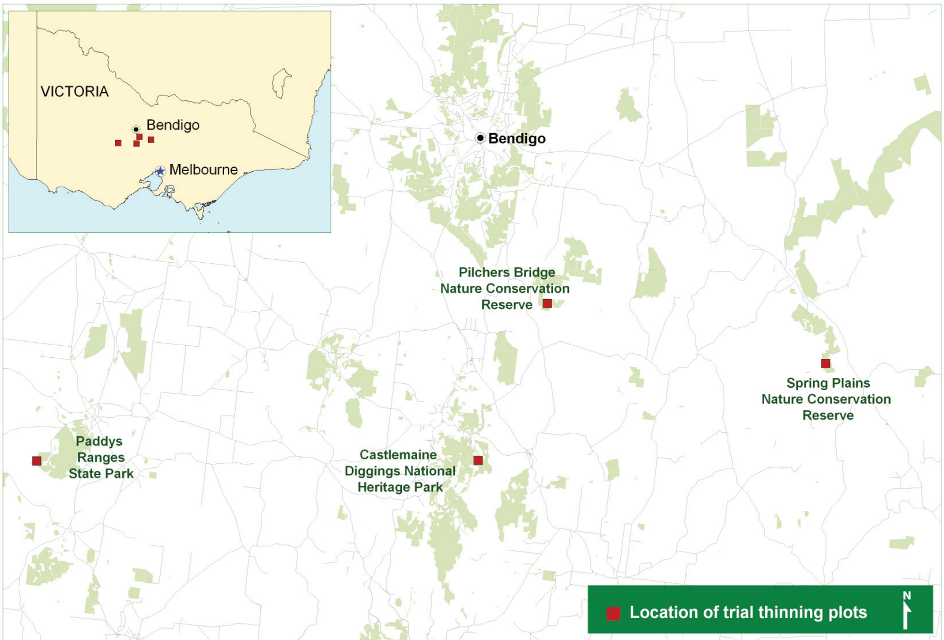

Fig. 1. Location of 'Sites' for the Box–Ironbark Ecological-Thinning Trial near Bendigo in central Victoria (extracted from Pigott et al. in press).

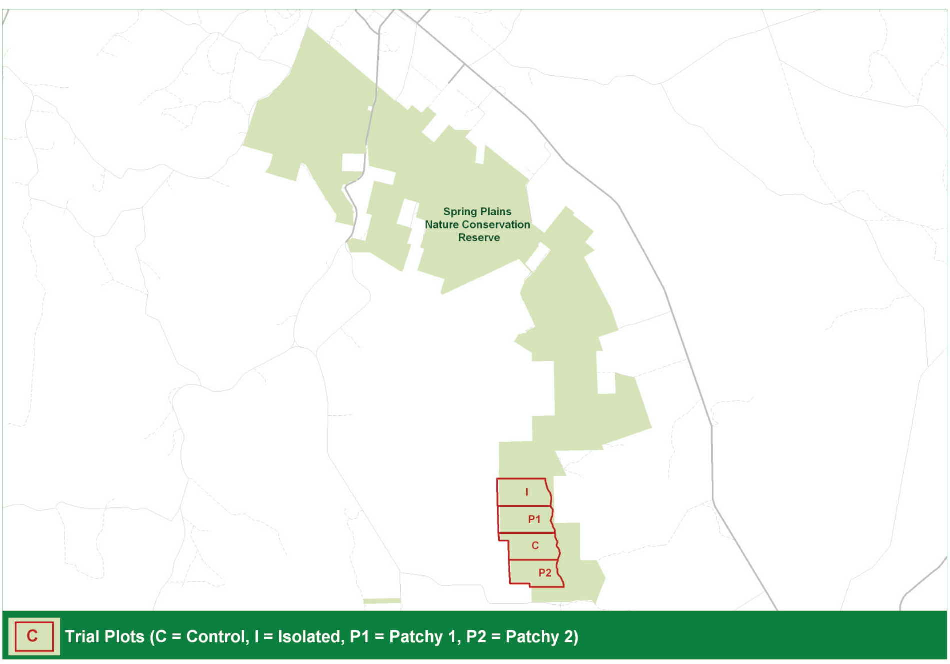

Fig. 2. Ecological thinning treatment 'Plot' layout for Box–Ironbark Ecological-Thinning Trial Site at Spring Plains Nature Conservation Reserve (extracted from Pigott et al. in press).

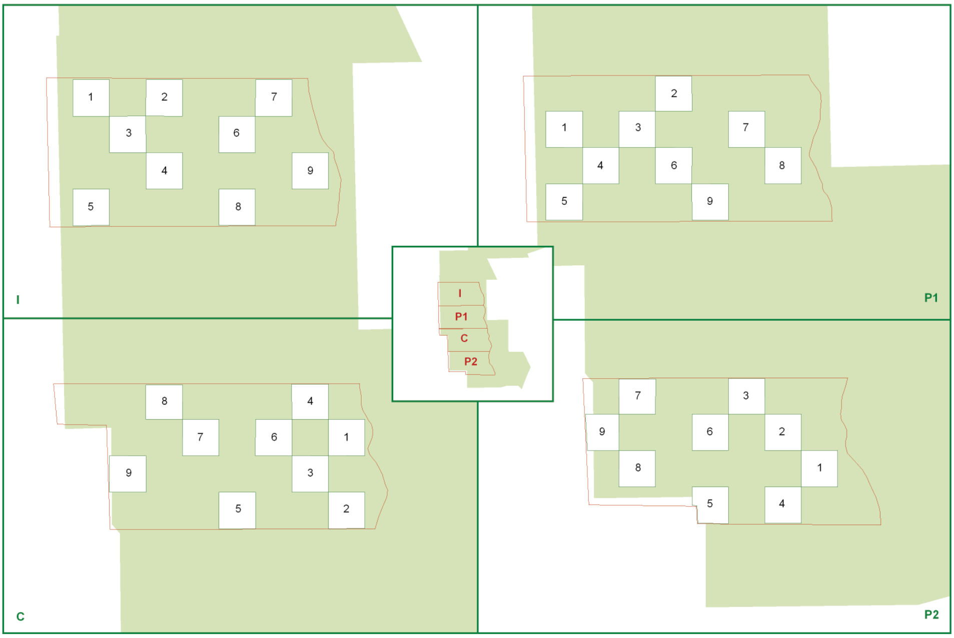

Fig. 3. Layout of Woody-Debris Removal treatment 'Sub-plot' replicates for the Box–Ironbark Ecological-Thinning Trial Site at Spring Plains Nature Conservation Reserve (extracted from Pigott et al. in press).

Tree felling was selected over chemical injection as the appropriate thinning treatment to test in the Trial because it was considered important to increase canopy space as well as reduce stem competition.

Timber removal treatments

In addition to different thinning treatments, the Trial is also examining the effects of removing woody debris on the ecosystem. The intent was to remove debris generated by felled tree stems from thinning treatments rather than natural processes. This would provide a better understanding of the impacts of increased woody debris from thinning as well as impacts of its removal (see Pigott et al. in press). Two timber removal treatments, as well as an experimental control are being used (Table 2).

Research and monitoring

A research and monitoring program focusing on forest structure, selected biodiversity elements and habitat features has been established to examine the impacts that the different experimental treatments have on key components of Box-Ironbark forests. In addition, several modelling and statistical analysis projects were also established to assess effects of treatments and time on biodiversity and habitat variables and examine possible post-thinning habitat outcomes. These projects and their broad aims are summarised in Table 3.

The initial phase of the field monitoring projects involved pre-treatment monitoring to collect baseline information followed up by post-treatment monitoring approximately 12 months after thinning. The program also included management, analysis and reporting of data collected for all pre- and post-treatment monitoring surveys.

The research and monitoring program is the core of the Trial and provides the basis for understanding the suitability of ecological thinning as a management technique. Projects were developed with an aim to provide a baseline for assessment whereby change in a number of variables could be measured over time. The research and monitoring program is managed by Parks Victoria's staff in consultation with the SRG and members of Parks Victoria's Research Partners Panel (RPP).

Table 1. Description of thinning treatments used in the Box-Ironbark Ecological Thinning Trial (extracted from Pigott et al. in press).

Treatment	Procedure	
Control		No thinning treatment is applied i.e. no trees are cut and removed
Isolated	Density:	Thinning of trees to a basal area 50% of pre-thinning status and representing a moderate reduction in tree density.
	Pattern of retention:	No vegetation is retained in the experimental area i.e. no patchiness between retained trees.
Patchy 1	Density:	Thinning of trees to a basal area 25% pre-thinning status and representing a heavy reduction in tree density.
	Pattern of retention:	About 10% of the experimental area is unthinned i.e.10% of vegetation is retained in patches.
Patchy 2	Density:	Thinning of trees equivalent to a basal area 50% pre-thinning status and representing a moderate reduction in tree density.
	Pattern of retention:	About 25% of the experimental area is unthinned i.e. 25% of vegetation is retained in patches.

Table 2. Description of timber removal treatments used in the Box-Ironbark ecological thinning trial (extracted from Pigott et al. in press)

Timber removal treatment	Description
100%	All felled woody debris over 60 mm diameter removed from 3 by 1 ha sub-plots in each 30 ha thinned plot
50%	Half of all felled woody debris over 60 mm diameter removed from 3 by 1 ha sub-plots in each 30 ha thinned plot
Control	No woody debris removal (3 by 1 ha sub-plots in each 30 ha thinned plot)

Table 3. Summary of Research and monitoring projects for the Box-Ironbark ecological thinning trial (extracted from Pigott et al. in press)

Project and theme	Broad aim
Forest Mensuration (forest structure)	Monitor and describe changes in composition, density and area of canopy trees
Key Fauna Habitat (habitat features)	Monitor and describe changes in forest habitat values e.g. tree-hollows or leaf litter
Floristic Survey (biodiversity indicators)	Monitor and describe changes in richness and composition of understorey flora
Selected vertebrates (biodiversity indicators)	Monitor and describe changes in species richness and numbers of selected vertebrates (birds, mammals)
Invertebrate Indicators (biodiversity indicators)	Monitor and describe changes in species richness and numbers of selected invertebrates (ants, spiders)
Habitat Response Modelling (Bayesian modelling)	Predict changes in habitat quality for selected fauna
Integrated Research Project (Statistical analysis)	Analysis of combined pre- and post-thinning monitoring data to assess effects of treatments and time on biodiversity and habitat variables
Advanced Data Analysis (Bayesian hierarchical modelling)	Further analysis using Bayesian hierarchical modelling techniques

Monitoring Projects

(a) Forest Structure Measurements **-** It is anticipated that ecological thinning generates change in both understorey and overstorey components of Box-Ironbark forests leading to increased development of habitat features and subsequently over time responses to these changes by habitat-dependent fauna. As such, measuring forest structure and monitoring change across time is an essential aspect of assessing impacts of different thinning treatments on the forest ecosystem.

Detailed information about the current forest structure at the Sites was needed, and tree species, size-class and density were considered suitable variables that could be measured to provide this. Using the 'Triangular Tessellation Technique' (TTT) to sample tree density (both pre and post-Treatment), nearest neighbour distance was recorded for 50 sets of three trees in each Plot (Pigott et al. in press). Diameter at Breast Height over Bark (DBHOB) and tree species was also recorded to enable calculation of Basal Area and classification of size-classes, important measures for understanding forest structure (McEvoy 2004).

(b) Key Fauna Habitat - The significance of Box–Ironbark forests and woodlands for faunal habitat has been well documented: the relatively high species richness of canopy trees, mostly eucalypts a contributing factor. The most important of these being hollows present in older or veteran trees (ECC 2001).

Monitoring of habitat values was split into two sets of habitat features, arboreal (e.g. hollows) and ground level (e.g. leaf litter). Arboreal habitat features were recorded during Forest Mensuration surveys and included splits and hollows in tree boles, stump hollows and the ends of broken branches. The depth and size of the opening for tree hollows were measured individually. Tree canopy cover was also recorded post-thinning with hemispherical photographs (see Palmer et al. in press).

Ground level habitat features included litter cover and depth, fine woody material and coarse woody debris (CWD) were recorded along three 'measurement transects' within the Sub-plots (Fig. 4). Cover values for other ground-cover elements such as rocks and bare ground were also recorded. CWD above 6 cm in size was measured for sorting into size-classes for further analysis.

(c) Understory flora - The understorey flora is an important component of the Box–Ironbark ecosystem, providing structure, habitat and a primary foodsource. Responses by flora (mostly vascular plants) to ecological thinning are poorly understood; it may lead to improved regeneration and levels of diversity, but there may also be negative effects stemming from higher levels of felled woody debris.

Projected foliage cover of dominant understorey species (mostly small shrubs and perennial tussock grasses) was determined using the point-quadrat method along each unmarked, 20 m 'temporary' measurement transect. From this native and exotic vascular plant composition (richness, evenness, diversity) a species/generic level or life form could be determined. Some ecological factors such as regeneration and recruitment events (eucalypts, woody shrubs, annual and perennial exotics) were also recorded.

(d) Selected Vertebrates - Visible, charismatic fauna such as birds and arboreal mammals as important components of the Box–Ironbark system and highly valued by the community (ECC 2001). These faunal groups have significant ecosystem value and also respond to structural changes in overstorey as a result of ecological thinning.

Birds were surveyed using area-constrained diurnal censuses (recording all birds) and nocturnal audio playbacks (to record owls). Mammals were surveyed using spotlight transects and hair-tube sampling (for arboreal and terrestrial species) and echolocation call detectors (for bats). These survey techniques were expressly developed for sampling birds and mammals, and are well established and regularly employed by field biologists.

Each of the standard survey techniques described below was used during the sampling periods at each site. The techniques of diurnal-bird census, hair-tube survey, spotlight survey and ultrasonic bat detection were incorporated into each survey of each Treatment (nine Sub-plots in each of the four Plots at each Site). Owl call-playback was used at the Plot scale.

(e) Invertebrates - The effects of different Treatments were examined pre-Treatment and initial post-Treatment for invertebrates at the Ordinal levels and for selected invertebrate groups at the lower taxonomic levels for ants and spiders. However, due largely to resourcing constraints of the Trial during the establishment phase, only ants were chosen as representative invertebrates for detailed assessment. Ants were chosen because of their dominance of the invertebrate fauna in Box–Ironbark forests, as well as their roles

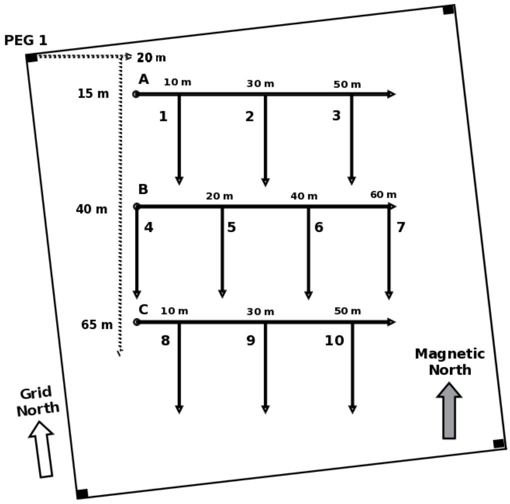

Fig. 4. Layout of 'Permanent Transects' and 'Measurement Transects' located in each Sub-plot for the Box-Ironbark Ecological Thinning Trial (extracted from Tolsma 2008). Layout of transects within each experimental sub-plot. Horizontal arrows (A, B, C) show the location of permanently marked transects, while vertical arrows (1 to 10) show the location of the temporary transects.

in a range of different ecological processes (Palmer et al. in press). They are particularly active in disturbed environments in Australia, and when present in functional groups they can be good indicators of ecosystem change (Hoffman & Anderson 2003). Ants were collected by pitfall trapping using test tubes.

IMPLEMENTATION OF TREATMENTS

Thinning and Wood Removal Program

In the original scoping of the Trial, timelines for planning, thinning operations and monitoring were estimated to take about two and a half years. In reality operational work alone took one year longer. Following some test thinning, full implementation of ecological thinning treatments commenced in April 2004 and was completed in July 2007. Timber removal from sub-plots, carried out in conjunction with thinning at all sites, was finally completed in September 2007.

A major factor was that mean stem densities for all sites were found to be much higher than the pre-trial estimates of 250-500. For example densities in Castlemaine plots were between 820 and 1430/ha. This meant that much higher than expected volumes of cut timber were removed from the four sites: wood volume taken from 1 ha sub-plots in Castlemaine 'Isolated' were estimated at 50-180 m^3. The likely reason for this is that most basal area measurement techniques underestimate wood volumes based on sampling of dense small-stem forests (i.e. coppice regrowth).

Other contributing factors to delays in completing operations were steep and rocky terrain (at Heathy-Dry forest sites), weather extremes, personnel changes and crew fire management obligations (Pigott et al. in press).

These delays forced a revision of the original timelines for completion of monitoring, resulting in development of a three year post-treatment program.

RESEARCH AND MONITORING IMPLEMENTATION

Monitoring projects

The monitoring framework was established with Parks Victoria's RPP (Parks Victoria 2007) to include three stages: pre-thinning monitoring, post-treatment monitoring and analysis/reporting. Detailed pre-treatment and post-treatment surveys provide a basis for assessment of any immediate impacts caused by implementing the prescribed treatments and attempt to establish the benchmark reference.

The original 3 year Trial timeline was extended to 5 years following delays in completion of thinning and timber-removal treatments. Post-treatment monitoring was then scheduled over three years (2005, 2006 and 2007) with surveys planned for spring, an optimum time for sampling forest biota such as flora and invertebrates. A 12 month gap between thinning and timber removal operations and post-treatment surveys was agreed as desirable for a number of reasons (Palmer et al. in press).

Treatment audit

As part of completing the implementation of treatments an audit was conducted in 2007. An assessment of ecological thinning in treatment plots found some discrepancies within Plots and between Sites, most notably Spring Plains P2 (patchiness) and Castlemaine P1 (stem density) (Pigott et al. in press). The woody-debris Sub-plot audit found that additional or missing replicates were present in each thinning plot at each Site (i.e. a minimum of two of either 50% or 100% treatments were present in each Plot).

These findings are acceptable given the scale of plots, the long implementation period and the number of crew workers involved. Recording the treatment status at the completion of works, and at both scales, marks an important beginning for monitoring of change. Given considerable variation post-thinning across monitoring targets, the value of this information increases with each repeated assessment (Palmer et al. in press).

DISCUSSION

Achievements

The implementation of ecological thinning and woody-debris removal treatments was delayed due to (1) a greater density of stems than originally estimated; (2) steep terrain delaying removal of cut stems from the sites; and (3) field staff called away for fire duties. The thinning and woody-debris removal was completed by September 2007. Consequently, this compressed post-treatment timing for some Plots at some Sites (Pigott et al. 2009b). All immediate post-treatment monitoring was completed by February 2008 and reporting completed soon afterwards. Results from individual projects have been summarised by Palmer et al. (in press).

The trial provided many valuable lessons on the logistics associated with ecological thinning operations. These need to be considered for any future ecological thinning operations. These included:

- Specialised training/supervision is required for thinning staff to ensure ecological thinning is correctly implemented;
- Good understanding of tree densities and the number of trees to be felled to achieve thinning targets is required for accurate planning of resource allocation;
- Timber removal is labour-intensive and time-consuming accounting for more than half of the thinning costs. This was included as an experimental treatment within the Trial but substantial time-savings could be achieved if this was not part of future thinning operations;
- Site access and terrain affects the efficiency of thinning operations;
- Alternative techniques (e.g. stem injection or mechanised tree-felling) could be considered as an alternative to using chain-saws however this would need to be evaluated appropriately before being applied as a management approach;
- Development of the EMS should consider management of coppice regrowth in high density stands and some minor weed invasion.

A major achievement of Phase I was reporting of monitoring projects finalised during 2008 and subsequent analysis and interpretation of collated data (Palmer et al. in press). Additionally, the long-term nature of the project means that management and curation of research data sets is critical and requires ongoing planning.

Adaptive management

Whilst there have been some lessons from the Trial to date, particularly in relation to operational aspects of forest thinning, many ecological responses will occur over years or even decades. Consequently, understanding the longer-term effects of the thinning treatments will require ongoing monitoring and evaluation. To deal with these different time scales there are two distinct phases of the Trial:

- Phase I – deals with the establishment of Trial infrastructure and collection of data prior to and one year following thinning (i.e. pre and post treatment surveys), and the communication of outcomes. Phase I Monitoring has been completed and reported on in 2008;
- Phase II – will consider on-going research and monitoring, maintenance of infrastructure, analysis and communication of longer-term outcomes and strategies for future ecological thinning.
- Phase II will run parallel to further development of the Box-Ironbark EMS.

The Trial's AEM framework has been set up to examine responses of forest composition and structure, habitat and biodiversity variables to alternative management approaches. As the Trial progresses, results collected improve understanding of how Box-Ironbark forests function, strengthening the knowledge base on which these areas are managed.

While many of the lessons from Phase I are thinning practice and logistical ones, the ecological information collected to date is sizeable and of considerable value. This includes extensive data on forest structure composition, flora and fauna before and in the short-term following thinning. These results provide a baseline against which any future changes resulting from ecological thinning can be assessed. In addition, they make a significant contribution to flora and fauna records for the Box-Ironbark region.

The IRP is an important conclusion to Phase I monitoring and should provide important direction to the EMS and Phase II monitoring.

Further analysis and reporting

A workshop involving PV staff, RPP project team members and the Box-Ironbark SRG, was held in 2008. It was agreed that as a consequence of trial design (e.g. level of replication, scales at which different data sets were collected) there are limitations to statistical analyses of the data collected. Consequently a new research project was developed (the Integrated Reporting Project - IRP):

- Explore how each of the variables monitored through each of the component projects of the trial vary with regard to experimental treatments, as well as exploring inter-site variation
- Examine (where possible) relationships and interactions among different variables (compiled at the workshop) and discuss the implications of any effects (treatment, location) and/or relationships detected for the management of Box-Ironbark forests and woodlands.

This project was developed jointly by ARI and CEM and commenced soon after the workshop, with assessment of methodology and compilation of data from all partners.

Initial analysis using correlation matrices' at two collection scales has highlighted possible relationships between monitoring elements.

The final report (Palmer et al. in press) assesses the consolidated data-set for Phase I and discusses results and the various methodologies used. It also discusses these results in relation to short-term outcomes of the trial, as well as potential future trajectories. Assessment of thinning and debris-removal impacts on the aspects of the Box-Ironbark ecosystem is contributing to the development of future monitoring and will provide guidance to Parks Victoria in developing the EMP and other strategic planning.

A project was developed to describe forest structure and habitat variables and the impact of thinning treatments on elements such as tree canopy (Walshe & Vesk 2007). A modelling framework was developed using Bayesian Belief Networks which provided the basis for predicting habitat requirements for selected Box-Ironbark fauna using logic trees. This modelling has the potential to be further developed. Another project was initiated to for further data analysis to be carried out using the same data set as the IRP. Bayesian Hierarchical Modelling techniques were used to explore associations between biotic response variables and measured habitat variables (Thomson 2010).

Other outcomes: communication and community involvement

The establishment of the Trial, including procedures, protocols and documentation were used as a case study to test a proposed 'Knowledge Development Life Cycle' (Pigott et al. 2009a). A knowledge based management system was populated, and organisational readiness in context of the AEM was assessed.

There has been significant community group involvement in the Trial. With assistance from the Department of Justice and local government authorities, woody-debris removed throughout the Trial's operational stage has been made available to community groups for non-commercial purposes. Parks Victoria formed valuable partnerships with over 20 local, non-commercial community organisations to remove timber and distribute it in the towns of Maryborough, Castlemaine, Harcourt and Heathcote. Profiles in various corporate newsletters, radio interviews, agency briefings and workshops have publicised the establishment and objectives of the Trial. Since the commencement of the Box-Ironbark Parks and Reserves Program in 2003, there has been increased interest in Box-Ironbark forests and woodlands and the way they are managed, including the new thinning Trial. A number of presentations were made to community groups, including those directly associated with Box-Ironbark Forests. Community group involvement in timber removal has introduced many people to their local forest environments. Site tours were also made available to members of the public at Trial sites.

Presentations and facilitated discussions with many secondary and tertiary classes were given and two higher education research projects using the Trial framework were completed (e.g. Olsen 2010). Additionally a variety of presentations have been made to several scientific conferences e.g. Tenth International Congress of Ecology (2010, Brisbane Australia).

Future Ecological Thinning

Data collected during 2003-2008 is being analysed to develop future monitoring programs. As determining the effects of thinning on Box-Ironbark forests will require an ongoing commitment to monitoring and evaluation, it is acknowledged that responses for some indicator groups to thinning in Box-Ironbark forests will take some time to detect. More specifically, tree growth and hollow development could take decades, while some elements such as invertebrates, floristic structure and ground litter are likely to show some short-term responses.

With regards to general park management in Victoria, decisions on expansion of the ecological thinning program for Box-Ironbark forests and woodlands should wait at least until the feasibility of Phase I (scientific and logistic) is evaluated and an EMS framework developed. This will be an important policy consideration given the growing interest in the use of thinning for habitat management (and other ecological objectives) across the Box-Ironbark region.

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