Mallee Fire and Biodiversity Project

Determining appropriate fire regimes in the Murray Mallee

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Project overview November 2006.

Project Aim:

To identify the properties of habitat mosaics produced by fire that enhance the persistence and status of a broad range of taxonomic groups (birds, mammals, reptiles, key invertebrates and plants) in eucalypt-dominated mallee habitats.

Key Research Questions

1. What are the properties of fire-induced vegetation mosaics that enhance the status of different taxonomic groups (birds, mammals, reptiles, selected invertebrates and plants) in eucalypt mallee vegetation?

2. How do these favoured properties vary between different taxonomic groups, and between different species or guilds within groups?

3. What are the site-level attributes that influence the status (presence/absence, abundance) of different species and taxonomic assemblages?

4. Are fire mosaics and sites that are suitable for plant species identified as 'key fire-response species' also suitable for faunal groups (i.e. are the fire- response plants reliable surrogates for biodiversity planning?)

Team

Leaders:	Assoc. Profs. Mike Clarke (La Trobe) and Andrew Bennett (Deakin)
Project Officer:	Dr Kate Callister
Technical Officer:	Ms Lauren Brown
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Postgraduate students:	Lisa Spence-Bailey (reptiles)
	Sarah Fergusson (termites, psyllids and scorpions)
	Rick Taylor (birds)
	Sally Kenny (plants)
	Dale Nimmo (reptiles)
	Luke Kelly (mammals)
	Simon Watson (birds)
Honours student:	Geordie Kuzniarski (ants)

Timing

The study commenced in March 2006. Most field work will be carried out over the Spring and Summers of 2006/07 and 07/08. PhD students aim to complete their studies by March 2009. Aim to have modelling completed by mid 2010.

Study design

The following study design is relevant to all taxonomic groups. Protocols for monitoring the biota in each group are outlined separately, below.

Study areas

The study is being carried out in the Murray Mallee region of south-eastern Australia, encompassing parts of Victoria, New South Wales and South Australia (Figure 1). Study locations include:

- Victoria: Murray Sunset National Park, Hattah-Kulkyne NP
- SA: Billiatt Conservation Reserve, Gluepot Reserve, Dangalli Conservation Park
- NSW: Tarawi Nature Res., Scotia Sanctuary, Mallee Cliffs NP, Petro Station and Lethero Station

Selection of study mosaics

Twenty-eight landscape mosaics have been selected for study; each a circular area of 2 km radius (12.56 km^2). These mosaics were selected based on three major criteria.

1) *Geographic position*. Mosaics were selected in the northern part of the study region (Gluepot, Tarawi, Scotia, Dangalli) and in the south (Murray Sunset, Hattah, Billiatt, Mallee Cliffs).

2) *Percentage of long unburnt mallee*. Mosaics were chosen to represent a gradient in the proportion of long unburnt mallee, from 100% down to 0%. Long-unburnt mallee was subjectively defined as mallee not having been burned for >40 years (Figure 2).

3) *Number of post-fire age classes present*. Mosaics were chosen to represent variation in the number of post-fire age classes present, from 1 to 5 age classes (Figure 2). This represents a measure of the heterogeneity of the 'visible' mosaic. It also offers the opportunity to investigate the 'invisible' mosaic because mosaics with multiple fires have a history of a sequence of burns over the last 40 years. We will develop measures to quantify the temporal pattern of burns on each mosaic.

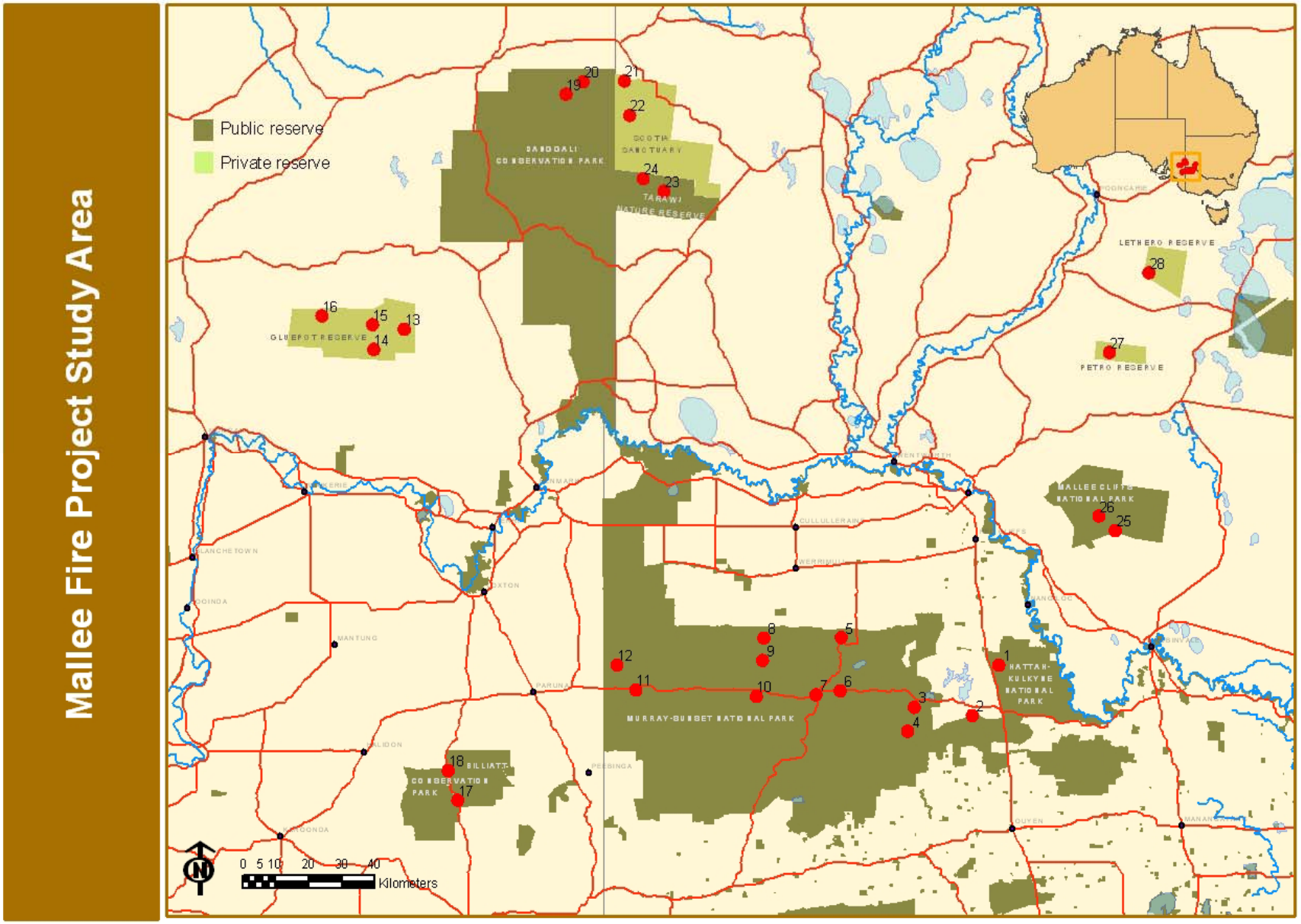

Figure 1 Location of study mosaics across the Murray Mallee

Mosaics were also selected such that there was a minimum of 2 km between the boundaries of adjacent mosaics, and they were generally established in pairs to allow survey teams to service two mosaics simultaneously.

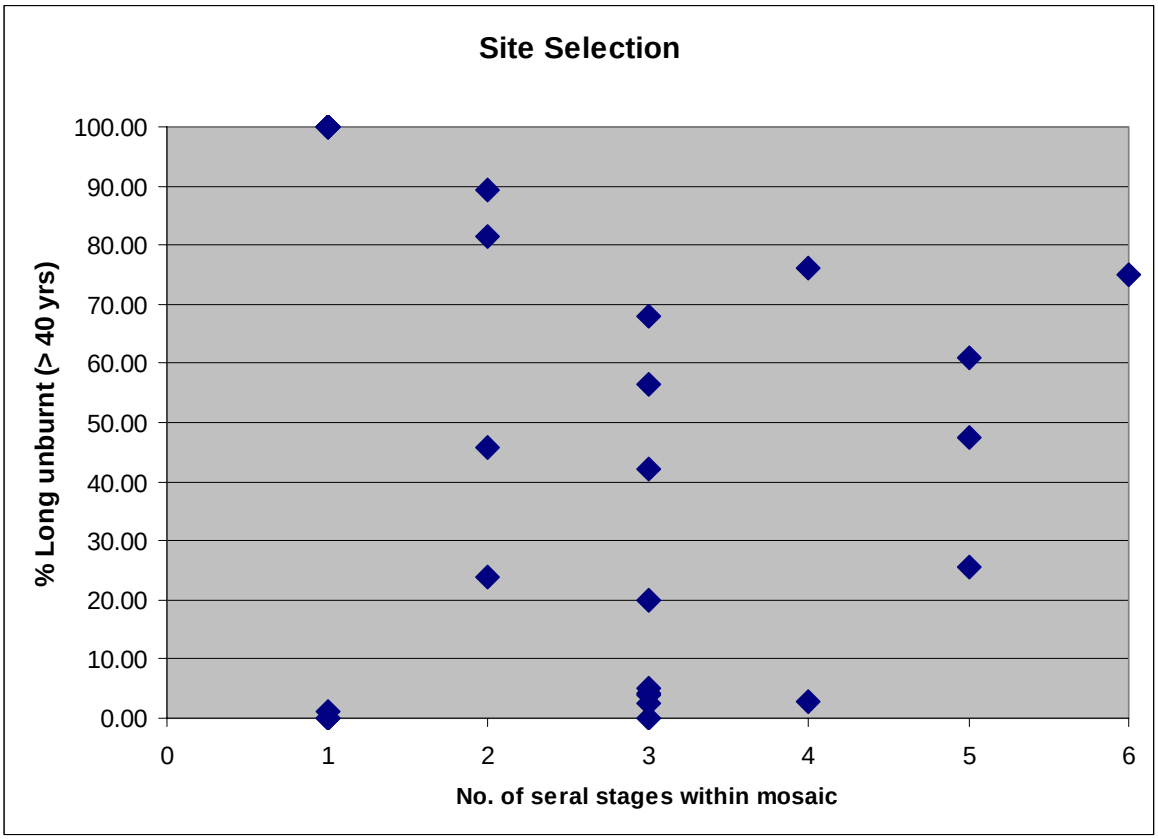

Figure 2 Characteristics of the 28 mosaics selected for the study

Focal Taxa

Mammals, Reptiles and Amphibians

Research questions

- What are the broad-scale biogeographic distributional patterns of mammals, reptiles and amphibians in the region?
- What are the landscape-level properties of fire mosaics that determine:
  a) the richness and composition of assemblages? and
  b) the occurrence and abundance of individual species?
- What are the site-level attributes shaped by fire that determine: a) the richness and composition of assemblages? and b) the occurrence and abundance of individual species?
- What are the habitat requirements of individual species?

Methods

Each mosaic will be surveyed at 10 survey points. The location of these survey points has been stratified based on the proportion of each fire age class in the mosaic. For example, if an age class makes up 50% of a mosaic than it was allocated 5 sites. Where possible, survey points were placed to include:

- topographic variation within each age-class (dune/swale)
- sites with different fire frequencies within the same post-fire age-class.
- at least one survey point in each quadrant of the study mosaic
- all sites being at least 100m from fire boundaries, at least 25m from access roads and at least 200m apart.

At each survey point a pitfall line consisting of ten 20 L buckets connected by a 50 m drift fence was installed. Each pitfall line will be surveyed for five days in each of the spring and summer of 2006-2007 and 2007-2008 and will result in a trapping effort of 56,000 trap nights. Elliot traps will be placed at each site during spring sampling sessions to survey mammals, such as Mitchell's Hopping Mouse, that are not readily captured in pitfall traps and will result in 14, 000 trap nights. Captured small mammals will be marked with individual ear tags and weight, age-class, reproductive condition and sex recorded.

Larger mammals (macropods, echidnas, foxes) will be recorded at each site based on the presence of tracks, diggings, scats and incidental observations. Records from each site in a mosaic will be pooled to represent the mammal, reptile and amphibian assemblages for each of the 28 mosaics.

Statistical models will be built to examine the influence of mosaic properties and faunal composition, diversity and occurrence/abundance. The influence of the following sets of variables will be tested:
- elements within the fire mosaic (size, shape, perimeter: area ratio, context, nearest neighbour/proximity)
- mosaic properties (extent, composition, configuration, geographic position)

A number of predictor variables will be collected at each spatial scale:

1) At a *mosaic*-scale predictor variables will include the extent of old mallee, and the composition and configuration of other post-fire seral stages, including seral stage diversity (i.e. based on the proportion of mosaic area exposed to different times since fire).

2) At a *site*-scale predictor variables will include seral stage, number of times site has been burnt in last 34 years, length of intervals between fires, the percent-cover of: *Triodia*, canopy cover, fine leaf litter, course leaf litter, shrub cover, bare ground and coarse woody debris. Other predictor variables include a measure of mallee DBH, amount of trees, number of hollows (divided into canopy and coppice hollows), and leaf litter depth. Each site will be stratified according to its topographic location (for example, dune or swale).

3) At a *bucket*-level predictor variables will include percent cover of: *Triodia*, canopy cover, fine leaf litter, course leaf litter, shrub cover, bare ground and course woody debris, as well as leaf litter depth. Other variables such as number and size of trees within plots may also be recorded.

Mosaic surveys

X Pitfall sites

Bird walks

All sites:

- flora
- invertebrates

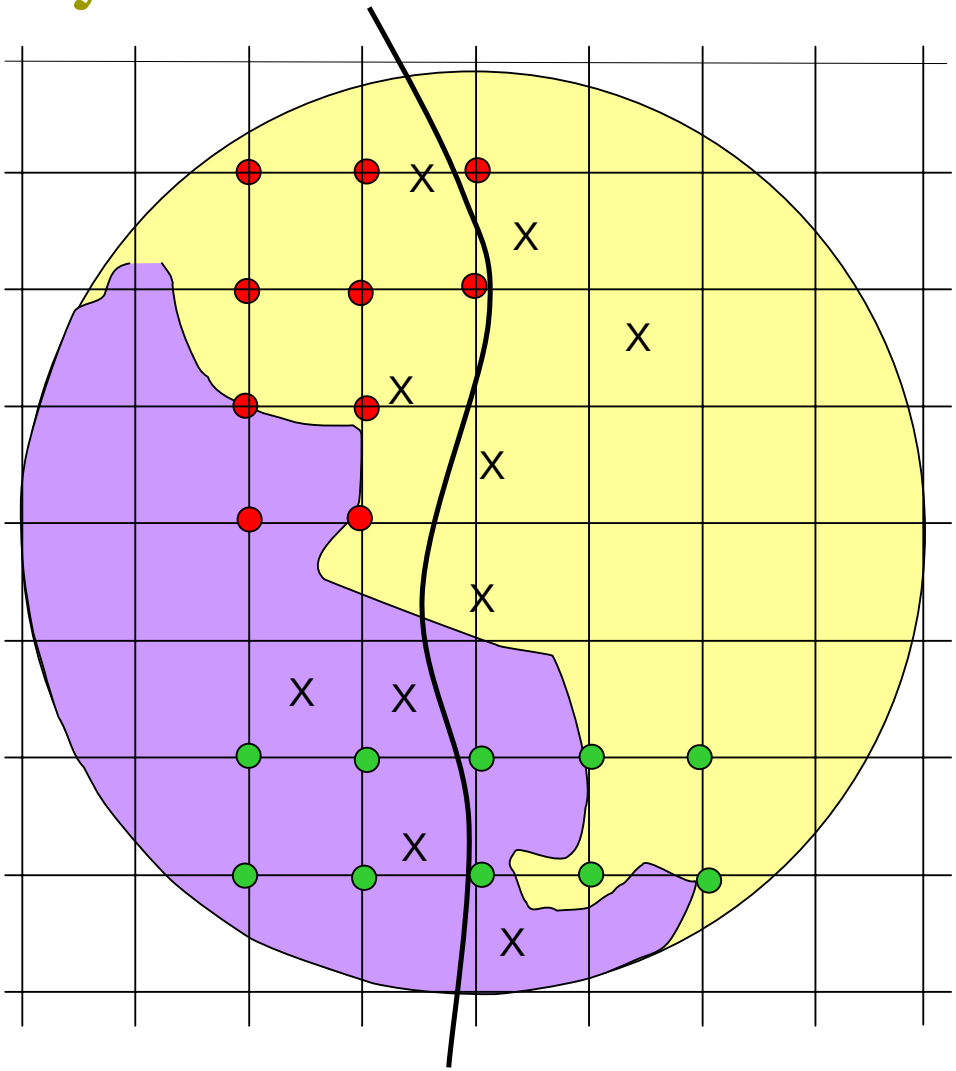

Figure 3 Example of sampling scheme within a mosaic

Birds

Methods
Bird surveys will be undertaken both at the site and landscape (mosaic) levels. Each of the 28 mosaics will be surveyed four times, twice each over the spring/summer periods of 2006/2007 and 2007/2008. These surveys coincide with major breeding periods of birds (a time of higher vocalisations and consequently higher detectability rates) and the arrival of summer migrants.

Two main survey methods will be used in each mosaic (see Figure 3), both carried out along a 10 km transect through the mosaic. This will be divided into two five-km sections to be completed by two observers (Rick Taylor, Simon Watson). Thus, each mosaic will have equal survey effort by each observer.

Point counts
Twenty point-count surveys, positioned ~500 m apart along these transects.

- Each point count will be of 5 min duration
- Distance from the centre point will be measured for individual birds seen or heard, using a laser rangefinder, within the 5 min survey period.
- Concurrent recording of all birds will also be made within the following categories: (a) seen within 30 m, (b) heard within 30 m, (c) seen outside 30 m, (d) heard outside 30 m.
- Rare/secretive species may remain undetected during transect walks and point counts. Therefore, upon completion of the five minute point count, a standardised call playback will be used to establish presence of certain target species. Based on pilot survey work, species chosen include Red-lored Whistler (*Pachycephala rufogularis*), Striated Grasswren (*Amytornis striatus*), Mallee Emu-wren and Black-eared Miner (*Manorina melanotis*). These species represent a subset of rare/threatened species that possess one or more of the characteristics: (a) secretive (low calling rates) (b) minimal vocalisations (c) cryptic.

500 m transects
There will be 20 transects of ~500 m between point count sites, and these will also be used to survey birds.

- Species will be recorded as present or absent within several categories: (a) seen within 30 m, (b) heard within 30 m, (c) seen outside 30 m, (d) heard outside 30 m
- Species flying above the canopy during surveys will be recorded separately

The dependent variables for bird sampling are:

- Bird species richness measured as the presence or absence of species within a fire mosaic. This represents the avifaunal assemblage of that mosaic;
- Bird species abundance (index) – measured as the incidence (or reporting rate): the number of 500 m transects in which a species was recorded divided by the total number of 500 m transects surveyed (each 500 m length of transect runs between point count sites);
- Bird species abundance (relative) – number of birds counted within a 30 m radius of each point count (this data will be collected in conjunction with distance sampling data; and
- Bird species abundance (density) – density of individual species using distance sampling at point counts.

Invertebrates

Rather than attempting to determine responses to fire by "invertebrates in general" from broad taxonomic surveys of all mallee invertebrates, this project has chosen to focus on a small number of what we believe are keystone groups; namely termites (Isoptera), psyllids (Hermiptera), scorpions (Scorpionida) and centipedes (Chilopoda). (Friend 2003; van Heurck and Abbott 2003). We believe these will be the most informative invertebrate subjects for study.

Termites (Isoptera) and psyllids (Hermiptera) are food sources for insectivorous animals and abundances of these invertebrates may in turn influence vertebrate populations. Wood-nesting termites also generate hollows in trees and coarse woody debris which may be key habitat features for many other animals. There are approximately 16 species of termites found in the mallee areas of the eastern states (Watson and Abbey 1993) and it is likely that they play important ecological roles. In addition, scorpions and centipedes (Chilopoda) are relatively large invertebrate predators that may potentially have a profound influence on structuring invertebrate communities.

Methods

Termites are cryptic insects, often living underground or in dead wood and foraging via subterranean tunnels. There are a number of methods used to detect termite presence including active searches along transects and the use of baits. Baiting is less labour intensive than searches and allows data collection on a larger scale, as is required for this project. The disadvantage is that not all species will be attracted to the baits. The choice of bait material for this project is toilet rolls. Toilet rolls have been widely used in termite studies, are pre-packaged and easy to use, lightweight and easily replaced in the field. The toilet rolls used are 400 sheet, 2 ply, bleached and unscented.

Grids of 6 rolls spaced 5 m apart have been placed at 20 sites within each of the 28 mosaics. Ten of these sites are alongside the pitfall lines used for the reptile/mammal/invertebrate collections. The pitfall line sites were chosen to represent the percentages of fire age classes as well as the vegetation types present within the mosaic. Sites were placed in both dunes and swales. Rolls were buried just below the soil surface so they were accessible to both surface and subterranean foraging species.

A further 10 grids will be placed along the bird transect walks in each mosaic. The bird transects consist of two 5km transects per mosaic, with GPS-marked stops every 500m. The toilet roll grids will coincide with every second bird survey stop, with adjustments to include proportional fire age class sampling and dune/swale samples.

A total of 120 rolls will be buried per mosaic, giving a total of 3360 rolls. Rolls were installed in July/August 2006 and will be checked in the October/November 2006 and January/February 2007 field seasons. During sampling, each roll will be lifted and checked for termite presence. If present, any soldier and worker castes will be removed with forceps and collected into a vial of 70% ethanol for later identification. Each grid of 6 rolls will be considered an independent sample Rolls will be left in position until the end of the study, although they will be replaced if missing or more than 80% of the roll has been consumed. More intensive sampling may take place in contrasting (termite diversity) sites within a mosaic and in comparable mosaics in the landscape, once the broad-scale survey has identified termite-rich and termite-poor habitat types.

Active searches for termites will also be carried out at each mosaic, in addition to baiting. Baits may attract only a particular set of species and active searches, while more time consuming, will provide more information about the termite species present in the mallee habitats. The active searches will take place once during the project. The timing of the searches is not dependent on season as the colony structures are long-lasting and may be present for many years. Searches will therefore be carried out when convenient and volunteers are available. Active searches will be carried out along the bird transects.

Three 500m transect lines will be selected along each bird walk. All possible termite habitats within 10m of the transect line will be searched: dead wood, litter, stumps, rotting trees. Any visible nest on the ground or in trees will be recorded. Three 20m x 20m plots will be randomly chosen along the 500m transect. These plots will be intensively searched for termite species. This will include 10 soil cores (10cm x 10cm x 10cm), all dead wood lifted and searched, hollow branches removed from trees and trees examined for nests to a height of 2m. Any termites found will be recorded and specimens of soldier and worker castes collected into vials for identification.

The sites for psyllid sampling will coincide with the sites selected for toilet roll grids along the bird transects. Ten sites will be located in each of the 28 mosaics. Using these sites means that fire age classes and vegetation types will be representatively sampled, as well as making efficient use of time in the field. Multi-stemmed eucalypt species will be identified at each site and 10 trees will be selected for sampling. The trees will be chosen as representative of the proportion of each tree species in the local area. Leaf surfaces on the selected trees will be observed through binoculars for lerp presence and presence/absence will be recorded. Trees observed to have lerps present will be ranked as having low, medium or high levels of psyllid infestation. Those trees having high or medium levels will have 20 leaves randomly sampled for accurate lerp counts and species identification. A maximum of 10 trees will have leaf samples taken per mosaic to limit the amount of post-field work required. A voucher specimen of each psyllid species observed will be collected for identification. Collection of adult psyllids will be required to assist with identification. The method for collection of adults will be branch tapping over a white sheet to dislodge the adults from the tree. All specimens will be collected for later identification.

Centipedes and scorpions will be collected from the pitfall traps installed for the reptile and mammal surveys. Traps will be open for five nights consecutively. The reptile and mammal teams will check the traps every morning. The selected invertebrates found in the traps along each transect line in October/November 2006 will be collected and put into a jar of 70% ethanol for later identification and quantification.

Plants

Research questions

1. How well do the current Key Fire Response Species serve as surrogates in reflecting the state of the floristic and structural composition of tree mallee communities?
2. Are there other species of plants that would be better Key Fire Response Species? What attributes do they share?
3. Does a high number of seral stages within a mosaic equate to high floristic and structural diversity?
4. What are the thresholds of burning frequency which, if crossed, lead to effectively irreversible changes in floristic and structural composition of plants communities?

Methods – Pilot study – Spring 2006:

Before sampling is undertaken at all sites in all mosaics, a pilot study will be conducted to identify the most appropriate methods to gather data that will address the botanical questions listed above, as well as provide detailed habitat data for the faunal components of the study.

Initially mosaics to be sampled will be subdivided between northern and southern landscapes, as aridity increases to the north. Thirty sites will also be chosen based on topographic position with an attempt to get an even spread of dune vs. swale within each time-since-fire category. The Time Since Fire categories will be 'old' (pre-1970s), 'intermediate' (1980s), and 'recent' (2004-2006). For the pilot study, 10 sites will be studied for each TSF category. The sites to be used will be located beside the pitfall lines used for the reptile and mammal surveys. The quadrats used will be 5x5m, 10x10m, 20x20m, 30x30m, 40x40m and 50x50m in a nested formation. The two largest quadrats have been chosen as trial quadrats undertaken in Murray-Sunset in June 2006 have shown that species number was still increasing in the 30x30m quadrats.

Within each quadrat the following will be recorded:

b. All new species as they occur
c. Number of individuals present for key species e.g. eucalypts, *Triodia* and shrubs.
d. Number of eucalypt stems and their DBH in the 20x20m quadrat.

One 100m transect will also be carried out at each site in order to quantify percentage cover and height of key species. The point intercept method will be used to measure cover and height of species along the transect. Height classes will be used.

Habitat variables that will also be measured include:

1. Structure – height classes along a line transect
   - stem density and DBH of eucalypts within a 20x20m quadrat
   - cover values for each height class along a line transect
2. Litter – estimate amount/measure depth
   - descriptive information e.g. centred around eucalypts or evenly distributed etc (would develop categories)
   - separate into size classes e.g. fine (<6mm) or coarse (>6mm)
   - collect for fuel load estimation (summer 2008)
   - presence/absence of logs (within certain size classes)
3. Bare ground – percent cover along a line transect (or within a quadrat)
4. *Triodia* measurements – number of clumps
   - estimate cover
   - size measurements e.g. circumference
5. Identification of dominant (and/or all) species within an 'x*x'm quadrat (size of quadrat to be determined from the pilot study)
6. Habitat complexity score

Seed bank studies

Plant biodiversity does not include only those species that are present above-ground but must also include those species present in the soil seed bank. Some species have very long-lived soil seed banks and thus there absence from the above-ground community does not necessarily equate to an absence from future communities if a relevant environmental cue occurs (e.g. rain, increase in accessible light). Do certain species (e.g. fire ephemerals) drop out of the seed bank as time-since-fire increases?

Methods

Sample within a subset of very old, intermediate and very young sites across s time-since-fire categories Collect ten 5cm soil cores at each site within a 10x10m quadrat.. These samples will be pooled within a site before establishing glasshouse trials. Samples will be subdivided across the topographic gradient (i.e. dune vs. swale), soil type (i.e. deep vs. shallow sand) and vegetation communities (i.e. loamy sands vs. woorinen sands). Germination will be stimulated using cues such as smoke water, charcoal and heat for fire, and watering for a set period to simulate a large rainfall event. Control samples with no treatments except water will also be used.

Modelling

Data gathered by the team in the field will be used to generate mathematical models which identify the most powerful predictors of biodiversity responses to fire. Insights gained from these models will then be combined with GIS data layers to generate further models to predict flora and fauna responses to fire. These GIS-based models will then be used to generate spatially explicit models and maps for the region that identify areas of high biodiversity value

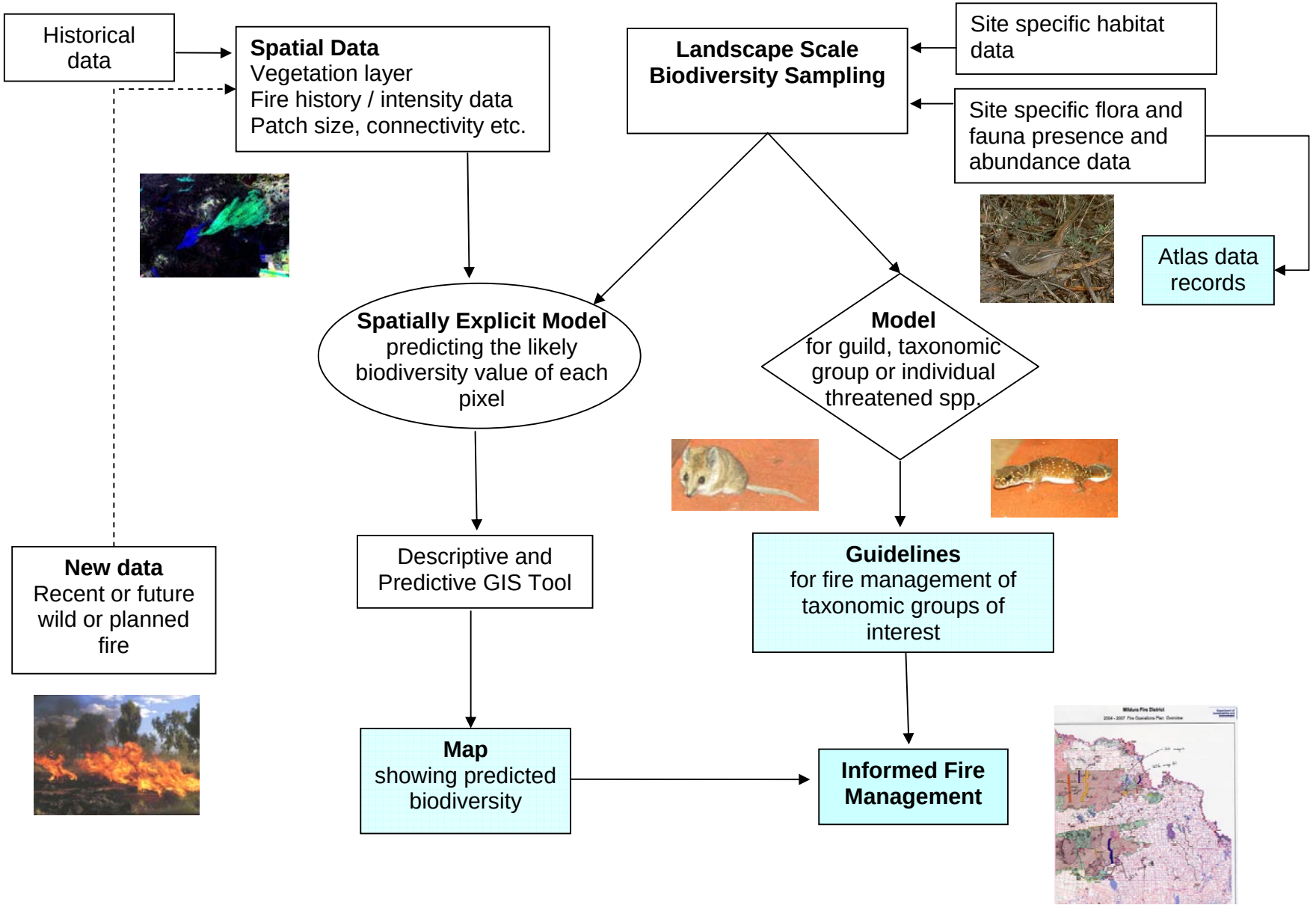

Figure 4 Schematic overview of project