Project Plan SP 2019-048

Investigating the causes of change in forest condition

Ecosystem Science

Project Core Team

Supervising Scientist	Katinka Ruthrof
Data Custodian	Katinka Ruthrof
Site Custodian	

Project status as of May 27, 2020, 1:58 p.m.

Approved and active

Document endorsements and approvals as of May 27, 2020, 1:58 p.m.

Project Team	granted
Program Leader	granted
Directorate	granted
Biometrician	granted
Herbarium Curator	not required
Animal Ethics Committee	not required

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Biodiversity and Conservation Science Program

Ecosystem Science

Departmental Service

Service 8: Implementation of the Forest Management Plan

Project Staff

Role	Person	Time allocation (FTE)
Research Scientist	Katinka Ruthrof	0.5
Research Scientist	David Tarrant	0.05
Research Scientist	Ricky Van Dongen	0.1

Related Science Projects

SPP 2019 068, which is my other project.

Proposed period of the project

June 19, 2019 – Jan. 31, 2021

Relevance and Outcomes

Background

Southwestern Australia is particularly vulnerable to climate change (Climate Commission 2011), which is characterised by a long-term declining trend in precipitation and increasing temperature over the past 40 years (Bates et al. 2008), as well as severe drought and heatwaves in the last decade. Associated environmental responses have included dropping groundwater levels (Hughes et al. 2012), decreases in streamflow (Petrone et al. 2010), forest die-off in vulnerable parts of forest (Matusick et al. 2013, 2016; Ruthrof et al. 2015), and a range of secondary effects following forest die-off (Ruthrof et al. 2016; Hopkins et al. 2018; Walden et al. 2019). Forest die-off is particularly concerning, given the importance of the forest ecosystem for carbon sequestration, timber production, recreation, habitat, and a range of ecosystem services, including water.

Recent work by DBCA has shown a decline in vegetation density in the eastern portion of the forest ecosystem, specifically the following forest ecosystems: Jarrah North East; Jarrah North West; and, Western Wandoo Forest and Woodlands (Conservation and Parks Commission 2019). Previous research in the north-eastern forest suggests that key canopy species, *Eucalyptus marginata* and *Corymbia calophylla,* are susceptible to frost (Matusick et al. 2016). In the same region, *E. wandoo* has been undergoing a series of declines in health, associated with drought and increasing temperatures (Brouwers et al. 2013). In addition, *E. wandoo* has been affected by a Buprestid beetle, *Cisseis fascigera* (Hooper and Sivasithamparam 2005; Hooper et al. 2010), which is thought to become active when vapour pressure deficits (VPD) levels reach a particular level and trees become drought-stressed (Hooper 2009). An associated fungal pathogen is also suspected in the decline of this eucalypt (Hooper and Sivasithamparam 2005) but has not yet been identified and described.

Although these patterns of tree decline are broadly consistent with climate change prediction models, other factors may also be contributing. Little is known about the landscape, site, and stand characteristics that predispose forest to decline. Without this, we cannot predict how the forest will respond to further climate change in the future. This project will build on the information gained from preliminary examination of vegetation decline, investigate the cause/s and further quantify contributions by other factors. This will provide a greater understanding of the vulnerability of the forest to climate change and assist in developing evidence-based management intervention techniques. The project has four key areas: 1) trend map investigation; 2) forest validation; 3) trajectories in recovery post-fire; and 4) climatic influences.

1) **Trend map investigation.** The decline trend in forest vegetation cover over the period of the previous Forest Management Plan, which was revealed via remote sensing, will be examined against landscape characteristics including fire history, aspect, elevation, soil types, and other topographic variables. Interactions may be important in this regard, such as aspect combined with time needed to recover from fire.

2) **Forest validation.** Declining and stable forest plots identified via remote sensing will be examined in the field. Site and stand level characteristics investigated will include soil type, vegetation type, stand structure, stand composition, stand and tree health, and fire impacts. The information from the on-ground forest survey will be used to test and validate the remote sensing analysis, so that we have a high level of confidence in what is being detected via remote sensing, and so that remote sensing, combined with Departmental datasets, can be utilised to identify similar areas of decline, or vulnerable forest sites.

3) **Post-fire recovery.** The speed of vegetation recovery from disturbance events, such as fire, may be influencing the trend of cover at particular sites. That is, different forest ecosystem types recover at different rates following disturbance, depending on factors such as site index (i.e. productivity), which is dependent on rainfall, soil type, elevation, slope, etc. Furthermore, the recovery from a particular fire event is also dependent on a range of factors such as ecosystem type. These nuances in forest responses to fire will be investigated and incorporated into trend analysis in the future, and included in the next FMP if necessary.

4) **Climatic influences.** Although the forest is responding to climate change, the climatic factors responsible for acute and chronic forest decline need to be investigated. If vegetation thresholds at particular sites during key climatic events or trends can be understood, then it may be possible to project this understanding into the future and predict when and where the forest will respond with a decline in vegetation cover.

Aims

The aim of this SPP is to *investigate the cause/s of decline in vegetation density and further examine contributions by other factors*. This will be achieved through the following objectives:

1. Further understand the temporal and spatial trends in the forest vegetation cover and identifying declining, and stable, forest plots in key ecosystem types;
2. Investigate the factors contributing to vegetation cover decline, and validating remote sensing data with ground-based measurements;
3. Examine the recovery time of key forest ecosystem types to different fire intensities; and,
4. Investigate the climatic drivers that have occurred in the vicinity of forest decline.

Expected outcome

This project will improve our understanding of the extent and causes of forest vegetation decline and hence our ability to predict how the forest will respond to future climate change, and management intervention. This part of the SPP (Aims 1, 2 and 4) directly address the Forest Management Plan Mid-Term Review KPI1, Recommendation 1: That the *Department further investigates the cause of decline in vegetation density and provide further information to the Commission on the factors that may have contributed to the outcomes of lower vegetation density in the affected forest ecosystems by January 2021.* In addition, these objectives directly align with the Science Strategic Plan 2018-21, as they will develop a clearer understanding of the impacts of climate change on the forest ecosystem.

By investigating the responses and recovery of different forest types to different fire intensities (Objective 3), we can incorporate new information into planning for intervention in the future. The objective directly contributes to the Ecosystem Science Program Plan 2018-21 via: Program Approach: Conduct research into the physical and ecological processes mediating the impacts of climate change and the responses of the biota to inform mitigation strategies. This SPP accomplishes this through conducting research of the responses of biota to inform mitigation strategies.

Outputs include:

- Scientific publications in peer-reviewed journals
- Conference presentations
- Summary research bulletins, as required.

Outcomes include:

- Enhanced ability to report on the condition of forests managed under the FMP

- Improved management of the forests managed under the FMP through improving mapping of vegetation change, understanding the causes of vegetation decline, the location of vulnerable sites and how management intervention affects vegetation recovery.

Knowledge transfer

The outcomes and outputs generated by the SPP will be directly used by DBCA staff, including staff from Remote Sensing, Forest Management Branch, and various Districts. Research findings from the project will be integrated into the next Forest Management Plan, management planning, and management responses including future research. Knowledge gained will be delivered to relevant staff in the form of technical reports and presentations. Inclusion of staff from the Forest Management Branch and Remote Sensing will ensure knowledge transfer. Research findings will be published in peer-reviewed journals so that it is available to researchers and managers locally, nationally and internationally. Findings will also be communicated to a wide range of stakeholders through reports, seminars, and newsletters local media and popular articles, as required. Findings may also form part of the basis of an Australian Research Council grant application.

Tasks and Milestones

Project planning - Sep 2019

Remote sensing: Understand temporal and spatial trends in forest cover, and identify declining and stable plots - Oct 2019

Field work: Forest reconnaissance, and validate remote sensing with a targeted forest survey - Initial study: Sep 2020, Longer term: Sep 2022.

Examine the recovery of forest types from fire - Sep 2022

Report completion: Internal reports - Sep 2020, Sep 2022, factors involved in vegetation decline (peer-reviewed paper) - Sep 2021, different forest types recovery from fire (peer-reviewed paper) - Sep 2022, Landscope article - Jul 2021, Public lecture/ symposium - Jul 2021.

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Study design

Methodology

1. ***Trend map investigation:*** To examine the trend in declining vegetation cover the rate of decline will firstly be converted to a quantitative change in vegetation cover. To do this, calibration sites, which will constitute approximately 100, 90 by 90 m polygons, will be located across the Northern Jarrah Forest. At each of these sites, canopy-cover estimates, calculated via automated methods from aerial photography, will be regresses against indices from Landsat imagery. Once an index has been chosen (the highest r^2 value against canopy cover), the highest levels of decline can then be identified across the FMP area. Landscape attributes for different forest ecosystem types and levels of decline will subsequently be investigated, such as aspect, elevation, soil type. In addition, declining and stable polygons will be identified and points within those randomly chosen for the field survey (below).

2. ***Forest validation:*** To validate what is being identified by remote sensing, an appropriately scaled survey will be developed. That is, Landsat-derived data is at the 30m x 30m pixel size and this scale needs to be incorporated into field measurements. Declining and stable forest areas (polygons of at least 4 Landsat pixels) will be identified via remote sensing, plots (variable radius plots) within those pixels selected randomly, and then surveyed. Plot characteristics recorded will be those most likely to influence reflectance, while also capturing the ecological characteristics necessary to determine the potential drivers of decline. Stand-scale characteristics that will be included are: overstorey, midstorey and understorey (dominant) species present, percent cover (rock, litter, CWD, soil, canopy), and health, size (height, DBH), and percent die-off of a number of larger canopy trees, in addition to the level of resprouting and sizes of dead branches (in order to assist with carbon loss measurements). In addition, representative sites will be chosen, and a stand sweep will be undertaken by FMB staff, in order to synchronise methods used between Science and FMB, and to make the overall results applicable to much larger forest management questions and across larger scale. Declining and stable plots will be compared at the landscape scale (e.g. aspect, fire history, elevation etc) and stand scales. Non-normally distributed variables will be analysed using non-parametric methods to determine the difference between groups. For others, mixed effects models, using site as a random factor, will be used. Multiple comparison tests can then be used to determine differences.

3. ***Postfire recovery:*** Different forest ecosystem types recover following fire at different rates and depend on a number of landscape and site factors. Expected recovery curves from prescribed burns or wildfires for each forest ecosystem type would give the ability to determine where changes from the expected recovery are occurring. Firstly, a number of sites will be chosen within key forest ecosystem types, ideally across the precipitation gradient that naturally occurs across the forest management area. Recovery of vegetation cover will then be tracked over a time series, pre to post burn, using one of the spectral indices available, for example, i35 (Van Dongen et al. 2019). Secondly, this will be undertaken at sites with different levels of fire severity (e.g. extreme wildfires c/w prescribed burns). This recovery time can then be incorporated into trend maps for each forest ecosystem type.

4.Climate influences: The ability for independent variables (e.g. precipitation, SPEI [standardised precipitation and evapotranspiration index], VPD [vapour pressure deficit] and the long-term changes in these variables to predict tree die-off will be tested using a logistic regression modelling approach. Other variables, in addition to the long-term changes in SPEI and VPD over time, will also be tested.

Dissemination of information: information gathered throughout this SPP will be written and submitted as internal reports, as well as submitted for publication in peer-reviewed journals. In addition, the results will be disseminated through conference presentations, lectures, and popular articles (where appropriate).

Biometrician's Endorsement

granted

Data management

No. specimens

0

Herbarium Curator's Endorsement

not required

Animal Ethics Committee's Endorsement

not required

Data management

Notes and descriptive data will be archived, maintained on the T:\ drive and my computer, and backed up regularly. Remote Sensing data will be archived within the Z:\ drive. Data will be placed on Data Catalogue to ensure visibility to all DBCA staff.

Budget

Consolidated Funds

Source	Year 1	Year 2	Year 3
FTE Scientist	0.5	0.5	0.5
FTE Technical	0.4	0.4	0.4
Equipment	13	13	9
Vehicle	5	5	5
Travel			
Other			
Total	18	18	14

External Funds

Source	Year 1	Year 2	Year 3
Salaries, Wages, Overtime	0		
Overheads			

Source	Year 1	Year 2	Year 3
Equipment Vehicle Travel Other Total			