## Project Plan SP 2019-068

# Understanding the implications of a drying climate on forest ecosystem function to inform and improve climate change adaptation

**Ecosystem Science**

### Project Core Team

| | |
|---|---|
| **Supervising Scientist** | Katinka Ruthrof |
| **Data Custodian** | Katinka Ruthrof |
| **Site Custodian** | |

### Project status as of June 11, 2021, 10:21 a.m.

| | |
|---|---|
| | Approved and active |

### Document endorsements and approvals as of June 11, 2021, 10:21 a.m.

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

# Understanding the implications of a drying climate on forest ecosystem function to inform and improve climate change adaptation

## Biodiversity and Conservation Science Program

Ecosystem Science

## Departmental Service

Service 8: Implementation of the Forest Management Plan

## Project Staff

| Role | Person | Time allocation (FTE) |
|---|---|---|
| Supervising Scientist | Katinka Ruthrof | 0.0 |
| Research Scientist | David Tarrant | 0.05 |
| Research Scientist | Ricky Van Dongen | 0.05 |

## Related Science Projects

SPP 2019 - 048, which is my other project

## Proposed period of the project

Sept. 10, 2019 – Dec. 31, 2021

# Relevance and Outcomes

## Background

Southwestern Australia has experienced a changing climate over 40 years, characterised by a long-term declining trend in precipitation and increasing temperature (Bates et al. 2008), as well as acute events, including a severe drought in 2010 and a series of heatwaves in 2011 (Ruthrof et al. 2018). These stacked meteorological events, which can interact (Matusick et al. 2018) have been associated with a range of ecological responses. These include forest die-off in vulnerable parts of forest (Matusick et al. 2013; Brouwers et al. 2013a; Andrew et al. 2016; Steel et al. 2019), and flow-on effects such as increased fine fuels (Ruthrof et al. 2016), altered structure (Matusick et al. 2016), altered composition (Steel et al. 2019), shifts in fungal communities (Hopkins et al. 2018), movement of carbon from live to dead pools (Walden et al. 2019), outbreak of woodboring beetles, *Phoracantha semipunctata* (Seaton et al. 2015) and further south, an outbreak of the gum leaf skeletoniser, *Uraba lugens* (Wills and Farr 2017).

In addition to the acute response of the forest to drought and heatwaves in 2011, a chronic decline in vegetation cover in the eastern portion of the forest ecosystem over the past decade has also been noted (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. 2014), and, in the same region, *E. wandoo* has been undergoing a series of declines, associated with drought and increasing temperatures (Brouwers et al. 2013b). 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 more active in *E. wandoo* when the vapour pressure deficit (VPD) 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. The decline in *E. wandoo* health has had flow-on effects for its phenology (Moore et al. 2016), bird use (Moore et al. 2013) and small mammal use (Moore et al. 2014). Both the acute forest die-off events in vulnerable parts of the forest, as well as chronic decline in vegetation cover, are concerning for the functioning of the forest and the biodiversity that it supports.

Little is known about the effects of climate change on the forest ecosystem. Without a broader understanding of the range of effects that climate change is currently having on forest ecology and functioning, we cannot predict how the forest will respond in the future. By increasing our understanding, management intervention techniques may be applied to reduce the severity of changes the forest will undergo. The recent Mid-Term Review of the Forest Management Plan 2014-23 (Conservation and Parks Commission 2019), recommends a continued focus of research towards understanding the implications of a drying climate on ecological function, biodiversity and forest health, through KPI 12: *Increased knowledge of trends in climate,* and KPI 13: *integrate research and monitoring programs to inform and improve climate adaptation and mitigation*.

The aim of this project is, therefore, to understand the implications of a drying climate on forest function, biodiversity and health to inform adaptation and mitigation. The project has key areas which address KPI 12 and 13 in the Mid-Term Review: 1) understand the effects of climate change type drought and wildfire on forest structure, composition and functioning, 2) investigate functioning across climatic gradients and management intervention, 3) undertake a review of ecological thinning, and 4) explore the Landis II model to map forest change over time.

1) **Effects of drought and wildfire on structure, composition and functioning.** The effects of chronic drought, acute drought/heatwave events, and wildfire (as represented by the Yarloop research sites), which have a range of prescribed burn and harvest histories, will be examined for canopy recovery, ecophysiological functioning, carbon dynamics, regeneration capacity, understorey diversity and response, and changes in ecological function.

2) **Review of ecological thinning.** Ecological thinning to enhance forest resilience to climate change has been described in a number of Mediterranean forest ecosystems. This project will examine data and literature on forest sites in the southwest that have been thinned to lower basal area and stem density to determine the potential for silvicultural intervention to increase forest resilience in a drying climate. In addition, remote indices will be used, such as i35 (Van Dongen et al. 2019) to examine the stability, or otherwise, of vegetation trajectories of thinned sites compared with adjacent unthinned sites.

3) **Potential: Modelling forest change over time.** Landis-II is a landscape-scale forest ecosystem model used for simulating ecological processes, including forest growth, forest succession, and disturbances (wind, fire, insect outbreaks, drought, timber harvesting). It has been used to assist forest managers and policy-makers estimate likely outcomes of alternative management strategies (Swanson 2009). Landis II was originally developed in North America in collaboration between United States Department of Agriculture Forest Service and Universities. However, the model has an open source platform and since development has been used successfully in forest ecosystems throughout North America, South America (Columbia and Chile), and Europe (Sweden, United Kingdom, Italy, Ukraine, and Russia). This project aims to determine changes in forest composition, landscape pattern, tree biomass, and habitat for wildlife. The projections can be made for areas as small as 5,000 and as large as 1 million hectares for time periods ranging from 50 to hundreds of years. Two catchments have been identified for a pilot study.

## Aims

The aim of this SPP is to *Understand the implications of a drying climate on forest function, biodiversity and health to inform adaptation and mitigation.* This will be achieved through the following objectives:

1. Understand the impacts of climate change and extreme events on structural, compositional and functioning of the forest;
2. Undertake a desktop review of ecological thinning;
3. Investigate the use of the Landis II model to examine the implications of climate change on forest composition and management intervention techniques.

## Expected outcome

This project will improve our understanding about the vulnerability of the forest to climate change, hence our ability to predict how and where the forest may change, and how management intervention could assist with mitigation and adaptation. This SPP directly addresses the Forest Management Plan Mid-Term Review KPI12, Recommendation 12: *That there is a continued focus of research towards understanding the implications of a drying climate on ecological function, biodiversity and forest health including considerations of treatments to improve the forests resilience in a future drier climate.* In addition, the SPP addresses KPI13, Recommendation 13: *That the Department engages and collaborates with research providers to prioritise and integrate research* *and monitoring programs to inform and improve climate adaptation and mitigation with the aim of meeting information needs to support the development of the next FMP*.

This SPP also aligns with the Science Strategic Plan; Theme: *Impacts of climate change on biodiversity and ecosystem function* and The Strategic Goal: *Impacts of climate change on biodiversity are better understood and adaptation strategies are incorporated into conservation management and planning.* The project will contribute to these by understanding the responses of the forest ecosystem to climate change, such as recent declines, to inform mitigation strategies.

The SPP also 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* by conducting research of the responses of biota such as overstory and understory plant diversity, composition and structure, 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 structure, composition and function of forests managed under the FMP
- Improved management of the forests managed under the FMP through understanding the causes of changes in structure, composition and functioning and how management intervention can affect 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, Remote Sensing and BGPA 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 - Oct 2019

*Impacts of climate change on structure, composition and functioning:* Structure and ecophysiological functioning, regeneration - Dec 2020, Understorey diversity and structure - July 2020

*Review of ecological thinning* - Dec 2020

*Potential: Landis II: pilot study commenced* - Dec 2021

*Report completion:* Internal reports - Sept 2020, Structural changes following drought+WF (peer-reviewed paper) - Sept 2022, Understorey diversity and structure (peer-reviewed paper) - Sept 2021, Landscope article - Jul 2021, Public lecture/ symposium - July 2022

## References

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# Study design

## Methodology

1. *Effects of drought and wildfire on structure, composition and functioning:* To examine the impacts of climate change, and extreme events on the forest ecosystem, the project will utilise the Yarloop research sites to determine the responses to canopy recovery, ecophysiological functioning, carbon dynamics, regeneration, understorey diversity. There are 47 sites in this study: 10 control, unburnt sites, and 37 sites with a 2 x 2 design, made up of low and high drought vulnerability, and high and very high fire severity. The sites also have different harvest and prescribed burn histories, which have been mapped in collaboration with the FMB. Analysis undertaken will be to quantify differences between low and high drought vulnerability, and high and severe wildfire, and thus include comparison with control sites. 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. This design will provide a wealth of information regarding the forest responses to drought and extreme events against the backdrop of various management interventions.

2. *Review of ecological thinning:* This project will examine data and literature of forest catchments that have been thinned to lower basal area and stem density to determine the potential for silvicultural intervention to increase forest health in a drying climate. Sites that have been thinned include Ingehope, Yarragil, Wungong, Well-Bucket. One of the spectral indices available, for example, i35 (Van Dongen et al. 2019) will be used to explore the vegetation cover trajectory in thinned and unthinned (control) plots.

*3.Modelling forest change over time:* The Landis-II model may help answer questions such as what the implications of projected climate change on forest composition, pest populations, disease, fire, and can management intervention assist? This project will collaborate with the Forest Management Branch to source stand-level data for data from two catchments as a pilot study.

*Dissemination of information*: information gathered throughout this SPP will be written and submitted as internal reports, and also 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 | 0.1 | 0.1 | 0.1 |
| Equipment | 11 | 6 | 6 |
| Vehicle | 2 | 2 | 2 |
| Travel | | | |
| Other | | | |
| Total | 13 | 8 | 8 |

## External Funds

| Source | Year 1 | Year 2 | Year 3 |
|---|---|---|---|
| Salaries, Wages, Overtime | | | |
| Overheads | | | |
| Equipment | | | |
| Vehicle | | | |
| Travel | | | |
| Other | | | |
| Total | | | |