Project Plan SP 2022-042

Forest ecosystem resilience and stand management

BCS Ecosystem Science

Project Core Team

X X **Supervising Scientist** Katinka Ruthrof
Data Custodian Gavan McGrath

Project status as of April 22, 2024, 5:11 p.m.

X X Pending project plan approval

Document endorsements and approvals as of April 22, 2024, 5:11 p.m.

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

Forest ecosystem resilience and stand management

Program

BCS Ecosystem Science

Departmental Service

Service 8: Implementation of the Forest Management Plan

Project Staff

X X X **Role Person Time allocation (FTE)**

Supervising Scientist Gavan McGrath 0.2

Research Scientist Tim Bleby 1.0

Supervising Scientist Katinka Ruthrof 0.2

Technical Officer Lauren E Hayles 1.0

Technical Officer Alannah Rowe 1.0

Research Scientist Dr Sean Tomlinson (Curtin University) 1.0

Research Scientist Ricky Van Dongen 0.05

Research Scientist Martin van Rooyen 0.0

Research Scientist Josephine Hyde 0.2

Technical Officer Allan Wills 0.05

Research Scientist Richard Mazanec 0.05

Related Science Projects

SPP 2019-068
SPP 2000-003
SPP 2011-20

Proposed period of the project

July 25, 2022 – None

Relevance and Outcomes

Background

A warming and drying climate in southwestern Australia has, and increasingly will, put forest ecosystems under chronic and acute moisture and temperature stress (Matusick et al. 2013; Bureau of Meteorology and CSIRO, 2020; DWER 2021). A decline in rainfall since the 1970s and increased frequency of heatwaves have resulted in declining groundwater levels, reduced streamflow, and less plant-available water (Petrone et al. 2010; Hughes et al. 2012). Concurrently, past management of the forest for timber production have produced legacies of altered stand structure. Portions of the forests are currently characterised by dense stands of regrowth, which may be increasingly vulnerable to warming and drying because they use more water than a more mature forest (MacFarlane et al. 2010; Silberstein et al. 2012). There may also be flow-on consequences of these changes in water availability and use for the biodiversity that the forest sustains, including for riparian ecosystems and habitats.

This project expands on SPP 2000-003 (Hydrological response to timber harvesting and associated stand management in the intermediate rainfall zone of the northern jarrah forest) and SPP 2011-20 (Long-term stand dynamics of regrowth forest in relation to site productivity and climate), both of which will be closed. SPP 2000-003 provided an important, long-term record of the groundwater and stream flow responses of the jarrah forest (via the Yarragil research catchments) to a drying climate and forest thinning. Hydrological responses to a recent thinning, in 2019, will continue to be monitored by this new project.

Knowledge gaps remain regarding the coupling of the forest to groundwater and the unsaturated zone and there remains a need to develop ecohydrological models to support decision making regarding forest management for biodiversity and forest resilience outcomes. SPP 2011-20 demonstrated the effects of forest thinning on growth and inter tree competition in regrowth stands of jarrah and karri, and produced important information on thinning activities in relation to Armillaria root disease and organic matter build up. However, that project had a timber resource focus so did not address many of the ecological questions that we now need answered about forest health, fuel loads, fauna habitat and biodiversity responses. This new project will build on the outcomes of these previous projects and will help fill knowledge gaps regarding forest conservation and management under the challenges of ongoing and predicted climate change, as outlined in the FMP 2024-2033.

One of the main intervention techniques to help the forest adjust to a drying and warming climate is to alter forest stand structure via thinning to reduce competition for water. A range of thinning trials were established as part of harvesting for timber production in southwestern Australia in the past 50 years. These show that thinning can increase available water, and may increase protection of riparian zones and other habitats, and increase growth rates of remaining trees. However, the ecological implications of thinning for conservation outcomes are less well known.

To understand how thinning may assist in increasing the resilience of south-west forests to a drying and warming climate, this project will investigate three main components: 1) climate drivers and forest health: that is, how forest responds to climate variability under differing management treatments; 2) hydrology: how forest structure and health influence and in turn are influenced by the storage of water in the vadose and groundwater zones and how this in turn influences streamflow and evapotranspiration; and 3) thinning: can changing stem number (functional sapwood, basal area) increase resilience, and what are the ecological responses to thinning. In addition, the forest, with and without thinning, will experience disturbance interactions such as fire, pests, pathogens, and thus these will also be investigated.

Previous social research suggests that in some areas thinning may not be palatable to the wider community. This requires further work to understand attitudes and perceptions to thinning and forest management.

Aims

The aim of this project is to examine the potential of stand management such as thinning to maintain or increase forest ecosystem resilience and inform management for forest adaptation to climate change. Specifically, aims include:

Climatic drivers and forest health

Examine, using remote sensing and geophysics, depth to groundwater and bedrock, when and where forest cover changes are occurring, to identify key thresholds and inform stand management.

Examine responses of thinned forest, riparian zones, dense regrowth, and old growth, during drought/ heatwaves using remote sensing (e.g., NDVI, i35, LAI).

Mine FORESTCHECK data for relationships between biological diversity, composition and stand density, e.g., examine the temperature and precipitation gradient across the forest to show impacts of a drying and warming climate on forest structure, composition, and function.

Maintain, periodically monitor (5-10yrs), and report on stand management measurements, e.g., population and health, for long-term trials in jarrah (Yarragil 4L, 4X, 6C, Wungong, Inglehope, Munro) and karri forest (Warren, Treen Brook, Sutton blocks).

Hydrology and ecophysiology

Quantify hydrological responses (soil moisture, groundwater, surface water and evapotranspiration) to thinning and declining rainfall in experimental catchments and examine how forest structure regulates streamflow volumes/quality at landscape scales. Apply novel technologies, geophysics, remote sensing, water tracers and soil analyses to measure these responses.

Develop models for landscape-scale assessment of ecohydrological responses to climate change and management such as thinning.

Undertake research to understand water use and responses to thinning of key forest species.

Thinning

Examine habitat values and use (foraging, roosting, nesting) of thinned and unthinned catchments (e.g., Wungong) by fauna (key species and broader diversity measures) using novel techniques (e.g., eco-acoustics, camera traps, eDNA) and compare with traditional methods.

Identify the effects of thinning on forest function (e.g., water, soil carbon, nutrients, microbes), and soil disturbance (movement, compaction), and understorey diversity (Wungong, Munro).

Quantify herbicide residue following thinning operations.

Interactions

Examine the vulnerability of thinned and unthinned forest blocks to high severity fire.

Quantify fuel loads and fire potentials following different methods of thinning using standard and publishable fuels surveys, for older (e.g., Wungong) and newly thinned sites (e.g., Munro, Hamilton).

Examine the responses of Phytophthora cinnamomi -affected forest, in thinned and unthinned areas using remote sensing techniques, validated with in situ data collection.

Social licence

Understand current perceptions regarding forest thinning. Build on the Beckwith et al. (2010) study from Wungong to determine the barriers to social acceptance of ecological thinning.

Assist with ecological thinning demonstration sites to increase understanding of ecological thinning.

Expected outcome

A clearer understanding of the responses of forest ecosystems to climate change with and without intervention activities such as thinning.

Findings will be shared with EHB and FMB as part of the FMP implementation via guidelines, manuals, and procedures. Outputs will include journal papers, presentations, science notes, etc., as required.

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 Regional and District offices. Research findings from the project will be integrated into forest management planning, implementation of the Forest Management Plan and guide 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.

Tasks and Milestones

Climatic drivers and forest health

- Examine, using remote sensing and geophysics, depth to groundwater and bedrock to identify key thresholds and inform stand management. Aug 2025.
- Examine responses of thinned forest, riparian zones, dense regrowth, and old growth, during drought/ heatwaves using remote sensing. Dec 2024.
- Mine FORESTCHECK data for relationships between biological diversity, composition and stand density, Ongoing, as needed.
- Maintain, periodically monitor (5-10yrs), and report on stand management measurements. Ongoing.

Hydrology and ecophysiology

- Quantify hydrological responses to thinning and declining rainfall in experimental catchments and examine how forest structure regulates streamflow volumes/quality at landscape scales. Aug 2025.
- Develop models for landscape-scale assessment of ecohydrological responses to climate change and management such as thinning. Aug 2025.
- Understand water use and responses to thinning of key forest species. Aug 2025.

Effects of thinning

- Examine habitat values of thinned and unthinned catchments (e.g., Wungong) by fauna using novel techniques (e.g., eco-acoustics, camera traps, eDNA) and compare with traditional methods. Aug 2025.
- Identify the effects of thinning on forest function (e.g., water, soil carbon, nutrients, microbes), and soil disturbance (movement, compaction), and understorey diversity. Aug 2025.

- Quantify herbicide residue following thinning operations. Dec 2024.

Interactions

- Examine the vulnerability of thinned and unthinned forest blocks to high severity fire. Aug 2025.
- Quantify fuel loads and fire potentials following different methods of thinning. Jul 2024.
- Examine the responses of Phytophthora cinnamomi -affected forest, in thinned and unthinned areas using remote sensing techniques, validated with in situ data collection. Aug 2025.

Social licence

- Examine stakeholder attitudes regarding forest thinning. Build on the Beckwith et al. (2010) study from Wungong to determine the barriers to social acceptance of ecological thinning. Jul 2023.
- Assist with demonstration sites to increase understanding of forest thinning. Ongoing.

References

Beckwith J.A., Moore S.A., Clement S.E., Curnow B.D. and R. Admiraal. 2010. The Impact of Forest Thinning on Perceptions of Recreational Value and Forest Health. A Technical Report prepared as part of the Wungong Catchment Research Trial. Beckwith Environmental Planning and Murdoch University and: Perth.

BOM and CSIRO (2020) State of the Climate 2020. Melbourne, Australia. Available at: Australian Bureau of Meteorology. http://www.bom.gov.au/

Challis A, Stevens JC, McGrath G, Miller BP (2016) Plant and environmental factors associated with drought-induced mortality in two facultative phreatophytic trees. Plant Soil 404 (1–2):157–172. https://doi.org/10.1007/s11104-016-2793-5

DWER (2021) Western Australian Climate Projections Summary. Department of Water and Environmental Regulation. Government of Western Australia. Perth, Western Australia.

Hughes JD, Petrone KC, Silberstein RP (2012) Drought, groundwater storage and stream flow decline in southwestern Australia. Geophysical research Letters. 39 L03408, doi:10.1029/2011GL050797.

Macfarlane, C., Bond, C., White, D.A., Grigg, A.H., Ogden, G.N., Silberstein, R., 2010. Transpiration and hydraulic traits of old and regrowth eucalypt forest in southwestern Australia. For. Ecol. Manage. 260, 96-105.

Matusick G, Ruthrof KX, Brouwers NC, Dell B, Hardy G (2013) Sudden forest canopy collapse corresponding with extreme drought and heat in a mediterranean-type eucalypt forest in southwestern Australia. Eur J For Res 132(3):497–510. https://doi.org/10.1007/s10342-013-0690-5

Petrone KC, Hughes JD, Van Niel TG, Silberstein RP (2010) Streamflow decline in southwestern Australia, 1950–2008. Geophys. Res. Lett. 37 (11).

Silberstein RP, Aryal SK, Durrant J, Pearcey M, Braccia M, Charles SP, Boniecka L, Hodgson GA, Bari MA, Viney NR, McFarlane DJ (2012) Climate change and runoff in south-western Australia. Journal of Hydrology 475:441-455.

Study design

Methodology

Climatic drivers and forest health

- Examine, using remote sensing and geophysics, depth to groundwater and bedrock, when and where forest cover changes are occurring, to identify key thresholds and inform stand management. Using electrical resistivity tomography (ERT)(see methods in Challis et al. 2016), and other equipment as required, measure substrate depth and type to characterize the below ground environment in key sites to understand responses of forest stands to climatic extremes and management intervention.
- Examine responses of thinned forest, riparian zones, dense regrowth, and old growth, during drought/ heatwaves using remote sensing (e.g., NDVI, i35, LAI). Examine multiple forest stands across the rainfall gradient, different forest ecosystem types, and use time series patterns of different indices to show how forest responds to droughts and heatwaves. However, these methods will need to be developed. Thus, spatially explicit models that quantify change in remotely sensed NDVI data will be developed, accounting for the geospatial patterns in location, topography and specific vegetation types. These optimised models predict NDVI patterns uniquely to different forest types across the SWAFR by which

the effects of a management action (or type of forest) can be standardised at large extents, but at fine resolution. Microclimatic correlates of standardised NDVI metrices need to be interrogated to understand the mechanisms driving effects.
- Mine FORESTCHECK data for relationships between biological diversity, composition and stand density, e.g., examine the temperature and precipitation gradient across the forest to show impacts of a drying and warming climate on forest structure, composition, and function. Tidy and utilise the FC database as required.
- Maintain, periodically monitor (5-10yrs), and report on stand management measurements, e.g., population and health, for long-term trials in jarrah (Yarragil 4L, 4X, 6C, Wungong, Inglehope, Munro) and karri forest (Warren, Treen Brook, Sutton blocks). Use previous and new methods to examine historical trials. For example, using a karri thinning trial established in 1969 in the Sutton block, quantify how thinned karri responds to extreme drought in terms of health and structure using drone-based Lidar and NDVI.

Hydrology and ecophysiology

- Quantify hydrological responses (soil moisture, groundwater, surface water and evapotranspiration) to thinning and declining rainfall in experimental catchments and examine how forest structure regulates streamflow volumes/quality at landscape scales. Apply novel technologies, geophysics, remote sensing, water tracers and soil analyses to measure these responses.
- Develop models for landscape-scale assessment of ecohydrological responses to climate change and management such as thinning.
- Undertake research to understand water use and responses to thinning of key forest species. For example, examine the water potential of key species at the Munro thinning trial to determine whether thinning reduces the stress in the remaining trees.

Thinning

- Examine habitat values and use (foraging, roosting, nesting) of thinned and unthinned catchments (e.g., Wungong) by fauna (key species and broader diversity measures) using novel techniques (e.g., eco-acoustics, camera traps, eDNA) and compare with traditional methods.
- Examine carbon dynamics of thinned and unthinned catchments and ForestCheck plots and clarify allometrics and provide more accurate above and below ground carbon accounting.
- Identify the effects of thinning on forest function (e.g., water, soil carbon, nutrients, microbes), and soil disturbance (movement, compaction), and understorey diversity (Wungong, Munro).
- Quantify herbicide residue following thinning operations.

Interactions

- Examine the vulnerability of thinned and unthinned forest blocks to high severity fire. Aug 2024.
- Quantify fuel loads and fire potentials following different methods of thinning using standard and publishable fuels surveys, for older (e.g., Wungong) and newly thinned sites (e.g., Munro, Hamilton).
- Examine the responses of Phytophthora cinnamomi -affected forest, in thinned and unthinned areas using remote sensing techniques, validated with in situ data collection.

Social licence

- Building on the Beckwith et al. (2010) study from Wungong, the current attitudes to ecological thinning, and the barriers to social acceptance will be examined, via interviews with well-informed stakeholders long engaged in forest management issues in the southwest, and a review of the broader literature, as well planning documents.
- Assist with demonstration sites to increase understanding of forest thinning.

Biometrician's Endorsement

granted

Data management

No. specimens

Herbarium Curator's Endorsement

not required

Animal Ethics Committee's Endorsement

not required

Data management

Notes and descriptive data will be archived, maintained on Sharepoint and computer, and backed up regularly. Remote Sensing data will be archived on the Remote Apps virtual computer. All data will be placed on Data Catalogue to ensure visibility to all DBCA staff.

Budget

Consolidated Funds

to | X | X | X |

Source	Year 1	Year 2	Year 3
FTE Scientist	2.8	2.8	2.8
FTE Technical	2	2	2
Equipment			
Vehicle			
Travel			
Other			
Total	400000	200000	200000

External Funds

to | X | X | X |

Source	Year 1	Year 2	Year 3
Salaries, Wages, Overtime			
Overheads			
Equipment			
Vehicle			
Travel			
Other			
Total	124000		