Forest Management Plan 2024-2033

Forest Health Monitoring Program Implementation Plan

February 2024 to December 2033

GOVERNMENT OF WESTERN AUSTRALIA

Department of **Biodiversity, Conservation and Attractions**

Biodiversity and Conservation Science

Forest Management Plan 2024-2033

Forest Health Monitoring Program - Implementation Plan

Contents

INTRODUCTION

Native forests on public lands, vested in the Conservation and Parks Commission (the Commission) in the south-west of Western Australia are managed in accordance with a management plan under the Conservation and Land Management Act 1984 (CALM Act), known as the Forest Management Plan 2024-2033 (FMP). The FMP covers approximately 2.4 million hectares of nature reserves, national parks, conservation reserves, State forests and timber reserves, and facilitates management of the multiple values and uses of south-west forests, including biodiversity conservation, protection of Aboriginal cultural heritage, recreation and tourism, water resource protection and other forest-based industries.

Significant changes in government policy affecting management of the south-west forests were announced by the Western Australian Government in September 2021, the most significant of which was the cessation of large-scale commercial timber harvesting in native forests. The FMP gives effect to this policy position and the only timber to be removed from native forests will be sourced from management activities that aim to improve forest health (a process known as ecological thinning) or clearing for approved mining operations and infrastructure. This fundamentally different approach to forest management underpins the strategic goals of the FMP, which are:

1. To value and protect Noongar cultural heritage and support Noongar Traditional Owner involvement.
2. To conserve biodiversity and support ecosystem resilience.
3. To maintain or improve forest health and enhance climate resilience.
4. To deliver social, cultural and economic benefits through the provision of goods and services.

These strategic goals align with legislation, government policy, principles of ecologically sustainable forest management (ESFM), and meet Australia's obligations under the international framework of criteria and indicators of sustainable forest management, known as the Montreal Process. The FMP remains consistent with the Regional Forest Agreement for the South-West Forest Region of Western Australia (WA RFA), a 20-year agreement between the Western Australian and Commonwealth Governments that provides a strategic framework for the ecologically sustainable management and use of the south-west forests.

Implementation of the FMP will be assisted by a suite of monitoring programs to evaluate management effectiveness, inform decision making and to provide information to support reporting requirements. Management will be informed by understanding how pressures and disturbances are addressed through management intervention and how key forest values change over time. Monitoring data will be used to inform continual improvement of management activities and will enable measurement and reporting of the overall effectiveness of management activities and progress towards achieving each of the strategic goals over the life of the plan.

PURPOSE AND SCOPE

The Forest Health Monitoring Program (FHMP) will contribute to the evaluation of the management targets and performance measures outlined in Foundations 2 and 3 of the FMP, and address strategic goals that aim to conserve biodiversity, maintain or improve forest health, and support or enhance ecosystem resilience.

Under the FMP, a healthy native forest is defined as:

> "One that continues to sustain the natural ecosystem components, including biodiversity and biophysical, ecological and evolutionary processes. Ecosystem components are not static but

interact at varying scales and rates over time. Where forests are subject to disturbance, whether natural or human, their resilience can be described as their capacity to maintain or regain a healthy condition over time".

Other terms have the same meaning as the FMP Glossary (page 131).

The FHMP provides a contemporary, integrated, and cost-effective framework for monitoring forest health. To achieve its objectives, the FHMP will repeatedly measure the status of key biodiversity and environmental components of forest ecosystems (collectively described herein as "forest health components"); detect and quantify changes in forest health components to understand and predict patterns and drivers of change (pressures); and assist forest managers, the broader community, and policy makers to assess how forest health changes under the new forest management regime (response). Contemporary FHMP data sources will include monitoring undertaken at a network of fixed monitoring sites; and through the Western Shield program and ongoing land management and conservation activities, such as targeted surveys of threatened and priority species and ecological communities and weed and disease monitoring programs. Research associated with important management activities, including fire and ecological thinning will further contribute to understanding forest health, and forest ecosystem responses to interacting pressures and future environmental conditions.

Targeted scientific research will be undertaken in conjunction with the FHMP to address important knowledge gaps, particularly those relating to fire, ecological thinning and the ongoing impacts of climate change. This research will be especially important given that current knowledge of forest ecosystems is based on measurements and observations obtained under previous climatic conditions and silvicultural management regimes.

RELATIONSHIP OF THE FHMP TO FOREST MANAGEMENT

Changes in forest health (and its components) as measured by the FHMP, will provide information for adaptive forest management processes of the FMP and will contribute to reporting against Strategic Goals 2 and 3 of the FMP. The data collected through the FHMP will contribute to monitoring the effectiveness of management activities, which under section 6.3.3 of the FMP, will be evaluated biennially to assess progress on the delivery of management activities, and the condition of values and pressures on those values. These processes will be undertaken collaboratively by departmental scientists, managers and policy officers. Strategic goals 1 and 4 of the FMP will be informed by separate monitoring programs with a focus on disturbance activities, visitor satisfaction, and the levels of Traditional Owner engagement and involvement.

A key management action under the FMP is to promote forest health and resilience to climate change and reduce chronic moisture stress by reducing the stocking density of trees (thinning) in targeted forest areas dominated by dense regrowth from historical harvesting practices. Ecological thinning trials will be established in parallel to the FHMP to explore landscape-scale approaches relative to ongoing climate change. The trials will measure the responses of hydrology, plant water use, vegetation and other biotic and abiotic ecosystem components to ecological thinning practices. Streamflow and groundwater monitoring infrastructure to quantify response to thinning and the associated prescribed fire will be established in some sites. Complementary data from these trials may provide additional information on forest health that will be incorporated the FHMP, as appropriate.

OBJECTIVES

To inform the delivery of the FMP, the FHMP will contribute to the evaluation of performance measures for strategic goals 2 (to conserve biodiversity and support ecosystem resilience) and 3 (to maintain or improve forest health and enhance climate resilience). The FHMP objectives are to:

1. determine the condition of key biodiversity and ecological components of major forest ecosystems, and
2. detect and quantify changes in key forest ecosystem components to understand and predict patterns and drivers of change.

Data from the FHMP will also contribute to assessments of biodiversity conservation and environmental management effectiveness (responses) and inform forest managers, the broader community and policy makers on forest health outcomes.

OVERVIEW OF THE FHMP

A healthy forest sustains biodiversity and biophysical, ecological and evolutionary processes that support the composition, structure, and functions of forest ecosystems. Measuring representative components of forest health will inform on the status of forest health, and repeated measurements will allow determination of trends in forest health. Identification of the pressures or processes driving changes in forest health components has informed the selection of representative monitoring indicators (Figure 1).

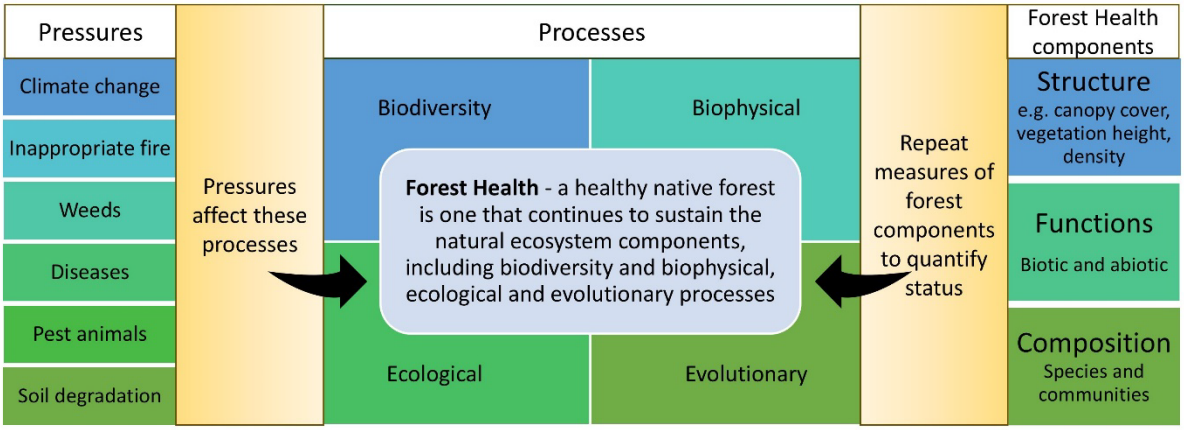

FIGURE 1: A conceptualisation of the FHMP approach where the targeted and repeated measurement of forest health components will identify trends in processes and forest health.

Monitoring indicators

Priority monitoring indicators have been identified across key forest ecosystem components relating to biodiversity, forest structure, ecological processes, soil and water. Indicators have been selected to be suitably informative of forest health responses to known and anticipated anthropogenic and environmental pressures, and to be representative of key components of forest biodiversity, function and structure. Indicators of forest health have been identified that will be sensitive to impacts from the following pressures:

Climate change – changes in the extent, structure, function, composition and resilience of forest health components under changing climatic conditions.

Inappropriate fire regimes – changes in the frequency, severity, interval, and season of fire across forest types, and consequences for the extent, structure, function and composition and distribution of forest health components.

Weeds – changes in the occurrence, extent, and diversity of weed species and impacts of significant weeds on the structure, function, composition and distribution of forest health components.

Diseases (of native flora and fauna) – occurrence of key pathogens and impacts on the extent, structure and composition of communities.

Pest animals – occurrence of key invasive species and impacts on persistence of native fauna and structure, functions and composition of flora communities.

Soil degradation – modification of soil characteristics, including salinisation, acidification, fertility, and microbiome resulting from anthropogenic activities such as mining, infrastructure development and maintenance, tourism and grazing.

TABLE 1

IDENTIFIED PRESSURES, IMPACTED FOREST HEALTH COMPONENTS, CANDIDATE FOREST HEALTH INDICATORS		
Pressure	**Impacted forest health components**	**Candidate forest health indicators**
Climate change	Biodiversity	Species (flora, fauna and fungi) occurrence, richness and composition; soil microbial composition.
	Demographics	Mortality, reproduction, phenology, recruitment, and dispersal.
	Forest cover, structure and processes	Canopy cover, tree density, size and biomass; vegetation health and structure (mid and ground).
	Fire regimes	See below.
Fire regimes	Biodiversity	Species (flora, fauna and fungi), occurrence, richness and composition; soil microbial composition.
	Demographics	Mortality, reproduction, phenology and recruitment of putatively fire sensitive species.
	Habitat availability	Microhabitat (logs, hollows etc.), litter, spatial arrangement of burn history.
	Forest cover and structure	Vegetation cover, structure and biomass
Weeds	Biodiversity	Weed occurrence, abundance, richness and composition of native species.
	Forest cover and structure	Vegetation cover, structure, condition and biomass, plant community structure and health.
Diseases	Biodiversity	Disease occurrence and type; native species health, occurrence, richness and composition.
	Demographics	Mortality, reproduction, phenology and recruitment.
	Forest cover and structure	Vegetation cover, structure, and extent.
Pest animals (vertebrate and invertebrate)	Biodiversity	Pest animal occurrence and composition; native fauna species occurrence, richness and composition.
	Demographics	Native fauna mortality and recruitment.

MONITORING ACTIVITIES

Landscape scale

At the landscape (entire FMP area) scale, forest cover monitoring is well established using Landsat and Sentinel-2 satellite imagery. Vegetation cover and structure data obtained from LiDAR and imagery instruments mounted on drones at representative monitoring sites (see 3.2) will be used to relate satellite data to relevant on ground measures of vegetation. Models developed with satellite data will enable landscape scale derivations of vegetation attributes including time series data for monitoring. Repeat measurements of plots will enable improvement of models and provide information for validation and accuracy assessment. Fire history, fire severity, and fire regime mapping from separate research programs will assist in interpretation of landscape monitoring outputs. Additionally, surface water inundation and hydroperiod, and disease impacts on canopy cover will be monitored from satellite imagery.

The measurement of structural components of forest health, including vegetation cover, height and density measures, can be achieved at high spatial resolution using drone-based LiDAR and imagery. LiDAR data will be processed to produce canopy height models, canopy density models and other relevant structural measures. Image classification will be undertaken to classify green vegetation, woody materials and litter, and bare ground. Collection of this information at representative monitoring sites (see 3.2) will enable development of relationships with satellite derived vegetation data for characterisation and quantification of changes observed at the landscape level.

Representative sites

A network of up to 100 fixed representative sites will be established where multiple monitoring approaches will be repeatedly applied to detect trends in forest health. The monitoring approaches will focus on a broad range of biological and physical indicators of fauna, flora, fungi and soil microbial communities, forest structure, habitat attributes and biomass.

A thorough selection process was undertaken to identify a well dispersed network of candidate monitoring sites across major forest ecosystem types that are representative of important climatic and topographical variables. Site selection was constrained to forested areas in which continued access could be assured over the life of the FMP, which restricted candidate sites to locations managed under the CALM Act and excluded areas that may potentially be mined. Additionally, sites were selected to be within the Western Shield baiting envelope and at least 100m from dieback infested areas or areas that are likely to be infested in the foreseeable future. The number of sites in each major ecosystem type (jarrah, karri, tingle and wandoo) was approximately proportional to the areas of those ecosystems managed under the FMP (Figure 2).

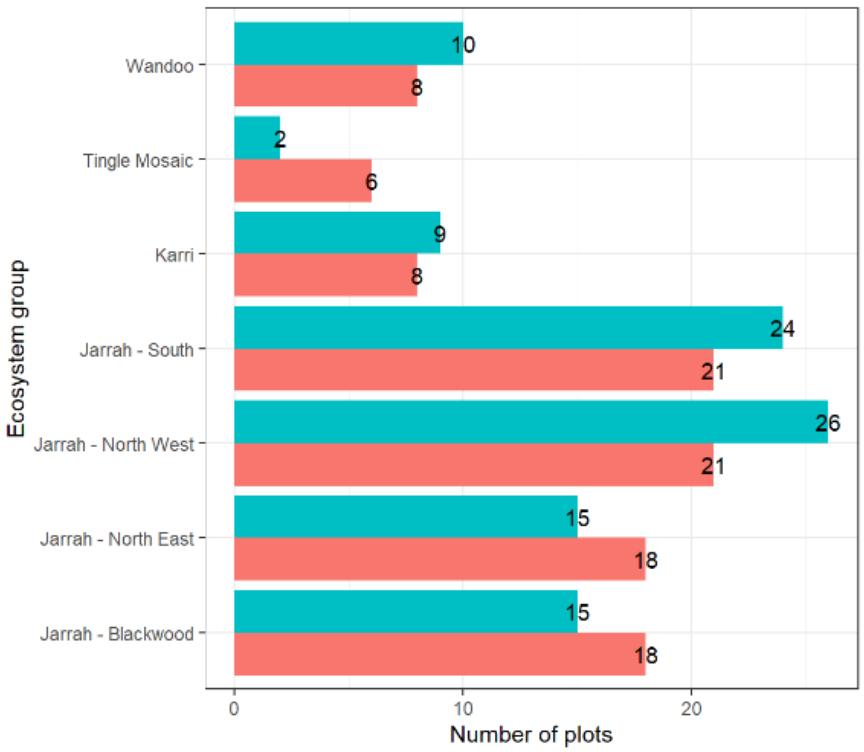

FIGURE 2: Numbers of candidate monitoring sites (red bars) by ecosystem group. Teal bars indicate the proportional contribution of those ecosystem types to the FMP area.

Temperature and rainfall data were aggregated and plotted for each ecosystem type and for an initially randomly located number of sites within each ecosystem area (using the numbers of sites in Figure 2). Candidate site locations were then iteratively adjusted as best as possible with the relatively small number of candidate sites in each ecosystem, to represent the means and ranges of climatic (temperature and rainfall) and topographical (elevation and valley depth) variables (Figure 3). A secondary check and final adjustment to site locations was undertaken to ensure that sites appropriately reflect the fire (time since last burn) and silvicultural histories of each ecosystem (Figure 4) to avoid introducing biases. Areas less than 3 years since last burn were generally avoided given that some sites are likely to be exposed to prescribed burns during the life of the FHMP, thus providing data for younger fuel ages. The final check also considered accessibility and alignment with FORESTCHECK monitoring sites, where silviculture and ecosystem recovery histories are well established. The final distribution of candidate fixed monitoring sites, relative to current climatic conditions is shown in Figure 5. Candidate sites include 18 ex- FORESTCHECK sites.

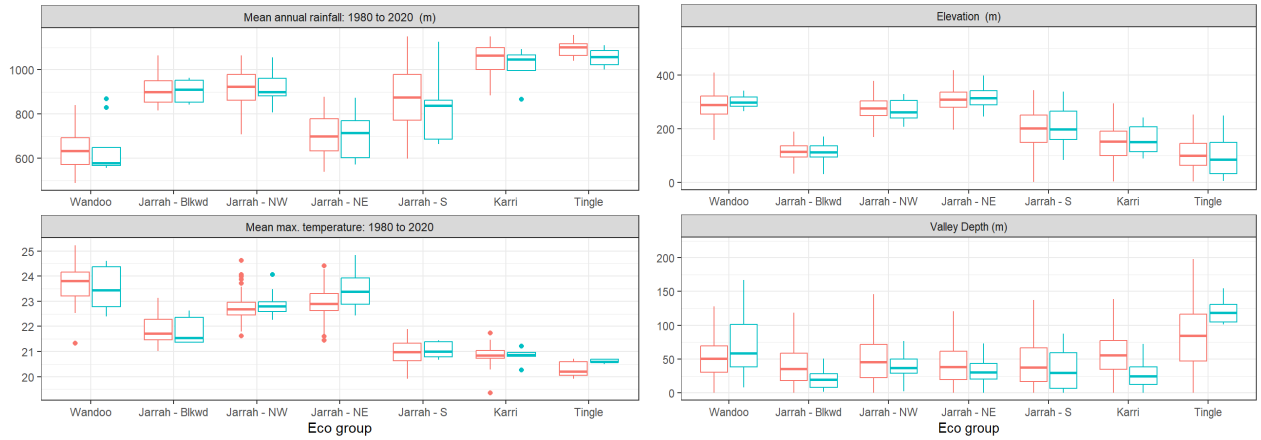

FIGURE 3: Distributions of annual rainfall (mm, top left panel), temperature (°C, bottom left panel), elevation (m, top right panel) and valley depth (m, bottom right panel) within each ecosystem type (red) and group of candidate monitoring sites (teal).

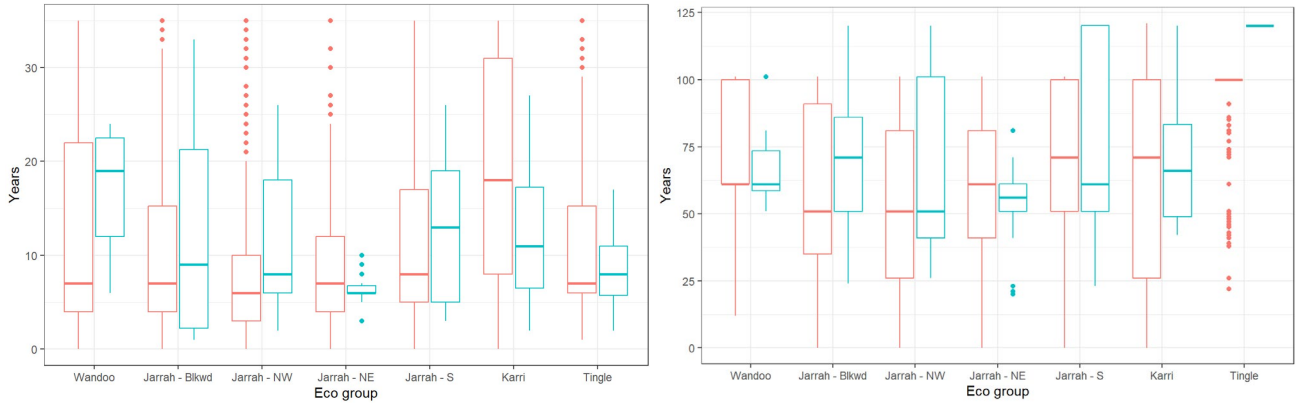

FIGURE 4: Time since last burn (left panel) and harvest (right panel) within each ecosystem type (red) and group of candidate monitoring sites (blue).

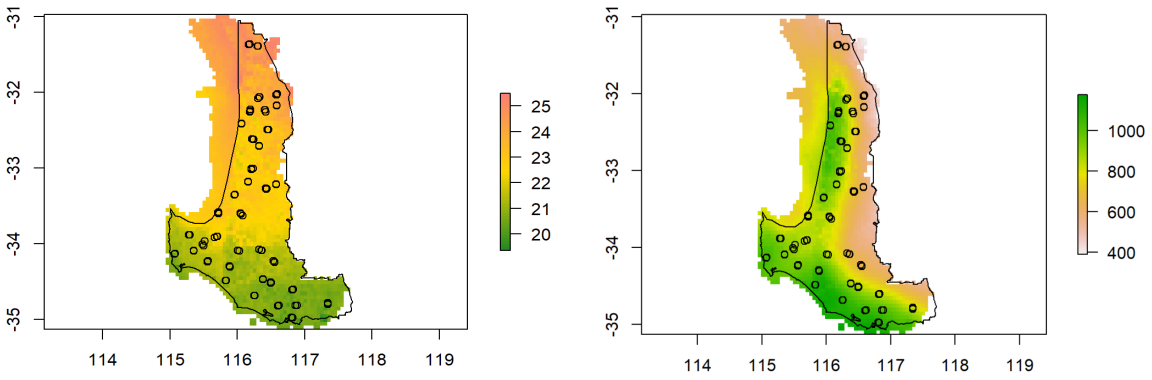

FIGURE 5: Candidate site distribution relative to temperature (left panel) and rainfall (right panel) gradients.

eDNA

Two approaches to using eDNA methods to monitor forest health will be applied.

Aerial insect metabarcoding

Flying insects are expected to show relatively rapid responses to climate shifts and other pressures due to their mobility, so will be an early indicator of ecosystem change. Malaise traps are a well-established and widely used method for passively sampling aerial insect communities. These rely on physically intercepting flying insects over a period of days to weeks and are a less taxonomically biased and a logistically simpler method compared to light traps or manual collection methods such as beating. Malaise traps will be deployed at each of the representative sites. Trap samples will be analysed through a metabarcoding approach, involving blending samples to extract DNA and identifying genetic 'operational taxonomic units' (OTUs) from the sequence data. This method separates out unique species based on genetic dissimilarity of sequences rather than through comparison with a genetic barcode library derived from sequencing taxonomically identified species. Development of an invertebrate barcode reference library is considered unfeasible due to the paucity of taxonomic expertise, number of taxa involved and the large proportion of undescribed morphospecies across the FMP area (only 10% of invertebrates collected through the FORESTCHECK project could be identified as formally described species).

Soil eDNA

Sampling DNA present in and on the forest floor will used to monitor two key forest biodiversity components.

Soil microbiome

Bacterial, archaean, viral, and fungal diversity (collectively known as the soil microbiome) will be characterised from soil samples. These organisms play critical roles in forest ecosystem processes and health, from decomposition of organic matter, biogeochemical cycling of nutrients and organic compounds, disease from plant and animal pathogens, and plant nutrition through mycorrhizal associations. Spatial patterns and changes in the composition and diversity of these microbial groups will be used as indicators of soil health and diversity. Composition of the soil microbiome will be sampled once in spring at each of the sites, every second year.

Soil invertebrates

The diversity and composition of ground and soil dwelling invertebrates such as insects, earthworms and arachnids, will be determined from soil-borne DNA. Mesic and short range endemic invertebrate groups with limited dispersal capacity, such as velvet worms, flatworms, spiders, millipedes and earthworms are potentially more at risk from climate change and other pressures due to their limited dispersal capacity.

As with analyses of samples from Malaise traps, a metabarcoding approach will be used to genetically distinguish OTUs and examine trends in community composition. Extraction of invertebrate eDNA from soil samples will occur every second year, alternating with the soil microbiome analyses.

Eco-acoustics

Community scale monitoring of forest soundscapes

Acoustic recordings will identify and describe acoustic contributions to forest soundscapes. Soundscape metrics will be used to describe and track the spatiotemporal patterns of site-specific acoustic communities. This information will be used as an indicator of community response to natural and anthropogenic change. Sound pressure levels (of specific frequency bands), and soundscape indices will be calculated to describe and monitor the soniferous contributions of several broad taxonomic groups including birds, bats, insects, and anurans. These indices rely on the acoustic niche hypothesis, which predicts that within an ecosystem, species will avoid competition by vocalising within unique frequency bandwidths, or pitches, at unique times. This approach benefits from not being reliant on ground-truthed call libraries, so it will be available from commencement of the FHMP.

Species or taxon group specific acoustic recognition

In addition to the community scale approach, there is potential to build capacity to acoustically monitor the presence of individual species of interest. These may include rare, endangered, priority, and indicator species of forest health. A species-specific approach will utilise manual call detection analysis and machine learning techniques to establish the distribution and acoustic activity of the respective species. Ground-truthed species-specific training datasets will be collated to assist with the development of automated tools for species-specific recognition. For example, acoustic recordings of bat echolocation calls will be provided to experts in bat call identification to assist in the development of automated call recognisers, to monitor species richness and composition efficiently. Occupancy analysis will be undertaken to identify correlates of individual bat species' occurrence. Automated machine learning tools for multi-species recognition (to give community composition) are advancing rapidly and may be also adopted for the FHMP if these tools reach maturity during this period.

The configuration of an eco-acoustics monitoring regime and the settings applied to each unit have been refined by trials undertaken in 2023-24.

Camera trapping

Vertebrate fauna abundance, distribution and community composition are key indicators of forest health, particularly in relation to disturbance and management related to predators and fire. Ground-dwelling mammal occurrence, species richness and community composition will be monitored using outwards facing cameras during four to six- week deployments in spring and summer.

Additionally, downwards facing camera traps with drift fences will be used to monitor reptile occurrence, species richness and community composition using both timelapse photography and motion detections. This approach will also produce data on small rodents and dasyurids. Some threatened mammals with restricted distributions, such as numbats, western ringtail possums, and quokkas will require a more targeted monitoring approach (see 4.3.1 below).

Vegetation monitoring

Forest stand biomass and tree and woody debris size distribution are important indicators of forest health, providing measures of forest productivity, carbon stocks and habitat for other biodiversity components. Tree and woody debris stand characteristics will be quantified at sites through measurement of size, density, composition and either tree health or woody debris decay class. These vegetation structural measurements provide crucial on-ground data to support drone- and satellite-based remote sensing to expand assessment of forest health from site to landscape scale.

The composition, richness, and cover of the vascular plant community, including invasive weeds, will be measured across the representative site network. A plant functional type approach will allow assessment of changes in patterns of occurrence of individual species over time and provide a means to assess impacts of specific pressures and disturbances through aggregating data for species with similar mechanistic responses.

The visual health of keystone overstorey tree species will be assessed using a crown condition scoring system based on published systems for native Australian forest trees, which considers a range of crown attributes including crown size and shape, foliar density, dead branches, epicormic growth and foliar damage. The health of midstorey and understorey vegetation will also be assessed via measures of cover for live and dead vegetation.

A minimum suite of remote-sensing measures for each monitoring plot will include canopy height profiles, canopy cover percentage and green vegetation cover percentage. For some sites, it may be possible to monitor number of crowns, crown size and other forest structural characteristics.

Targeted components

Biodiversity and forest health components that may not occur evenly across the FMP area or may be difficult to detect at fixed representative sites will be monitored by a variety of locally based monitoring programs.

Threatened and priority biodiversity components.

Threatened and priority biodiversity components (fauna, flora and ecological communities) with restricted distributions will be monitored at relevant sites throughout the FMP area to assess their responses to management and changing environmental conditions. Data relating to threatened species' distribution, presence, abundance and habitat condition will be systematically collected by a variety of methods, according to species. Together with biodiversity data collected at fixed monitoring sites, data from targeted monitoring will provide a synthesised understanding of forest health and will contribute to achieving the management objective of conserving and protecting biodiversity, including threatened and priority species and ecological communities in the planning area. Contemporary and historical data pertaining to threatened and priority biodiversity components will be sourced from the department's records to assist in interpretation of long-term trends in species occurrence. Ecoacoustic, eDNA and drone technologies may be employed to assist in monitoring particularly high conservation value and difficult to detect biodiversity components.

Cage and camera trapping

The presence and relative abundance of threatened and priority mammals, including black-flanked rock-wallabies, chuditch, numbats, quenda, quokkas and woylies will continue to be monitored by cage and camera trapping at long term monitoring sites across the FMP area. Data will be collected using standardised Western Shield and district monitoring program methods to enable effective comparison between sites and incorporation with historical data. Monitoring of these species will be enhanced at some sites by employing mark-recapture techniques to improve relative abundance estimates. Data collected through these activities will enable species specific occupancy modelling to monitor long-term trends in occurrence, and response to climate change and the new forest management regime.

Pitfall trapping

Pitfall trapping will be undertaken to monitor the occurrence, relative abundance and spatial distribution of ground-dwelling fauna, particularly invertebrates, reptiles, amphibians and small mammals. Data will be used to assess the distribution of cryptic short range endemic species, examine patterns in biodiversity with landscape features and assess species and functional group responses to threatening processes, including declining precipitation, increasing temperatures and fire.

Spotlighting, vehicle transects and other on-ground fauna monitoring

A variety of other targeted monitoring approaches will be employed to provide understanding of trends in other fauna biodiversity components. As much as possible, the methods used for these monitoring activities will be structured and standardised across the FMP area to allow comparison between regions and districts and with historical data. Spotlighting will be conducted on foot and by vehicle to monitor the distribution, abundance and habitat use of nocturnal animals, including critically endangered western ringtail possums. Vehicle and on-foot transects will be undertaken to measure the presence and abundance of black cockatoos, identify their roosting and feeding sites and quantify available nesting habitat. Acoustic recording units (ARUs) will be employed in addition to visual point counts to assist in detecting and estimating the relative abundance of threatened white-bellied, orange-bellied and sunset frogs. Pending the development of species-specific acoustic recognition algorithms, the targeted use of ARUs may also enable monitoring of other biodiversity components, such as microbats and woodland birds.

Flora population and vegetation composition and condition monitoring

The presence, abundance and condition of threatened and priority flora and ecological communities will be monitored via transect and quadrat counts, population mapping and photo point imagery at long-term monitoring sites. To the extent possible, methods will be structured and standardised across the FMP area to allow comparison between regions and districts and with historical data. The frequency of periodic monitoring will vary according to target taxa, specific threats and other local priorities. Additional targeted monitoring to assess management activity effectiveness and recruitment responses following bushfires and prescribed burning will also inform the FHMP.

Pest animals

Foxes (*Vulpes vulpes*) and feral cats (*Felis catus)* will primarily be monitored with camera and cage traps deployed throughout the FMP area, through the Western Shield program. Occurrences and impacts of other vertebrate pest species, including feral pigs (*Sus scrofa*), red deer (*Cervus elaphus*), fallow deer (*Dama dama*) and European rabbit (*Oryctolagus cuniculus*) will be monitored through targeted management programs and through incidental observations during other monitoring activities.

Western Shield camera monitoring for predators involves the use of automated wildlife cameras. Camera locations are chosen using a random point generator for each site with a minimum distance of 1.5 km between each point. The number of cameras at each location varies according to multiple location-specific factors. Data collected from predator cameras provide information on the effectiveness of different bait prescriptions in terms of reducing the abundance of predators and in effecting the conservation and recovery of target native wildlife species. Camera monitoring at representative fixed monitoring sites (see 3.2) and during threatened and priority fauna monitoring activities (3.3.1) may collect additional data on the occurrence of invasive vertebrates.

Weeds and disease

The focus of weed management activities under FMP, will be surveillance and monitoring of infestations of declared weed species, areas of higher conservation value and following disturbance activities, including fire. For disease management, there will be a continuing focus on *Phytophthora* dieback mapping, as well as monitoring for new and emerging diseases. In addition to targeted disease monitoring activities, data on the occurrence of weeds and some plant diseases (soil-based pathogens such as *Phytophthora cinnamomi* and *Armillaria*) will be collected through vascular flora and soil microbiome eDNA monitoring at the representative sites.

MONITORING FREQUENCY

Landscape monitoring

To align with satellite imagery, drone-based LiDAR and imagery captures will primarily be undertaken during the dry season, although it will be necessary to capture at other times of the year to answer questions of phenology, weed invasion and recovery. Aligning drone monitoring with site establishment and repeat vegetation monitoring will enable coincident captures of on ground structural and coarse woody debris measures with LiDAR and provide validation for satellite derived models. Where sites experience significant disturbance events, such as drought or bushfire, their recovery will be remeasured 1-3 years following the event, depending on the nature of the impact.

Representative site monitoring

Most variables will be monitored annually at each representative fixed site except that vegetation structural monitoring will be conducted at one third of sites every third year. Final monitoring will be completed by the end of 2032 to allow time for analysis and production of the final periodic performance assessment.

Targeted component monitoring

The frequency of targeted monitoring activities will vary according to the monitoring target, location and method.

TABLE 2

MONITORING ACTIVITIES AND FOREST HEALTH COMPONENT INDICATORS RELEVANT TO FMP IDENTIFIED PRESSURES						
Pressure	**Drone data and derived measures**	**Satellite data and derived measures**	**eDNA**	**Eco-acoustics**	**Camera and cage trapping**	**Drone data and derived measures**
Climate change	Canopy cover and forest structure from LiDAR and imagery. Bathymetry of dry wetlands to aid volume calculations. Where there is airborne LiDAR possibly identify streams and wetlands (overlap with DWER climate resilient rivers project) and vegetation cover on margins.	Canopy cover and greenness. Phenology, flowering may be possible for some canopy species with field information/*in situ* cameras. Surface water inundation and hydroperiod. Possibly soil moisture in exposed soils.	Soil microbial (fungal and bacteria) and invertebrate community structure. Fauna composition.	Soniferous fauna (birds, bats, insects) activity, community composition, and structure. Species-specific presence would require targeted projects to develop AI tools e.g., target bird species.	Occupancy of vertebrate species. Directed camera placement can monitor water levels and surface water movement.	Species presence, abundance and health, community composition and richness. Coarse woody debris, tree stand structure and biomass, ground cover, hollows, soil characteristics. Richness and composition of floristic communities.
Fire regimes	Canopy cover and forest structure from LiDAR and imagery.	Burn severity. Extent of canopy cover loss and recovery. Analysis of fire severity history and spatial arrangement e.g., distance to nearest unburnt patch of x years old. Phenological characteristics, e.g., flowering, may be possibly monitored for some canopy species with field information, e.g., *in situ* cameras.	Soil microbial (fungal and bacteria) and invertebrate community structure in response to fire.	Changes in fauna community (acoustic community). Bat species richness and composition and target bird species (e.g., hollow dwelling) would require targeted projects to develop AI tools e.g., target bat or bird species.	Occupancy of vertebrate species.	Species presence, abundance and health. Richness and composition of floristic communities. Coarse woody debris, tree stand structure and biomass, ground cover, hollows, soil characteristics.

Weeds	The potential for weed detection from drones requires further research.	The potential for detection of canopy weeds from satellites requires further research.				Weed presence and abundance. Native species presence, abundance and health. Richness and composition of floristic communities. Ground cover and stand structure.
Diseases	Canopy cover and forest structure from LiDAR and imagery.	If disease impacts on canopy cover, then it should be detectable.	Detection and identification of soil and airborne pathogens. Changes in the composition and structure of soil microbial and invertebrate communities.	.		Native species presence, abundance and health. Richness and composition of floristic communities. Stand structure.
Pest animals			Potential ability to monitor the presence of invasive species.		Occupancy of invasive vertebrate species.	Native species presence, abundance and health. Richness and composition of floristic communities. Coarse woody debris, stand structure and biomass, ground cover, hollows, soil characteristics.
Soil degradation		Bare ground at 10-20m scale detectable. Under canopy disturbance may be undetectable.	Soil microbial (fungal and bacteria) and invertebrate community structure responses to disturbance		Occupancy of vertebrate species.	Ground cover, soil characteristics.

REPORTING

The FHMP will deliver the following reporting outputs over the FMP.

- Biennial progress reports summarising activities and implementation of the forest health monitoring program.
- Provide for periodic performance assessments against achievement of the FMP strategic goals at years 5 (2028) and 10 (2033).
- Publication of scientific journal articles, technical reports, science information sheets and conference proceedings, as data allow.
- Input to the reporting requirements of Australia's State of the Forests Report and to inform the Commonwealth Government on concurrence with Montreal Process Criteria.

DATA MANAGEMENT

Data will be collected through a variety of media, depending on the methodological approach and the nature and volume of data. Raw data will be digitised (where necessary) and transferred to secure storage on return from the field or prior. A dedicated space in the Azure environment will provide a secure common storage location for shared FHMP data with redundancy. Protocols for data storage including standardised folder structures, file naming conventions and rigorous documentation will enable discoverability and sharing of data captured and analysed for the FHMP.

Data processing, including verification and validation will be undertaken on local computers, using software appropriate for the particular data. Curated data sets will be periodically shared through the DBCA Data Catalogue to facilitate discoverability, internal sharing and external collaboration.

Data will be made available internally to other business areas with responsibilities for delivering FMP, as required. Biodiversity data gathered through the FHMP will be shared with the department's threatened and native species databases and externally, with appropriate security for restricted access species data, through the biodiversity platform Dandjoo.