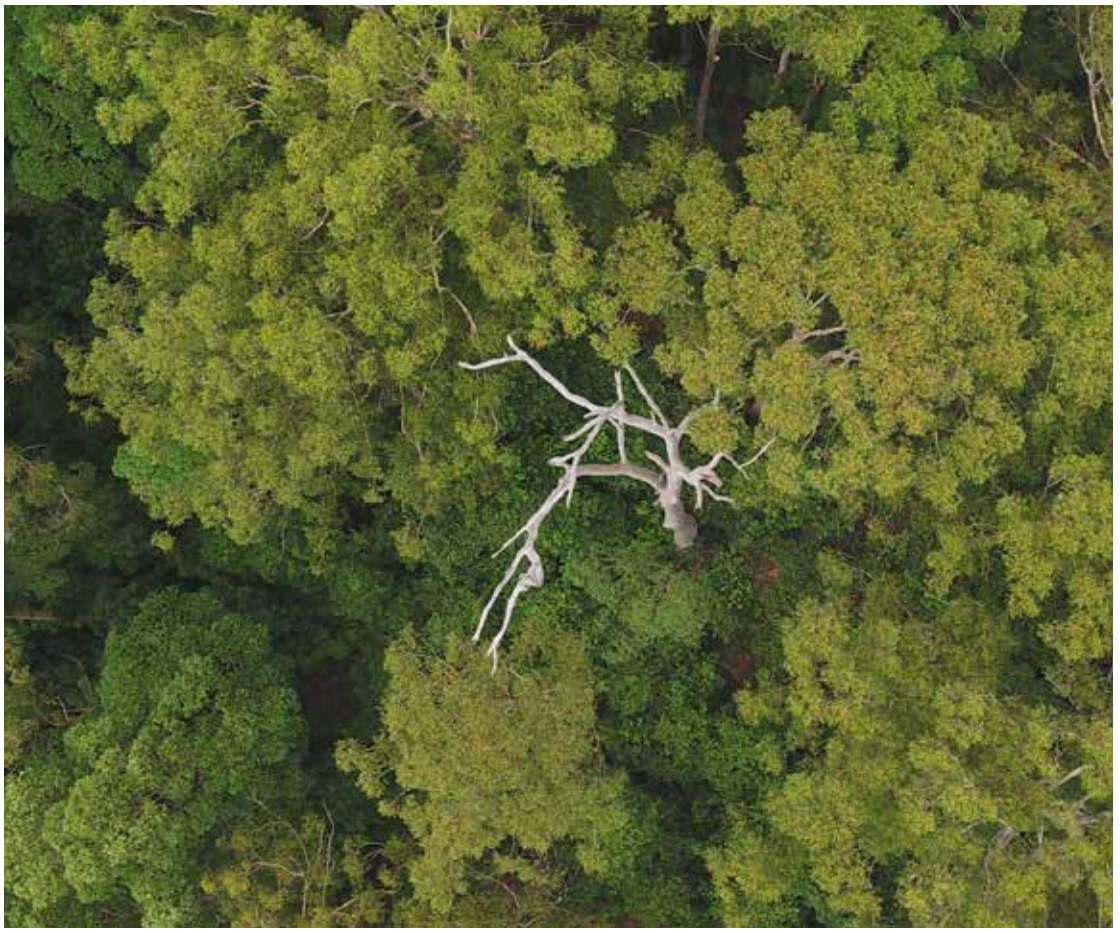
NSW GOVERNMENT

Coastal IFOA: Monitoring plan

Key habitat features

October 2020



Monitoring strategy summary	
Monitoring strategy	Key Habitat Features
Version 1.0	8 October 2020

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Part 1: Monitoring strategy details

1.1 Strategy title

Key Habitat Features

1.2 Protocol 38

- Protocol 38.3 (1)(a) Monitor and evaluate the effectiveness of the Coastal IFOA conditions, including but not limited to:

  (vi) protecting and recruiting hollow-bearing trees

1.3 Coastal IFOA condition and associated outcome statements

C63 (Tree retention clumps) and C64 (Retained trees)

Important trees are retained and protected for shelter and food resources for native species, and to support their persistence.

C49 (Category 1 and 2 Environmentally Significant Areas) and C51 (Large forest owl landscapes)

Habitat and environmental features are identified and retained to provide refuge, connectivity, and to support forest regeneration.

C76 (Nest, roost or den), C78 (Bat roost tree protection)

Site-specific measures are implemented to mitigate the impact of the forestry operation on fauna species and their habitat, and to support their persistence.

C57 (Broad area habitat searches)

Environment features, habitat and risks are identified to ensure that protections and management actions are implemented to mitigate the impact of the forestry operation.

1.4 Monitoring questions

- To what extent do retained habitat features maintain their function?
- Do the conditions support key habitat features to maintain fauna species within and across the forest?

1.5 Monitoring objectives

Design a program to monitor:

- mortality and recruitment of hollow-bearing trees retained in wildlife habitat clumps, tree retention clumps and dispersed through harvested areas

- use of wildlife habitat clumps, tree retention clumps and harvested areas by hollow-dependent species
- the occupancy of key habitat-dependent species in harvested local landscapes.

1.6 Strategy summary

The Coastal IFOA requires that the monitoring program evaluate the effectiveness of the Coastal IFOA conditions to mitigate the impact of the forestry operations on fauna species and their habitat, and to support their persistence.

The aim of the key habitat features strategy is to monitor if key habitat features are being provided in an appropriate number and configuration to ensure persistence of key habitat-dependent fauna and determine if habitat resources are being perpetuated within harvested areas at the number required to maintain fauna species. This will include three tasks:

- a review of hollow use by key dependent fauna
- hollow mortality and recruitment modelling
- occupancy analysis of key habitat-dependent species.

Review of hollow use by dependent fauna

The literature review is underway to identify the use of hollow-bearing trees by key species (identified for occupancy monitoring). The review aims to synthesise the knowledge about the use of hollow-bearing trees in the harvested landscape, to identify the required number and configuration of hollow resources in the landscape to maintain fauna species.

The review will inform the hollow mortality and recruitment modelling. It will also identify potential cost-effective, robust monitoring methods to identify the use of retained resources by hollow-dependent species, where the hollow simulation model inputs or results need to be verified for key species.

Hollow mortality and recruitment modelling

The mortality and recruitment of hollow-bearing trees retained in wildlife habitat clumps, tree retention clumps, dispersed through the harvested area and within the wider Local Landscape Area (LLA) will be assessed within a simulation modelling framework. The model will use data collected by FCNSW as part of their harvest planning and pre-harvest surveys, such as retained wildlife clumps, tree retention and Environmentally Sensitive Areas (ESAs) and additional data from the *Forest Structure, Health and Regeneration Monitoring Strategy*, such as forest functional attributes, connectivity, structure and composition).

Plot data, vector data and remotely sensed data, collected from net harvested areas will be used to populate a simulation model that evaluates whether hollow-bearing trees are being perpetuated and retained at target numbers and configurations in the landscape for the key fauna species. Historical hollow data, available for marked hollow trees from previous harvesting events will also be incorporated, as well as data from and longer unharvested controls.

Hollow numbers and configurations will be compared within the simulation modelling for key species using a combination of the hollow literature review and the occupancy modelling results, such as where key species populations are being effectively maintained, to identify appropriate levels of habitat retention.

The suitability of the Coastal IFOA conditions to maintain an appropriate number of hollows within the landscape for key fauna species and ensure future recruitment, will be analysed and assessed using the simulation model. Coastal IFOA condition effectiveness will also be

assessed using sensitivity analysis in the simulation model, testing different conditional requirements and management techniques, to inform which aspects of management and/or monitoring influence hollow mortality and recruitment.

Occupancy of key habitat-dependent species

Occupancy modelling is being undertaken as part of the *Species-specific Fauna Monitoring Strategy* and *Species Occupancy Monitoring Strategy*. Modelling data will be analysed for key habitat-dependent species to monitor changes in occupancy through time and based on different management practices across LLAs. This will include analysis of both hollow-dependent species and nectivores.

Occupancy modelling will be analysed to identify if enough key habitat features are being retained, in the right configuration, to enable persistence of key habitat-dependent fauna. Covariates for the analysis, representing Coastal IFOA conditions, such as ESAs, retained wildlife clumps, numbers of hollow-bearing trees, retained feed trees, management practices (i.e. silvicultural treatment and regeneration) and environmental variation like vegetation type and annual rainfall will be collected and measured at different scales against occupancy for each of the key species. Covariate data will include data collected by FCNSW as part of their harvest planning and pre-harvest surveys, such as retained wildlife clumps and retained trees, and additional validation plot and remote sensed data from the *Forest Structure, Health and Regeneration Monitoring Strategy*.

Changes in occupancy trends and area the of occupancy or extent of occurrence within the LLAs and management within these through time will be analysed. This will be undertaken in conjunction with the other parts of this monitoring strategy, to evaluate the adequacy of conditions designed to protect habitat features in the post-harvest landscape.

1.7 Outline of methods and approach

Review of hollow use by dependent fauna

The literature review is underway to identify the use of hollow-bearing trees by key species (identified for occupancy monitoring). The review aims to synthesise the knowledge about the use of hollow-bearing trees in the harvested landscape, to identify the required number and configuration of hollow resources in the landscape to maintain fauna species.

The review will inform the hollow mortality and recruitment modelling. It will also identify potential cost-effective, robust monitoring methods to identify the use of retained resources by hollow-dependent species, where the hollow simulation model inputs or results need to be verified for key species.

The specific objectives of the review are to:

- assess the state of knowledge on hollow use in the published literature for key species including:
  - arboreal mammals (gliders)
  - forest owls
  - microbats
- review the monitoring approaches used to determine hollow-use or hollow requirements for key species in the landscape
- identify any gaps in knowledge on the use of hollow-bearing trees in a harvested landscape for the key species and if any further research is needed

- identify if any key species could be used as indicators for hollow use in the forest landscape
- recommend cost-effective approaches to monitor the use of retained hollow bearing trees in harvested areas, exclusions zones or clumps.

The review will synthesise the knowledge about the use of hollow-bearing trees in the harvested landscape. This will assist in identifying the number and configuration of hollows required in the landscape to maintain fauna species, and to inform the hollow mortality and recruitment modelling. Dr Ross Goldingay from Southern Cross University has been engaged to complete the review.

Hollow mortality and recruitment modelling

The aim of this part of the strategy is to determine mortality and recruitment of hollow-bearing trees retained in wildlife habitat clumps, tree retention clumps, dispersed through the harvested area and within the wider Local Landscape Area (LLA) using simulation modelling. Local landscape areas are made up of a mosaic of different forest age classes, stages of regeneration and post-harvest management units that provide different habitat resources for species to occupy and move through the landscape.

As defined by the Coastal IFOA, a hollow-bearing tree is a tree that is alive and has:

- visible hollows, holes or cavities that have likely formed because of decay, injury or other damage as the tree has aged; or
- clearly inferred hollows as it is an older growth stage tree (in particular in a senescent tree) with one or more obvious deformities such as a burl, large protuberance or broken limb.

The model will use data collected by FCNSW as part of their harvest planning and pre-harvest surveys including:

- retained trees
- retained wildlife clumps
- ESA 1 and ESA2 areas
- harvest footprints (intensive, selective, mixed, alternative couple)
- for each harvest footprint, year of most recent harvest
- vegetation formation mapping.

Additional data from spatial maps collected by the *Forest Structure, Health and Regeneration Monitoring Strategy* including polygons showing:

- early regeneration harvestable forest (0-10 years)
- advanced regrowth harvestable forest (11-20 years)
- early mature harvestable forest (21-30 years)
- mature harvestable forest (>30 years)
- category 1 ESA
- category 2 ESA
- retained clump
- retained tree
- vegetation formations.

The function connectivity layer, a derivative of ecological carrying capacity coding from the NSW Biodiversity Indicators program, from the *Forest Structure, Health and Regeneration Monitoring Strategy* will also be used in the modelling.

In accordance with the *Forest Structure, Health and Regeneration Monitoring Strategy*, all data will be validated using plot data collected within the rotating schedule of LLAs (see **Table 1**). This data will also be used in the simulation model.

FCNSW digitally records trees retained as HBT throughout the harvest area and some within clumps but does not record outside these areas. To address this, plot data, as shown in **Table 1**, will collect additional hollow data that can be used as part of the hollow mortality and recruitment model. In addition, historical hollow data will also be incorporated into the model as well as data from and longer unharvested controls. Historic and plot data will be extrapolated across the forest strata to indicate how many hollows are likely to occupy the different treatment areas.

Table 1: Proposed metrics for use in Coastal IFOA forest plots

Metric	What is it measuring?
Tree diameter at breast height (DBH) (cm)	▪ Age/DBH class diversity ▪ Individual and stand tree growth, volume and mortality
Stand basal area and stocking density	▪ Basal area (m^2/ha) and stocking density (stems/ha) of ages/DBH classes of regenerating trees
Vegetation stratum heights and cover	▪ Canopy heights (m) ▪ Mid-story heights (m)
Tree species regeneration and recruit type	▪ Recruitment (tree additions due to natural and harvest-related regeneration) maintenance of tree species composition
Floristic composition	▪ Count of number of native species ▪ Floristic composition of shrubs and trees ▪ Foliage cover (percent) by growth form ▪ Weed composition and cover
Growth stage (Jacobsian[1]) (Collected as part of the forest structure and health monitoring strategy)	▪ Regenerating, regrowth, mature and senescing ▪ Senescent trees as a surrogate for hollow bearing
Coarse woody debris (CWD)	▪ Total length of fallen logs >10 cm diameter and decay stage[2]
Dead stems/stags (Collected as part of the forest structure and health monitoring strategy)	▪ Density of dead stems per DBH class

[1] Jacobs, M.R., (1955). Growth Habits of the Eucalypts. Forestry and Timber Bureau, Dept. of the Interior, Canberra
[2] Decay stage represents ecologically relevant habitat

Evidence of dieback **(Collected as part of the forest structure and health monitoring strategy)**	▪ Record occurrences of canopy suppression due to drought, fire, pathogens or bell miner associated dieback

Hollow numbers and configurations will be compared within the simulation modelling for key species using a combination of the hollow literature review and the occupancy modelling results, such as where key species populations are being effectively maintained, to identify appropriate levels of habitat retention.

The suitability of the Coastal IFOA conditions to meet and ensure future recruitment to allow for target hollow requirements, will be analysed and assessed using the simulation model. It is anticipated that modelling and analysis will be completed at a regional scale across the Coastal IFOA areas.

Coastal IFOA condition effectiveness will also be assessed using sensitivity analysis in the simulation model, testing different conditional requirements and management techniques, to inform which aspects of management and/or monitoring influence hollow mortality and recruitment (i.e., adaptive management and adaptive monitoring).

Using a modelling approach, predictions can be made with incomplete datasets, with sensitivity analysis completed to identify the extent this is impacting the prediction and where monitoring can be adjusted to better capture data (or stop collecting data) as appropriate. The sensitivity analysis can also be used to test parameters that represent management and those that represent uncertainty in the data, so the results can inform adaptive management.

To ensure that monitoring for key habitat features is cost-effective and fit-for-purpose, it is proposed that this monitoring will occur, along with several other program strategies, on a rotating schedule of local landscape areas (LLAs).

In any given year, there will be a minimum of local landscape areas monitored, spread across the IFOA sub-regions in the following way:

- Three LLAs in the Upper North East
- Three LLAs in the Lower North East
- Two LLAs in Eden
- Two LLAs in Southern

The local landscape areas will be rotated on a five-year cycle so that the monitoring will return to each validation area every five years.

As part of the rotating LLA monitoring, high density LiDAR and ground plot data will be collected for use in State-wide plot network, and monitoring approaches deployed from the following Coastal IFOA monitoring strategies:

- Forest structure, health and regeneration
- Key habitat features
- Species occupancy
- Waterway and wetland health

The number of LLAs, as well as the intensity in field monitoring conducted will be determined during the experimental design of the whole monitoring program following the

steering committee endorsement of the Coastal IFOA monitoring plans. Model simulation will be updated each year, for each of the regions. Each LLA will be updated with plot data collected with each round of monitoring within the rotating panel (e.g., every 5 years).

A pilot program for the plot surveys as part of the for the forest extent, condition and health baselines, drivers and trends project, will be undertaken over spring/summer 2020-2021. It is anticipated that a pilot of the simulation model will be completed using data obtained from the fieldwork campaign and pilot program. This will include developing the method and testing to determine the effectiveness of the approach, input into the experimental design of the monitoring, and identify any likely costs.

Occupancy of key habitat-dependent species in harvested local landscapes

To identify if enough key habitat features, including hollows, nectar, fruit and feed trees, are being retained across the landscape and in the right spatial configuration to enable persistence of habitat-dependent species, occupancy modelling will be analysed for key-habitat dependent species. This will include analysis of both hollow-dependent species and nectivores.

Occupancy modelling is being undertaken as part of the *Species-specific Fauna Monitoring Strategy* and *Species Occupancy Monitoring Strategy*.

The *Species Occupancy Monitoring Strategy* will collect information on forest-dependent fauna species using remote devices. **Table 2** below includes an initial list of the fauna species that have specific habitat requirement and for which occupancy data will be collected. This is a working list and will be refined over the course of the monitoring pilot.

Table 2: Working list of species for occupancy monitoring

Species	Habitat feature dependence
Barking owl	Hollows
Masked owl	Hollows
Powerful owl	Hollows
Sooty owl	Hollows
Boobook owl	Hollows
Glossy black cockatoo	Hollows and *Allocasuarina* for foraging
Brown treecreeper	Hollows
Noisy friarbird	Nectar
Eastern false pipistrelle	Hollows
Eastern freetail bat	Hollows
Greater broad-nosed bat	Hollows

Southern myotis	Hollows
Yellow-bellied sheath-tailed bat	Hollows
Grey-headed Flying Fox	Nectar/pollen/fruit
Koala	Eucalypts
Squirrel glider	Hollows
Yellow-bellied glider	Hollows
Sugar glider	Hollows
Greater glider	Hollows

The landscape will be stratified according to the *Forest Structure, Health and Regeneration Monitoring Strategy*, with spatial and plot data collected under that strategy used as covariates. Occupancy modelling will be completed regionally, incorporating data collected from the rotating panel of LLAs.

Covariates for the analysis, representing Coastal IFOA conditions (e.g. retained clumps, retained hollow-bearing trees, retained feed trees), management practices such as silvicultural treatment and regeneration and environmental variation like vegetation type and annual rainfall, will be collected and measured at different scales against occupancy for each of the key species. Covariate data will include data collected by FCNSW as part of their harvest planning and pre-harvest surveys such as, ESAs, retained wildlife clumps and retained trees with additional forest plot data collected through the *Forest Structure, Health and Regeneration Monitoring Strategy*, as detailed above for *Hollow Mortality and Recruitment Modelling* .

Occupancy modelling will be analysed to identify if enough key habitat features are being retained, in the right configuration, to enable persistence of key habitat-dependent fauna. An analysis of changes in occupancy trends and area the of occupancy or extent of occurrence within the LLAs through time will be used, in conjunction with the other parts of this monitoring strategy, to evaluate the adequacy of conditions designed to protect habitat features in the post-harvest landscape. This will be undertaken as part of the occupancy analysis which will be undertaken at 3- or 5-year intervals.

1.8 Summary of approach to develop baselines and benchmarks for adaptive management

Condition effectiveness baseline:

Baselines for metrics related to species occupancy and distribution are being developed as part of the State-wide/Coastal IFOA baselines, drivers and trends in species occupancy and distribution project. It is anticipated that the first 3-years of data collected be used to establish baselines for the implementation of the Coastal IFOA.

Benchmarks:

A key objective for this monitoring strategy would be to set benchmarks for the number and configuration of retained features across a harvested landscape.

The hollow mortality and recruitment simulation modelling will aim to identify and establish benchmarks to identify if hollow mortality and recruitment are equal over time. The modelling will also incorporate the findings of the literature review to identify the number and configuration of key habitat resources within LLAs based on the Coastal IFOA conditions and investigate the effect of this on species occupancy.

A benchmark would have to be set at a level that is appropriate for multiple-use native forests which are managed for both timber production and environmental values. To be consistent with ESFM ecological benchmarks developed for this monitoring, benchmarks need to relate to existing benchmarks and those emerging from the FMIP, as well as to the relevant key habitat features baselines established for coastal state forests.

The results of all Coastal IFOA monitoring strategies will be combined and analysed by a technical specialist team appointed by the FMIP Steering Committee to determine the adequacy of the monitoring, identify trends in the data and recommend benchmarks for adaptive management triggers.

Benchmarks will be established on completion of LLA assessments that comprise different area proportions and different spatial/temporal arrangements of silvicultural zones and informed by field assessments. It is likely that the program will require several years of data to establish benchmarks for management action triggers.

As part of the Coastal IFOA program, predictive occupancy maps will periodically assess the trajectory of focal species (changes in area of occupancy or extent of occurrence) within coastal state forests, modelling different scenarios including forest management practices and climate change. The exact modelling work will be identified as part of the species occupancy and distribution project currently underway.

Occupancy will be estimated, and trends plotted annually, as part of the monitoring programs annual review with the benchmarks set in the first program evaluation in 2024. Spatial modelling of occupancy will be completed annually, and trends will be analysed at 3- or 5-year intervals. Declines over a threshold (to be determined based on baselines) will be investigated in detail. Some short-term declines and fluctuations are to be expected with drought or fire, but any identified sustained declines will trigger a targeted program to investigate and, if appropriate, a change in management.

Adaptive management

As part of the decision-making framework being developed under the program's adaptive management strategy, the process to establish performance benchmarks, analyse the monitoring results and the adaptive management activities that are triggered to adapt the Coastal IFOA to better meet its desired outcomes for species occupancy will be described.

1.9 Existing programs and data that will inform the strategy

- DPI Forest Science Passive Acoustic Monitoring Program (Koala)
- FCNSW historic monitoring and reporting under existing SMPs
- FCNSW pre-harvest survey information on hollow-bearing trees

1.10 How the data will be stored, analysed and presented

Data will be collected and initially stored on FCNSW systems to the standards set out in the Forest Monitoring and Improvement Program data management system, including analysis and presentation, then made available for integration with the state-wide forest monitoring program analysis platform. The Coastal IFOA requires all data and information is made publicly available on SEED or similar.

1.11 Expected strategy outcomes

Evidence that retained habitat features are providing adequate resources for key habitat-dependent fauna and the Coastal IFOA conditions of approval adequately protect key habitat features (hollow bearing trees) to maintain ongoing occupancy of key habitat-dependent fauna species in the landscape.

1.12 Linkages and uses with the overall NSW Forest Monitoring and Improvement Program Framework

The state-wide and Coastal IFOA landscape-scale environmental values work will collect data on occupancy trends. The State-wide/Coastal IFOA baseline species occupancy and distribution project, which is currently underway, will identify the indicators and metrics to monitor trends in species occupancy across time across tenures.

The state-wide program has evaluation questions that guide the program, including:

- What is the occupancy and distribution of forest-dependent fauna and flora species, and what are the predicted trajectories?

A number of forest dependent species, as prioritised for the Forest Monitoring and Improvement Program with consideration of the Coastal IFOA monitoring, will be sampled by the proposed monitoring methods. Priority species are still being determined in collaboration with the FMIP technical working group.

The FMIP will also investigate the condition and extent of forest areas using remote sensing, including a detailed, permanent plot network where information on hollow-bearing trees and resources for nectivores will be collected through time.

Part 2: Timeline

Milestone description	Start date	End date
1. Review of use of retained resources by hollow-dependent species in harvested local landscapes	**June 2020**	**December 2020**
2. Experimental design of the strategy	**September 2020**	**February 2021**
3. Pilot program completed as part of the plot network pilot to finalise methods	**Spring 2020**	**June 2021**
4. Pilot of the hollow simulation modelling	**January 2021**	**March 2021**
5. First year local landscape areas	**Spring 2021**	**Summer 2021**
6. Data analysis	**December 2021**	**June 2022**
7. Reporting	**2022**	**ongoing**