Natural Resources Commission

NSW Coastal Integrated Forestry Operations Approval Monitoring Program

Annual Progress Report
October 2024

This document has been prepared by the NSW Natural Resources Commission on behalf of the **NSW Forest Monitoring Steering Committee**.

Enquiries

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Acknowledgement of Country

The Natural Resources Commission acknowledges and pays respect to traditional owners and Aboriginal peoples. The Commission recognises and acknowledges that traditional owners have a deep cultural, social, environmental, spiritual and economic connection to their lands and waters. We value and respect their knowledge in natural resource management and the contributions of many generations, including Elders, to this understanding and connection.

Acronyms

AI	Artificial Intelligence
ALS	Airborne Laser Scanning
ANU	Australian National University
DBH	Diameter at breast height
DCCEEW	Department of Climate Change, Energy, the Environment and Water
DPI	Department of Primary Industries
EPA	Environment Protection Authority
ESA	Environmentally Significant Areas
FCNSW	Forestry Corporation of NSW
FRAMES	Forest Resource and Management Evaluation System
IFOA	Integrated Forestry Operations Approval
LiDAR	Light Detection and Ranging (remote sensing method)
NPWS	National Parks and Wildlife Service
NSW	New South Wales
NSFI	Native Forest Strategic Inventory
PGP	Permanent growth plots

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Executive summary

The Coastal Integrated Forestry Operations Approval (Coastal IFOA) Monitoring Program has been underway since March 2020, generating data and information to support evidence-based decision making for forest management in NSW coastal state forests.

In 2023-24, the program:

- secured long-term funding of $1 million per year over 20 years from the NSW Government to fund new science and research.

- recently committed over $750,000 on 17 new research projects with leading scientists from institutions such as Western Sydney University and University of Newcastle

- published 8 new reports, research notes and datasets

- hosted webinars with scientists and expert panels to discuss results and findings with community.

Key new research delivered and commenced:

- modelling and data analysis to inform hollow bearing tree conditions, and the impact of fire on hollow tree retention

- post-fire forest recovery using plot and remote sensed data

- performance evaluation of Coastal IFOA modelling and surveys

- recent and historical forest regeneration analysis using LiDAR data

- data analysis and monitoring plans for greater gliders and koalas

- eDNA surveys for frog species.

Existing program monitoring continues to collect long-term data. For example, the fauna monitoring program has now completed over 624,000 survey hours resulting in 48,000 photos, 6,700,000 ultrasonic sound files and 74,800 sound files over the first two survey seasons (spring 2022 and autumn 2023). In comparison, ecologists estimate it takes a single person surveying over 40 years to collect the same quantum of data with traditional field methods. Computer-based Artificial Intelligence (AI) methods are now in use to generate insights on the relationship between fauna occupancy and environmental and management variables including harvesting.

The Commission will now focus on delivering the first five-yearly formal review of the Coastal IFOA Monitoring Program and its findings, drawing on recent commissioned science. The outcomes of this review process will inform the upcoming formal five-yearly review of the Coastal IFOA in 2025.

1   Introduction

The [Coastal Integrated Forestry Operations Approval](#) (Coastal IFOA) sets out the rules for native timber harvesting in New South Wales (NSW) coastal state forests and establishes environmental outcomes that must be achieved under the approval. The Coastal IFOA requires that the approval conditions are monitored to ensure they are effective in achieving the required objectives and outcome statements.[1]

The Environment Protection Authority (EPA) and Department of Primary Industries (DPI) have jointly approved the [Coastal IFOA Monitoring Program](#) proposed by the NSW Forest Monitoring Steering Committee (see **Table 1**). The program sets out the broad framework to evaluate the effectiveness of priority conditions in meeting the Coastal IFOA objectives and outcomes. It centres on strategies to monitor and research forest health, biodiversity, water quality and aquatic habitat, and wood supply.

This is the **fourth** annual progress report on the Coastal IFOA Monitoring Program.

1.1   Cross-agency collaboration and independent oversight

The design and implementation of the Coastal IFOA Monitoring Program is overseen by the NSW Forest Monitoring Steering Committee (the Steering Committee), which is independently chaired by the Natural Resources Commission (the Commission).

The Coastal IFOA requires that the Steering Committee include independent experts and agency representatives (**Table 1).**

Table 1: NSW Forest Monitoring Steering Committee

NSW Government agencies	Independent experts
▪ Natural Resources Commission (Chair)	▪ Professor Patrick Baker
▪ Forestry Corporation of NSW (FCNSW)	▪ Professor Phillip Gibbons
▪ Environment Protection Authority (EPA)	▪ Associate Professor Tina Bell
▪ Department of Climate Change, Energy, the Environment and Water (DCCEEW)	▪ Dr Peter Hairsine
▪ Department of Primary Industries (DPI)	
▪ The Office of Aboriginal Affairs	
▪ National Parks and Wildlife Service (NPWS)	
▪ Local Land Services	

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[1] .... [Coastal IFOA Conditions](#) (Chapter 8) and [Coastal IFOA Protocols](#) (Protocol 38).

1.2   Science based program

The program continues to deliver new science with researcher partners from leading universities, for example:

- Western Sydney University
- University of Newcastle
- Australian National University
- University of Melbourne
- University of Tasmania
- Central Queensland University

The program also partners with recognised researchers and experts from the private sector, for example:

- FlintPro
- Indufor
- Technical Forest Services
- Alluvium
- Jacobs
- EnviroDNA
- Biodiversity Australia

Leading scientists from the NSW DPI Forest Science Unit and DCCEEW Science & Insights Division, Biodiversity, Conservation & Science Group are also engaged to deliver research.

Program funded researchers have published articles in six peer-reviewed science journals to date on forestry and forest management matters including koalas and post-fire recovery.[2]

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[2] Law, B.S et.al. (2024) Broad-scale acoustic monitoring of koala populations suggests metapopulation stability, but varying bellow rate, in the face of major disturbances and climate extremes. *Ecology and Evolution,* 14e11351; Gibson R.K., Hislop, S. (2022) Signs of resilience in resprouting *Eucalyptus* forests, but areas of concern: 1 year of post-fire recovery from Australia's Black Summer of 2019–2020. *International Journal of Wildland Fire* **31**, 545-557.

2   Progress and achievements in 2023-24

Table 2 outlines the status of the program delivery since its inception in 2019. The remainder of this section details the projects completed or commenced in 2023-24.

Table 2: Progress dashboard

PROGRESS DASHBOARD		
Research and evaluation projects		
1 Implications of changing fire intensity and regimes	Completed (2021-22)	✓
2 Koala response to selective harvesting[3]	Completed (2019-22)[a] Commenced (2023-25)[b]	✓ »»
3 Koala and habitat response after the 2019-20 wildfires in north east NSW[4]	Completed	✓
4 Coastal IFOA koala browse tree review	Commenced Draft report under review	»»
5 Hollow-bearing tree mortality and recruitment modelling	Completed	✓
6 Impact of fire on hollow bearing trees	Commenced	»»
7 Novel techniques to detect and monitor Hastings River Mouse	Completed (2022-23)	✓
8 Drones to detect cryptic species	Completed	✓
9 eDNA to detect and monitor three *Mixophyes* (frog) species	Commenced Draft report under review	»»
10 Strengthening the evidence base to assess damaged trees	Completed	✓
11 Post-fire erosion mapping in southern NSW	Completed	✓
12 Reviewing the use of temporary log crossings in NSW coastal state forests	Completed	✓
13 Evaluating forest road network to protect forest waterways	Completed	✓
14 Monitoring class 1 drainage lines and exclusion zones	Commenced - Draft report under review	»»
15 Evaluation of species and habitat surveys	Completed	✓
16 Compliance evaluation	Commenced Stage 1 report under review	»»
17 Post fire recovery	Commenced – Draft report under review	»»
18 Risks from forest dieback	Commenced	»»

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[3] .... Part of the Commission's Koala Research Program, funded under the NSW Koala Strategy ((a) funded under the 2018-21 strategy and (b) funded under the 2021-26 strategy)

[4] .... Funded under the NSW Forest Monitoring and Improvement Program

PROGRESS DASHBOARD

19	Retrospective greater glider data analysis	Commenced	»
20	Philoria spp review	Commenced Draft report under review	»
21	Bird species review	Commenced	»

Fauna monitoring and analysis

22	Landscape baselines and trends for biodiversity	Completed (2021-22)	✓
23	Biodiversity – species occupancy monitoring	Completed (data capture) Analysis commenced	✓ »
24	Greater glider monitoring plan	Commenced Draft plan under review	»
25	Koala monitoring plan	Commenced Draft plan under review	»
26	Piloting eDNA for surveying 3 species of frog (*Mixophes sp.*)	Commenced Draft plan under review	»
27	Species management plan reviews[5]	4 Completed (2020-22) 4 Commenced	✓ »

Forest monitoring and analysis

28	LiDAR data capture and analysis	Completed (data capture) Analysis commenced Draft plan under review	✓ »
29	Carbon balance of NSW forests	Completed	✓
30	Retrospective flora species composition change	Commenced Draft report under review	»
31	Review of forest structure, health and regeneration method	Commenced Draft plan under review	»
32	Data integration and modelling	Commenced Draft plan under review	»
33	Landscape baselines and trends for forest extent and health	Completed (2021-22)	✓
34	Wood supply baselines and trends – Stage 1	Completed (2021-22)	✓
	Wood supply baselines and trends – Stage 2	Commenced	»

Reporting and adaptive management

35	Community forums and webinars	Completed (2019-23) Planning for annual webinar series ongoing	✓ »

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[5] .... 1 review completed in 2020-21 (yellow-bellied glider), 3 reviews completed in 2021-22 (Southern Brown Bandicoot, Milky Silkpod and Rusty Plum), 1 review underway (Giant burrowing frog).

PROGRESS DASHBOARD		
36 Annual health check	Completed	✓
37 Annual report	Completed (2019-23)	✓
38 Five yearly program review	Commenced	»

2.1   Research and evaluation projects

2.1.1   Tree hollow mortality and recruitment modelling

Researchers at the Australian National University (ANU), led by Professor Phil Gibbons have delivered research and recommendations to improve hollow simulation modelling on state forests.[6] This model predicts the number of trees with hollows perpetuated under the current Coastal IFOA conditions.

Working with modellers at FCNSW, the researchers used the Forest Resource and Management Evaluation System (FRAMES) to model the persistence and recruitment of hollow-bearing trees under a range of scenarios. A methods paper outlines the suitability of FRAMES to model persistence of hollows.

Overall, the researchers found:

- based on data from the Pacific Highway upgrade in northern NSW and published literature, less than 50 percent of hollow bearing trees are typically occupied by vertebrate hollow-dependent fauna; thus, using tree diameter at breast height (DBH) and tree species alone to predict how many hollow-bearing trees occur will over-estimate the number of hollow-bearing trees suitable for vertebrate species (**Figure 1**).

- the number of hollow-bearing trees and number of trees with hollows suitable for occupancy by vertebrate fauna were able to be predicted using a combination of FRAMES outputs, underpinned by long-term field inventory data, and hollow occupancy models

- simulations for the Coffs Harbour Timber Zone pilot study showed the Coastal IFOA conditions perpetuate 8-10 trees per hectare with visible hollows and 2-3 trees per hectare with hollows suitable for occupancy by vertebrate fauna in the net-harvest area over a 200-year modelling period; however, key model assumptions need further testing before expanding the model and drawing robust conclusions about the relevant CIFOA conditions

- in areas permanently excluded from harvesting (approximately 51 percent of the study area), trees with visible hollows were predicted to increase from a mean of 8 per hectare to 26 per hectare and trees with hollows suitable for occupancy by vertebrate fauna were predicted to increase from a mean of 3 per hectare to 10 per hectare.

The small number of field observations of occupied hollows across the Coastal IFOA region limits extrapolation of these findings to other regions. In addition, models used to predict which trees with visible hollows are suitable for occupancy by hollow dependent fauna had

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[6]   Gibbons, P. and Connolly O'Donnell, L. (2023) *Predicting how many trees contain hollows suitable for vertebrate fauna in forests in NSW*. A report to the Natural Resources Commission. Gibbons, P.(2024) *Perpetuating trees with hollows under the Coastal Integrated Forestry Operations Approval (IFOA). Report on a pilot study for the Coffs Harbour Timber Zone*. A report to the Natural Resources Commission

wide confidence limits, thus the predictions come with a reasonable amount of uncertainty. The analysis was also limited to a small set of variables recorded in FRAMES simulation outputs, namely DBH and tree species.

With further field data collection, including additional field variables and minor model changes, FRAMES can be used to simulate outcomes of the current Coastal IFOA and any proposed changes to the rule set on the tree hollow resource. In addition, FRAMES can be further improved over time to better simulate impacts, including the impacts of fire on hollow-bearing trees as mentioned in Section 2.1.2.
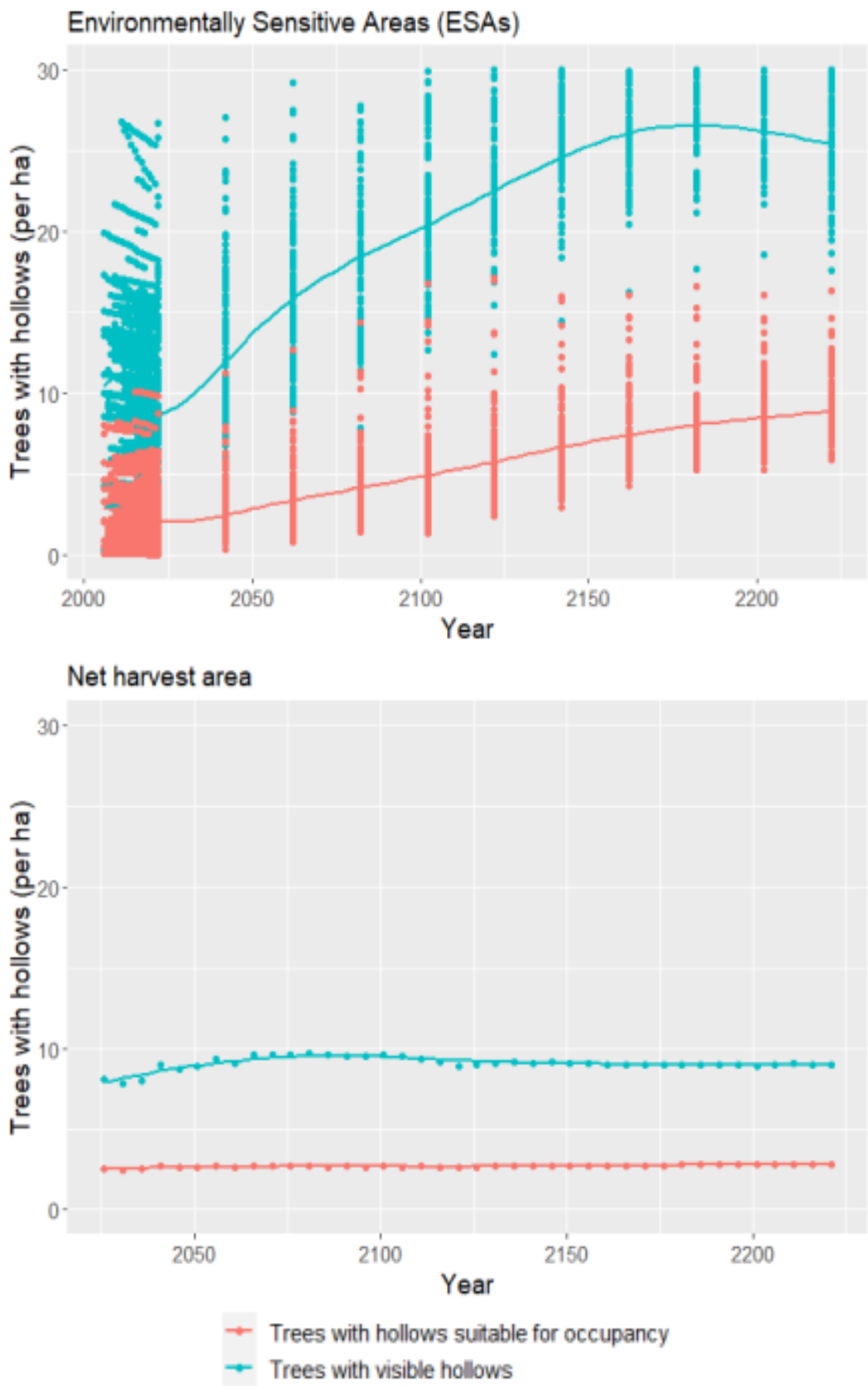
Figure 1: Projected tree counts with visible hollows (blue) and hollows under scenarios of no more harvesting (Environmentally Significant Areas (ESAs)) and ongoing harvesting (net harvest area) in the Coffs Harbour Timber Zone[7]

2.1.2   Fire impacts on hollow bearing trees

Based on recommendations from the work above, the Program engaged Dr Raphael Trouvé, a research fellow at the University of Melbourne, to investigate the effects of fire events on hollow-bearing trees and tree hollow formation within the Coastal IFOA region.

Overall, this research aims to quantify the rate of mortality, collapse and formation of hollow-bearing trees on state forests following fires of different intensities in the Coastal IFOA region. The work will deliver a model that can be used within FCNSW's FRAMES modelling system to predict the effects of a fire event based on other available covariates such as diameter at breast height and tree species group.

2.1.3   Species and habitat surveys evaluation

In 2018, the Coastal IFOA adopted a multi-scale landscape approach to minimise forestry impacts on endangered species, including conditions informed by modelling and mandatory pre-harvest surveys for identified species and habitats. The program engaged Dr Sarah Munks, University of Tasmania and Dr Phil Bell, Biodiversity Maintenance Australia to assess the Coastal IFOA surveys and models for their effectiveness in protecting threatened species and habitats.

Overall, the researchers found the Coastal IFOA surveys and models effectively detected focal species and habitats, with sound planning and field procedures with support for projects already initiated such as the review of the koala browse tree list and the continual monitoring and adapting monitoring that is conducted across the whole Coastal IFOA.[8] However, survey methods for some species like the Pugh's sphagnum frog (*Philoria pughi*) and Albert's lyrebird (*Menura alberti*) require refinement. The researchers recommended several ongoing methodological improvements, noting historical data gaps affecting conservation outcomes under the Coastal IFOA.

The review identified over 70 recommendations to improve models, methods, training and for further research and monitoring. This will address these gaps, enhancing conservation for species such as koalas and large forest owls. Specific monitoring plans are established for species such as the greater glider, koala, and southern brown bandicoot, aimed at enhancing conservation outcomes, with some reviews recommended to determine if additional species monitoring plans are warranted for other species.

2.1.4   Frog and bird survey reviews

Based on advice from Dr Munks and Dr Bell above, the program engaged Emeritus Professor Dr. Michael Mahony, University of Newcastle to conduct an independent review on existing habitat models and current Coastal IFOA survey methods (and opportunities to improve) for five *Philoria* frog species:

- red and yellow mountain frog (*P. kundagangan*)

- masked mountain frog (*P. loveridgei*)

- Pugh's sphagnum frog (*P. pughi*)

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[7] .... Gibbons, P.(2024) *Perpetuating trees with hollows under the Coastal Integrated Forestry Operations Approval (IFOA). Report on a pilot study for the Coffs Harbour Timber Zone.* A report to the Natural Resources Commission.

[8] .... Munks, S, and Bell, P (2024) CIFOA Monitoring Program - *Evaluation of species and habitat survey and modelling Final Report. Synthesis of evaluation outputs.* A report to the Natural Resources Commission.

- Richmond range sphagnum frog (*P. richmondensis*)

- sphagnum frog (*P. sphagnicolus*)

In addition to these species, the program also commissioned Adj. Professor Richard Loyn, La Trobe University to review survey methods for the marbled frogmouth (*Podargus ocellatus*), Albert's lyrebird (*Menura alberti*) and the rufous scrub-bird (*Atrichornis rufescens*).

2.1.5   Post-fire forest recovery in the Coastal IFOA region

Researchers at the Hawkesbury Institute for the Environment, Western Sydney University, led by Professor Brendan Choat, investigated the response, mechanics and rates of forest recovery since the 2019-20 wildfires and the preceding drought in the Coastal IFOA region.

Data from extensive field surveys conducted by Western Sydney University and Forestry Corporation of NSW since the 2019-20 fire season were analysed to explore relationships between fire severity, drought and major soil groups.

The draft paper is under technical review. Preliminary findings found high levels of tree mortality and canopy topkill were generally restricted to areas burnt at high and extreme severity, with forests growing on higher fertility granite-derived soils generally experiencing higher mortality than forests on lower fertility sandstone soils. High and extreme severity fires disproportionately affected the smallest and largest trees.[9]

2.1.6   Strengthening the evidence base to assess damaged trees

At the 2022 Coastal IFOA annual health check, FCNSW and EPA agreed to develop an evidence base to objectively assess the impact of injuries to retained trees during forestry operations. Currently there is no agreed understanding of the type and level of injuries that retained trees can sustain above which they are unable to provide the ecological function for which they were retained.

The program engaged researchers from the Hawkesbury Institute for the Environment, Western Sydney University to review the scientific literature covering current knowledge of how trees respond to physical injuries to the stem and crown. The review also investigated recovery times and/or the impacts on tree longevity following damage.

The types of retained trees included in the assessment are prescribed in the Coastal IFOA, such as hollow-bearing trees, nectar trees, giant trees, dead standing trees, Glossy Black cockatoo feed trees, Glider sap feed trees and Koala browse trees.

Based on scientific literature, the researchers found trees impacted by mechanical injuries during forestry operations respond in similar ways to those trees impacted by fire, drought and storms. Trees either resprout from epicormic buds beneath the bark or from underground lignotubers depending on the species. Only a small number of eucalypt species cannot resprout following severe injury and rely on seedling regeneration to recover.

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[9] .... Bendall E, Choat B, Gibson R, Nolan R (2024) *Review of forest recovery in the Coastal IFOA region of New South Wales following the 2019/2020 wildfires and preceding drought*, Hawkesbury Institute for the Environment, Western Sydney University. A draft report to the Natural Resources Commission.

Based on this literature review and evidence from field observations, the researchers have assessed the risk to the ongoing function of retained trees due to different types and levels of injury. The researchers have set out an approach, including further field data to set objective injury thresholds for different types of injuries for retained trees as codified under the Coastal IFOA.[10]

2.1.7   Retrospective greater glider data analysis

The program has engaged Associate Professor Criag Nitschke, University of Melbourne to conduct an analysis of historical data of the greater glider gathered by FCNSW.

Data has been collected from state forests since 1994. With these datasets occupancy trends over time and their correlation with environmental factors and management practices can be determined. The findings will inform the effectiveness of existing survey methods and help assess Coastal IFOA conditions for the greater glider (**Section 2.2.3**).

2.1.8   Koala browse tree review

The program commissioned researchers from the Western Sydney University and Australian National University to review the current list of the koala browse tree species for the Northeast region of the Coastal IFOA managed forests.

The Coastal IFOA identifies primary and secondary koala browse trees in state forests to facilitate ecologically sustainable forest management by imposing harvesting conditions that protect species and their habitats in coastal forest ecosystems. This includes the identification of koala browse tree species that must be retained during forest harvesting. According to the guidelines, primary browse trees must comprise at least 50 percent of the retained browse trees where feasible, with the remaining 50 percent selected from the secondary browse list.

A draft report is now under technical review. Findings from this review will guide future management decisions regarding tree retention in harvesting areas.

2.1.9   Other research and evaluation projects

The Coastal IFOA Monitoring Program has commenced several other research and evaluation projects that respond to existing and emerging issues, details of which are provided in **Table 3**: Ongoing research and evaluation projects.

Table 3: Ongoing research and evaluation projects

Project	Overview	Status
Koala response to harvesting	The Commission's Koala Research Program has been extended under the NSW Koala Strategy to further investigate the koala response to harvesting. The program has engaged researchers from Western Sydney University, University of Melbourne and the Department of Primary Industries (DPI) – Forest Science Unit to investigate habitat and population responses. Dr Andrew Hoskins, and an expert panel are providing expert oversight.	▪ Research underway

Project	Overview	Status
Compliance evaluation	Dr Peter Volker, Technical Forest Services is assessing whether non-compliances are compromising the outcomes or ability to monitor the effectiveness of the Coastal IFOA conditions. The project has completed an agreed assessment framework, and commenced stage 2 of the project.	▪ Stage 2 underway
Wood supply	Indufor are assessing how the Coastal IFOA influences wood supply in coastal native hardwood state forests. Indufor are developing an evaluation framework and methods for this assessment.	▪ Stage 2 underway
Class 1 streams	The program has engaged experts from Jacobs to assess whether the exclusion zone conditions for Class 1 drainage lines as codified under the Coastal IFOA are effective in minimising the impact of harvesting activities on waterway condition	▪ Draft final report under review

2.2   Fauna monitoring and analysis

The Coastal IFOA requires a monitoring program to establish scientifically valid environmental and wood supply baselines to evaluate the effectiveness or impacts of the approval on environmental values and wood supply[11]. In addition, the program must monitor trends in forest regeneration, biodiversity and water quality at the landscape scale.

2.2.1   Monitoring fauna species occupancy

Snapshot – fauna monitoring

- First four seasons of surveys in spring 2022, autumn 2023, spring 2023 and autumn 2024 is now complete.

- Covariate analysis and occupancy modelling is now underway.

- Data have been scanned and validated from spring 2022 and autumn 2023 surveys for koalas, powerful owls, sooty owls, masked owls, and sugar (Krefft's) gliders.

- The program has completed over 624,000 survey hours resulting in 48,000 photos (**Figure 2** and **Figure 3**), 6,700,000 ultrasonic sound files, and 74,800 sound files. Analysing this data manually would require over 40 years for a single person to complete, highlighting the significance of automated species identification programs.

Long-term biannual surveys continue across 300 sites (and 600 subplots) in state forests across coastal NSW (**Figure 4**). Spring and autumn surveys allow for seasonal variation in species detectability.

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[11] .... This work is complete and can be accessed here

Figure 2: Long-nosed bandicoot (_Perameles nasuta_) and joey captured on remote cameras in the Southern Region

Figure 3: Superb lyrebird (_Menura novaehollandiae_) captured on remote cameras in the Northern Region
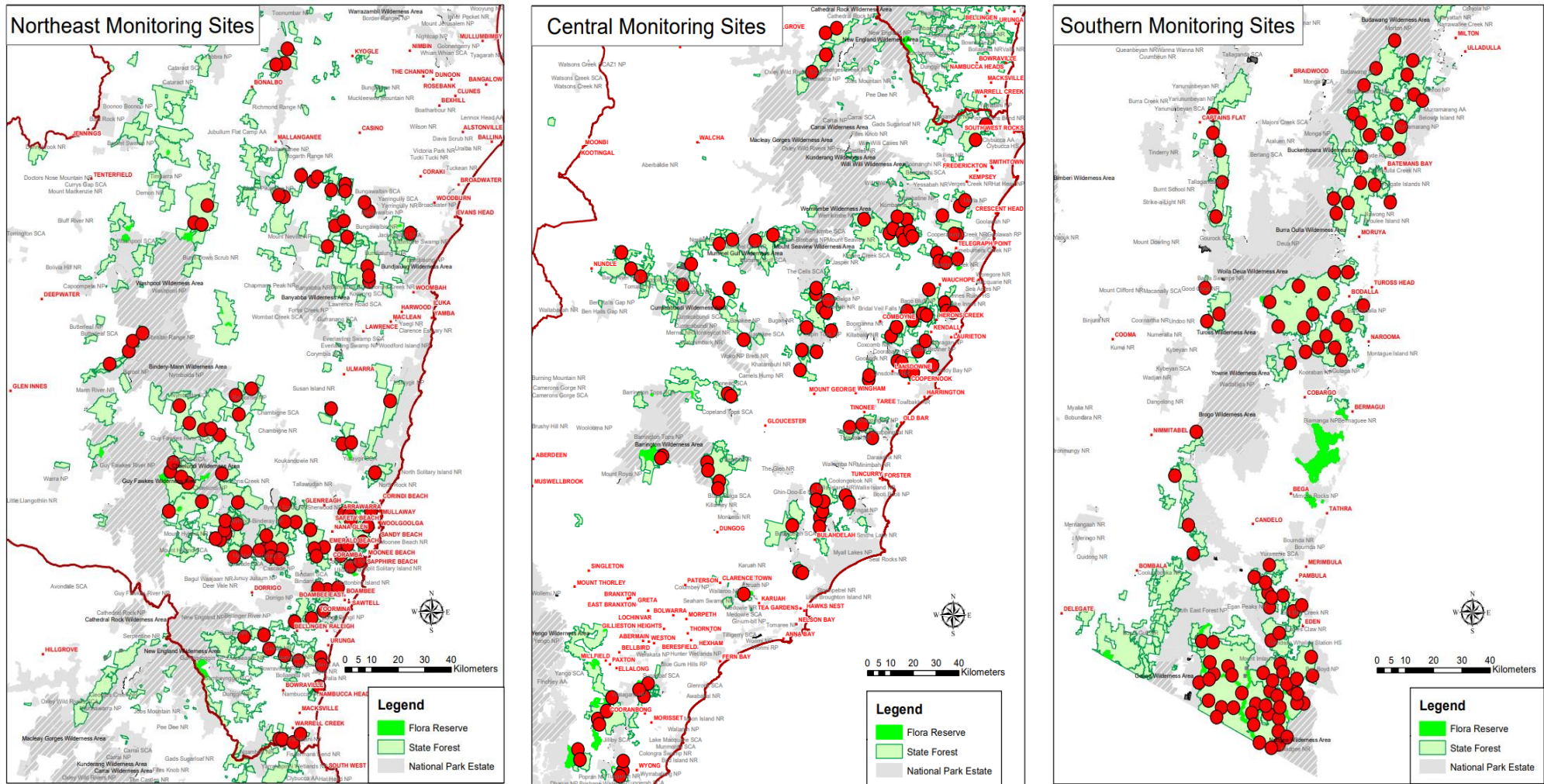
Figure 4: Locations of fauna monitoring sites (including both annual and 5-yearly monitoring sites)

DPI is now analysing data collected by FCNSW to model trends in species occupancy and distribution. To evaluate the effectiveness of Coastal IFOA protections and conditions in maintaining species occupancy, DPI will also analyse environmental co-variate data to explain trends and causes of change in species occupancy.

The monitoring targets species such as koalas and other arboreal mammals, hollow-dependent bats, nectivores, ground-dwelling mammals, and large forest owls. Data is collected using remote sensing technologies, including cameras, sound recorders for species emitting audible calls, and ultrasonic sound recorders for echo-locating bats. Recent research suggests remote senses acoustic sensors are the most cost-effective means to monitoring fauna for species such as the koala.[12]

To support the analysis of acoustic data, call recognisers have been developed for 13 target species, including the glossy-black cockatoo and selected priority nocturnal species, including owls, gliders, and the grey-headed flying fox. This collaborative effort involved the FCNSW, NSW Department of Primary Industries, Queensland University of Technology, and Victoria University of Wellington.

In addition to providing critical insights into focal native species, this monitoring captures the presence of pest animals in these areas. For example, camera traps have captured feral cats, deer and foxes. This information is critical for management and ensuring the persistence of local native species.

2.2.2   Species Management Plans

The program oversees annual reviews of species management plans made under the Coastal IFOA. The Commission, as independent chair of the Forest Monitoring Steering Committee, is required to advise the NSW EPA on opportunities to improve the plans.

In this reporting period, researchers at DPI Forest Science Unit have been tasked with analysing long-term occupancy monitoring data for the yellow-bellied glider and the southern brown bandicoot. This analysis will guide updates to their species management plans.

Draft reports are under technical review. Preliminary findings suggest that southern brown bandicoot occupancy was lowest from 2016 to 2019-20 at the peak of the major drought and immediately after the Black Summer fires. Yellow-bellied glider occupancy was generally low with a decline observed immediately post-fire in in 2020-21.

However, there has been a notable upward trend for both the southern brown bandicoot and the yellow-bellied glider since the southeast region experienced increased rainfall post 2020-21. This dataset will shortly be supplemented with this year's data, further informing the next review of the species management plans for the yellow-bellied glider and the southern brown bandicoot.

Investigations are underway for alternative survey methods for the giant burrowing frog (*Heleioporus australiacus*), which to date have relied on tadpole surveys. Environmental DNA (eDNA) is a new but recognised scientific method used to detect aquatic fauna,

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[12]   Beranek, C. T., Southwell, D., Jessop, T. S., Hope, B., Gama, V. F., Gallahar, N., Webb, E., Law, B., McIlwee, A., Wood, J., Roff, A., & Gillespie, G. (2024). Comparing the cost-effectiveness of drones, camera trapping and passive acoustic recorders in detecting changes in koala occupancy. *Ecology and Evolution, 14*, e11659. https://doi.org/10.1002/ece3.11659

including amphibians. The term 'environmental DNA' refers to DNA extracted from environmental samples such as water and soil.

The program has engaged EnviroDNA to conduct a pilot project to trial the use of eDNA sampling as a detection method. Emerging results suggest eDNA could be a viable alternative to the current survey method for the giant burrowing frog, especially for areas with difficult access.[13] Surveys also tested how many samples are needed to detect the species and found three surveys would be enough to detect the species (**Figure 5**). Next steps include further testing to assess the sensitivity and cost-effectiveness of eDNA.

(A) Number of water samples vs probability of eDNA capture

(B) Number of qPCR assays per water sample vs probability of eDNA detection
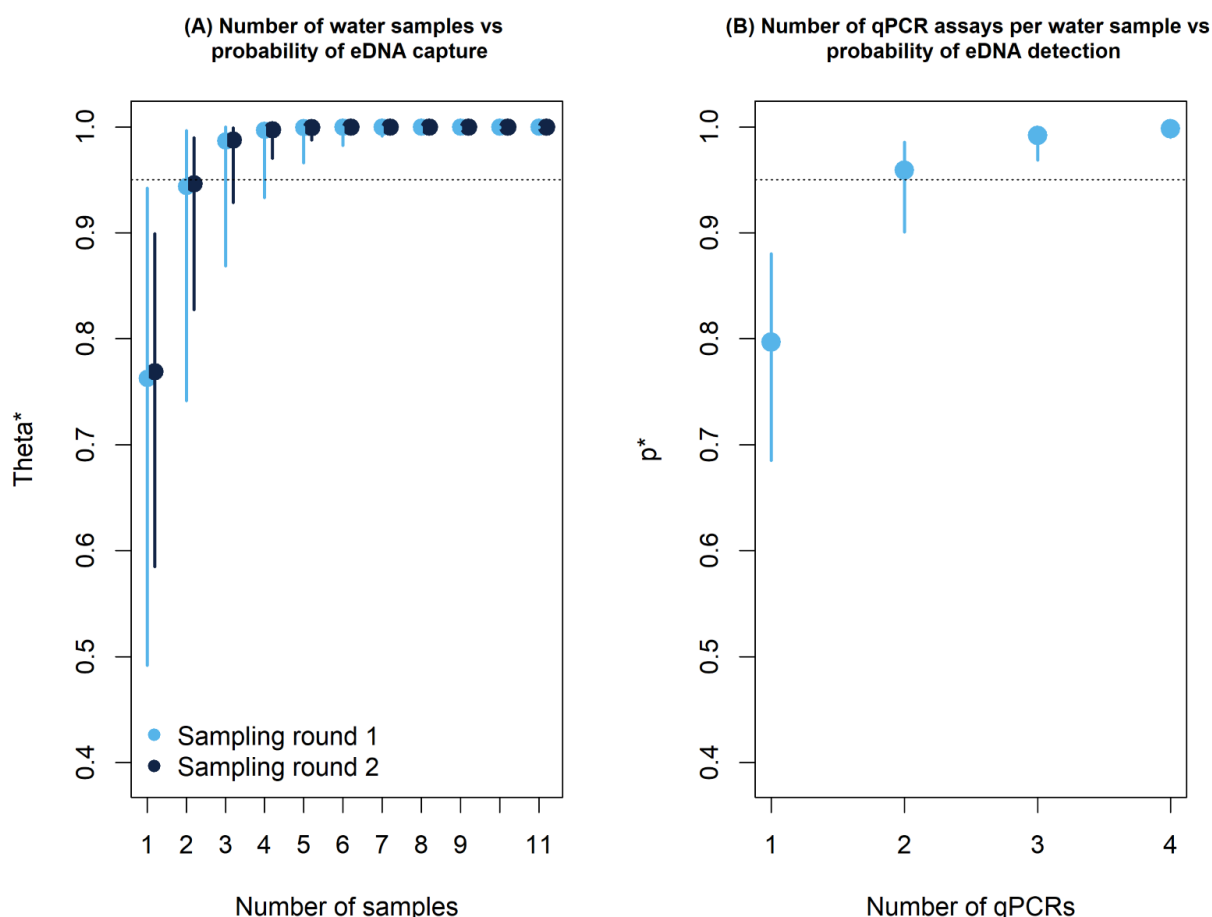
Figure 5: Probability of capturing eDNA in a sample (A) and probability of detecting eDNA via qPCR (B), as a function of the number of samples and qPCRs, respectively.

2.2.3   Greater Glider monitoring plan

The Coastal IFOA conditions and protocols set out protections for fauna species. In May 2024, a new site-specific biodiversity condition was included to provide additional protection for greater gliders. The Coastal IFOA also sets out requirements for species monitoring to evaluate the effectiveness of specific management prescriptions. The site-specific biodiversity condition for greater gliders in the Coastal IFOA region necessitates that the Coastal IFOA monitoring program undertakes the task of evaluating the

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[13] ....EnviroDNA (2024) *Pilot Study - Investigating the presence of Giant Burrowing Frog (Heleioporus australiacus) using environmental DNA.* A draft report to the Natural Resources Commission.

effectiveness of site-specific conditions aimed at safeguarding greater glider populations within areas the species has been previously recorded.

To meet these requirements, the program has engaged Dr. Rod Kavanagh, an Adjunct Associate Professor at Southern Cross University. Dr. Kavanagh will collaborate closely with a cross-agency technical working group that includes the EPA, FCNSW, DCCEEW, DPI and the Commission, to design and propose an appropriate plan for monitoring greater glider trends and the effectiveness of the new condition.

A draft plan is under technical review.

2.2.4   Koala monitoring plan

The Coastal IFOA monitoring program has engaged Dr. Alistair Melzer, an Adjunct Research Fellow at Central Queensland University, to develop a comprehensive, species-specific monitoring plan aimed at assessing the effectiveness of koala protection measures within the Coastal IFOA. Dr. Melzer will collaborate closely with a multidisciplinary technical working group comprising the EPA, FCNSW, DCCEEW, DPI and our team.

A draft plan is under technical review.

2.2.5   Piloting eDNA surveys for three frog species (*Mixophyes*)

The stuttering frog (*Mixophyes balbus*) and the giant barred frog (*Mixophyes iteratus*) are listed as focal fauna species under the Coastal IFOA species occupancy monitoring plan. The Stuttering Frog has recently been split into two species by the scientific community, with a new classification to differentiate the southern stuttering frog (*Mixophyes australis*).

The Coastal IFOA agency technical working group including the EPA, FCNSW, DCCEEW, DPI and the Commission agreed to further explore eDNA as a detection and monitoring tool given the similarity of the three species and the limitations of acoustic sensors to distinguish calls.

Following the eDNA trial with the giant burrowing frog (*Heleioporus australiacus*) eDNA survey, the commission has engaged EnviroDNA once again to pilot the use of eDNA sampling as a detection method for these species of *Mixophyes*. The aim is to assess feasibility for detecting populations as part of future long-term monitoring. The project will develop targeted species assays for each species and validate with samples from the field. The project will also provide insights into the similarity of each species and whether the technique will be able to accurately discern between each species. Sampling will begin this year with the findings report expected in early 2025.

2.3   Forest monitoring and analysis

This program investigates how harvesting distributed through space and time and examines how the retention of habitat features throughout the forest supports ongoing ecological function and connectivity for wildlife. This study aims to provide insights into effective forest management practices that balance timber extraction with the conservation of critical habitats and biodiversity.

2.3.1 Forest structure data capture and analysis

Researchers at the University of Newcastle were engaged to analyse variation in forest structure on state forests. Using recently captured airborne laser scanning (ALS, also known as LiDAR) data and other spatial and non-spatial data, researchers assessed the influence on forest structural diversity of natural and anthropogenic activities including management (harvesting, prescribed fire, areas set aside for conservation), natural disturbance such as wildfire, topographic position and forest type. Building on this work, researchers also analysed structural complexity, canopy gaps, harvested areas, and canopy foliage density.

ALS data captures consisted of roughly 10 terra bytes of data, which covered 540,000 hectares across NSW state forest. These included 27 state forests across seven regions (Eden, Batemans Bay, Bulahdelah, Wauchope, Coffs Harbour, Styx River and Casino) across three separate capture years (2012, 2016 and 2023) for some regions.

Findings suggests harvesting influences vertical and horizontal distribution of biomass, but this returns to pre-harvest levels within a short period (**Figure 6** and **Figure 7**). In addition, different areas show comparable rates of canopy regrowth over time despite variations in harvesting intensity.[14]

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[14] .... Coates Z, Liang G, Nguyen A, Grimmond J, Guilhaus F, Brown S, and Voeste J (2024) *Retrospective Analysis of Forest Structure Change: ALS Data Comparison and Interpretation – Draft.* University of Newcastle. A report for the Natural Resources Commission.
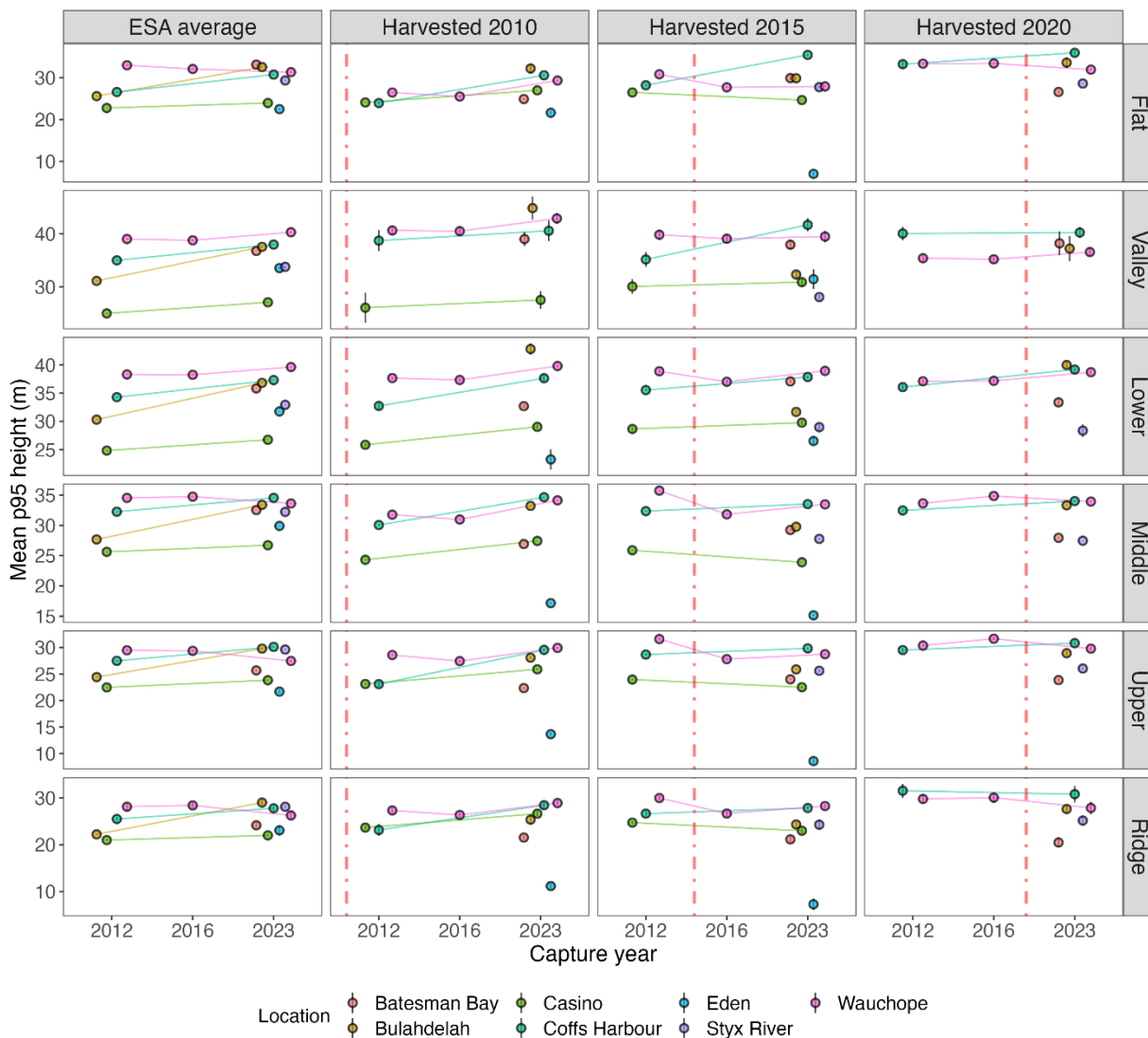
Figure 6: Plots outlining overview of mean p95(top canopy) heights for multiple captures with separate lines indicating forest capture region and vertical panels indicating slope classification. Across the panels, the vertical red dashed line is a visual guide of the approximate timepoint of silvicultural disturbance, noting the change in this timepoint across regions (horizontal panels).
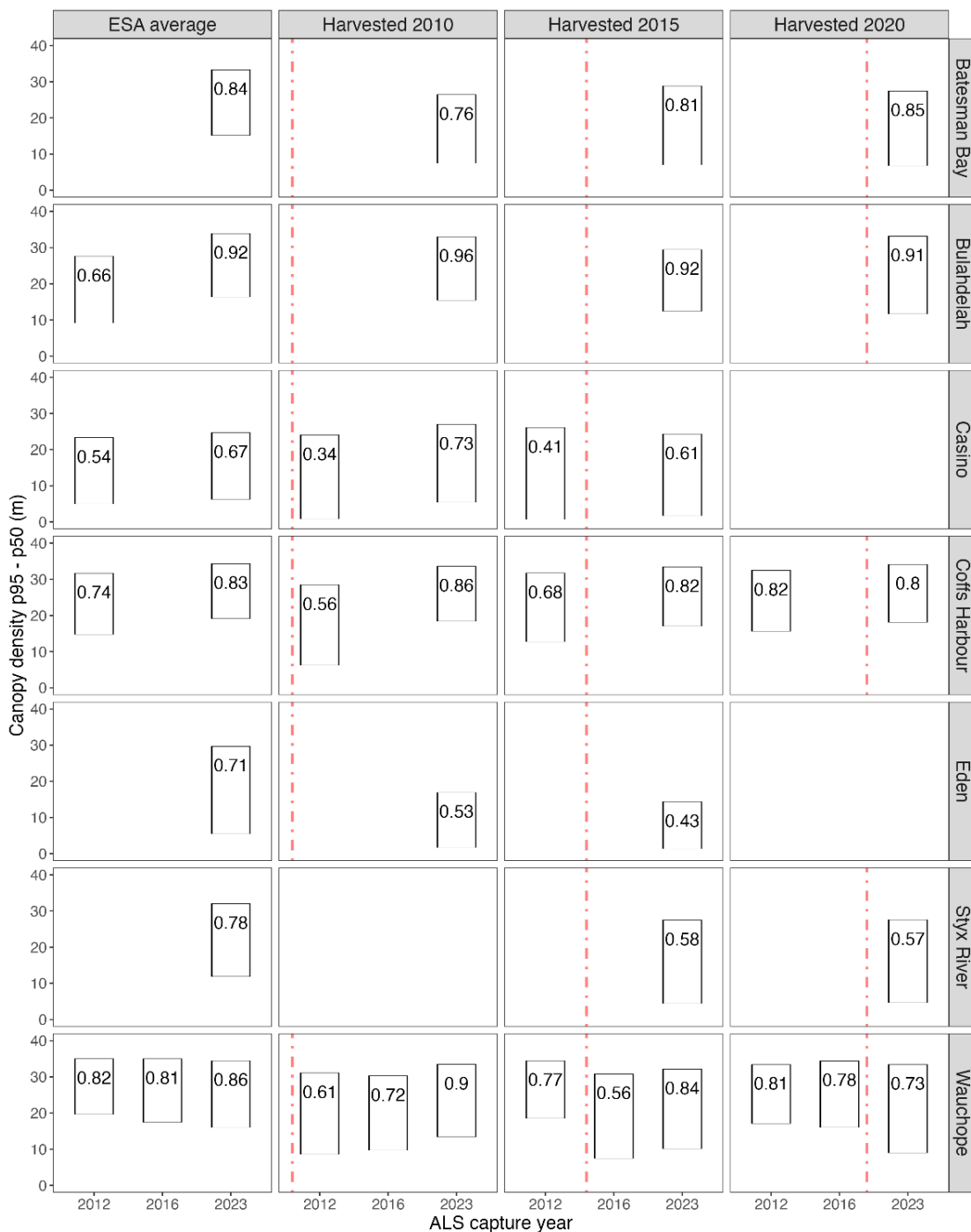
Figure 7: Canopy foliage density illustrated by combined metrics: top canopy (p95), understory regrowth (p50), and canopy occupancy (canopy coverage %) across harvested areas (2010, 2015, 2020) and forest regions.

2.3.2 Carbon balance of NSW forests

The Commission engaged FlintPro under the NSW Forest Monitoring and Improvement Program to update the carbon balance of NSW forests based on their initial assessment in 2022. The update capitalised on new data and improved methods. The analysis covered all tenures including state forests.

The update confirmed there was a general decline in forest carbon stocks from 1990 through to the mid-2000s, after which stocks increased through to 2019, prior to the fires. Between 1990 and 2021 NSW forests lost an estimated 165 million tonnes of carbon (tC), with most of this loss due to the 2019/2020 wildfires[15] (**Figure 8**).

Compared with fire and forest clearing on private land, movements of carbon associated with timber harvesting are relatively low (**Figure 9**). Data from the analysis[16] revealed native forests and plantations in state forests within the NSW RFA regions had a net positive carbon balance from 1990 (including harvested wood products), and before the 2019/20 wildfires **(Figure 10)**. In a typical year, carbon sequestered and stored in forests and wood products outweighs that emitted through fire (planned and unplanned) and harvesting operations.
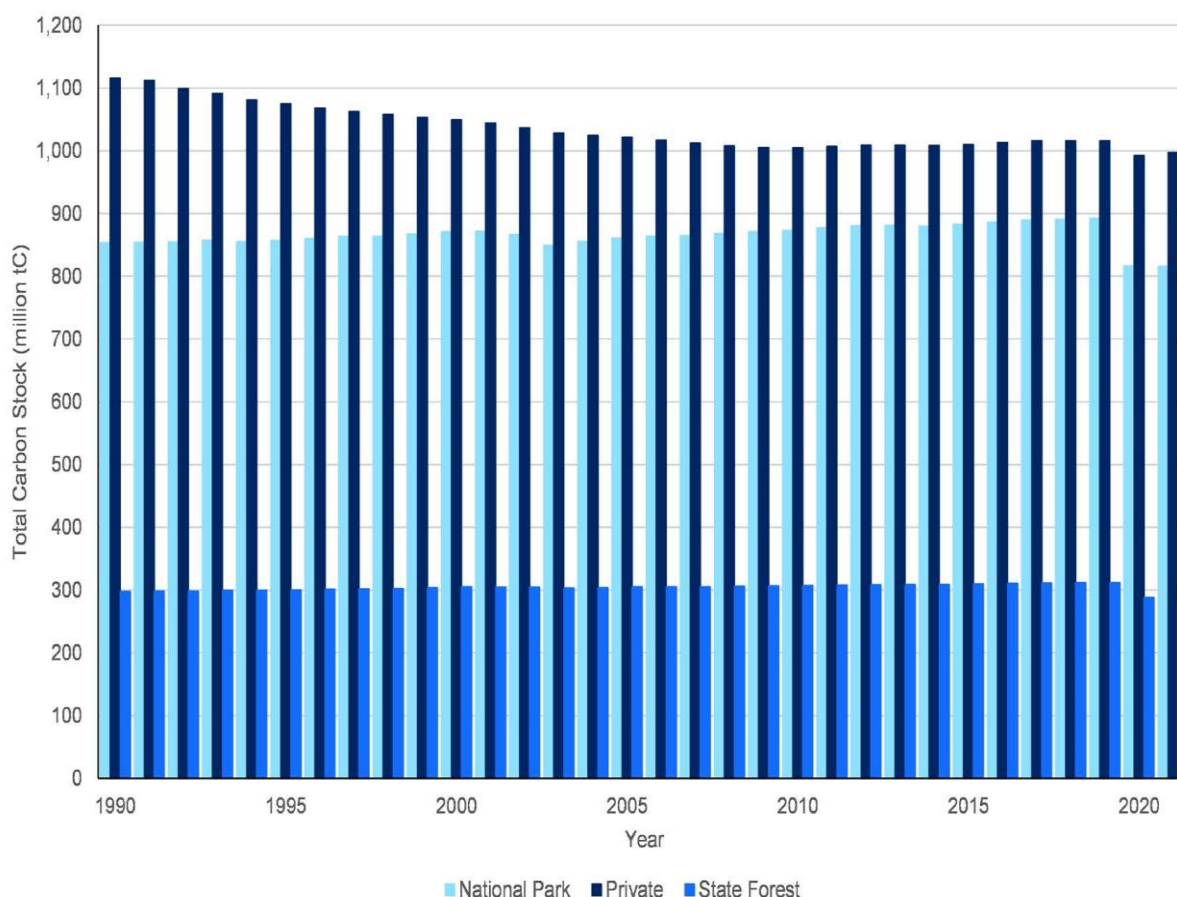

Figure 8: NSW Forest Carbon Stock 1990-2021, including Aboveground Biomass, Belowground Biomass, Dead Organic Matter and Harvested Wood Products in use

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[15] .... Roberts, G., Hislop, S., Johnson, T., Fitzgerald, E. (2023) Carbon Balance of NSW Forests – Update Report, NSW Natural Resources Commission. Link for access to data and interactive charts.
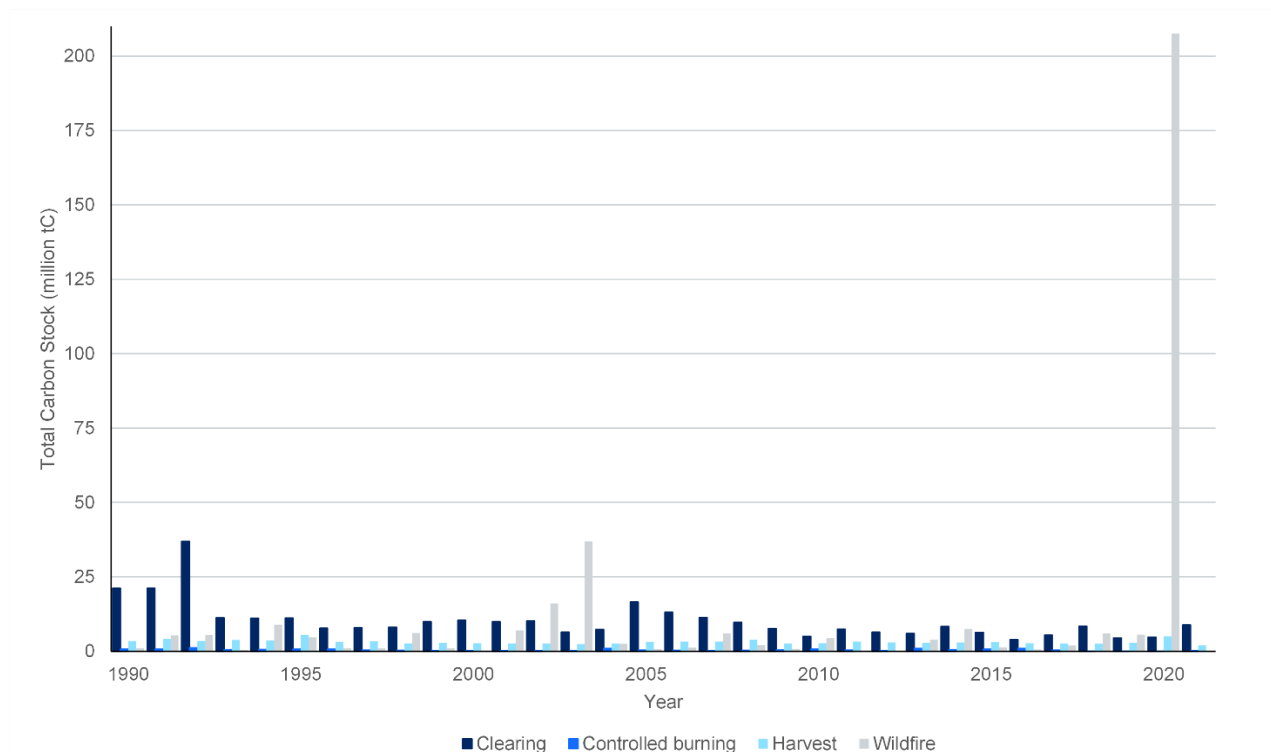
[16] .... Link for access to datasets.

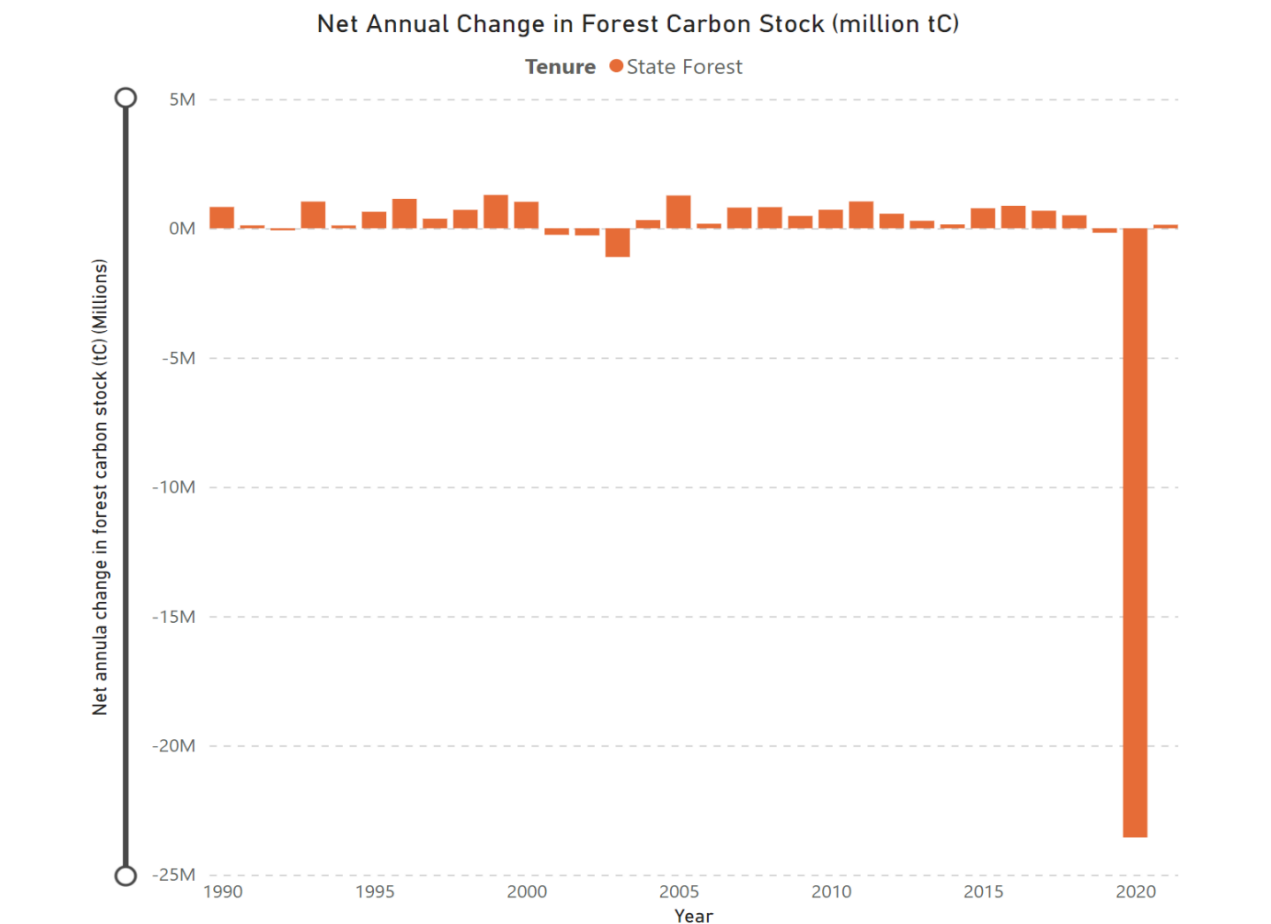**Figure 9: Total carbon fluxes by event type from 1990-2021**

Figure 10: Net annual change in forest carbon on state forests in the NSW Regional Forest Agreement regions

2.3.3 Retrospective analysis of flora composition change

The program has engaged researchers at the DPI Forest Science Unit to assess how tree composition has changed over time. Timber harvesting could alter tree species composition and potentially affecting the habitat and food quality for many species that depend on these trees.

The researchers will use extensive datasets from FCNSW to undertake the analysis. The study will also evaluate changes in key feed trees used by koalas, greater gliders, and yellow-bellied gliders (for example, tallowwood, grey gum, bloodwood), as well as significant non-browse and timber species (for example, blackbutt, spotted gum, turpentine).

2.3.4 Review of forest structure and, health and regeneration

Professor Belinda Medlyn, Western Sydney University was engaged to review the forest structure, health and regeneration monitoring methods used by FCNSW. This work assesses the suitability of existing methods to generate scientifically sound data to effectively address Coastal IFOA monitoring questions. The review is part of a broader design process to develop a cost-effective Coastal IFOA method for monitoring forest structure, health and regeneration.

Methods assessed included FCNSW's native forest strategic inventory, permanent growth plots (PGP) and native forest regeneration surveys. These methods provide extensive data that can be used in conjunction with airborne LiDAR and other spatial data for landscape-scale estimates. Data from these components feed into FCNSW's FRAMES modelling system, supporting strategic planning.

A draft report is under review. Emerging findings suggest the existing suite of measures collected by FCNSW can reliably inform long term monitoring on forest structure, health, and regeneration with some additions.[17]

2.3.5 Risks from forest dieback

The Coastal IFOA recognises bell miner associated dieback as one form of dieback and requires FCNSW to implement management actions to mitigate its further spread. Dieback is a term used to describe gradual deterioration of tree health sometimes leading to tree death. There are many potential causes of dieback including pests, disease, drought, fire and management actions.

The program has engaged Professor Brendan Choat, Western Sydney University to develop a method to assess how effectively new or existing areas affected by dieback are managed under CIFOA conditions. This assessment aims to evaluate the impact and performance of the Coastal IFOA's multi-scale landscape protections and outcomes. The proposed methods will likely combine remote sensing and ground survey techniques to help determine how various causal agents, such as pests, diseases, drought, fire, and management, contribute to the situation. This method will be then tested in a pilot region.

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[17] .... Medlyn, B (2024) *Independent Review of Forest Structure, Health and Regeneration Monitoring Method*. Hawkesbury Institute for the Environment, Western Sydney University. A draft report to the Natural Resources Commission.

The project will evaluate the potential of high-resolution satellite imagery to quantify historical and recent canopy dieback during the 2023 September-October drought, validate through ground surveys, produce a comprehensive map, and investigate associated factors including fire history, forestry operations, and land management.

2.3.6 Data integration and modelling

Conditions monitored under the Coastal IFOA are diverse, with data collection, analysis, and reporting undertaken by a range of state government agencies and academic institutions. Under the current Coastal IFOA program, several projects have been commissioned to address evaluation questions outlined in Protocol 38. Many projects directly target particular conditions with little cross-over between projects.

The program engaged FLINTpro supported by Western Sydney University, to consider the potential for integration and interpretation of the current data. This review focuses on how data could be integrated to generate new information products. Integration could involve combing multiples data types, either directly or in a model-data fusion. As many of the conditions require monitoring at multiple scales across the landscape, spatial integration will be a dominant theme.

2.4 Engagement and adaptive management

2.4.1 2023-24 Annual health check

The Coastal IFOA Monitoring Program commits to an annual review of the program, referred to as the 'annual health check'. The annual health check:

- considers the results of the monitoring program
- identifies any implications for the IFOA conditions
- considers the adequacy of the program and identifies priorities for further monitoring or research.

This process informs advice from the Commission, on behalf of the Steering Committee, to the EPA and DPI on how the Coastal IFOA can better meet its objectives and outcomes.

The Commission team hosted the annual Coastal IFOA health check in November 2023 with the EPA, FCNSW and DPI. The Commission presented program findings, and a progress update on commissioned projects. Parties discussed emerging issues associated with dead standing trees, retained debris and stream channel heads.

No new research or monitoring was proposed, noting the 5 yearly review would commence in 2024.

2.4.2 Annual stakeholder forums and webinars

In late 2023 the Commission hosted a series of webinars providing an opportunity for people to learn, ask questions and provide feedback about recent work relating to forestry and forest management (**Table**). Over the three series, more than 155 people attended the webinars.

Much of this work was carried out under the broader Forest Monitoring and Improvement Program but is also relevant for the Coastal IFOA Monitoring Program. All webinar

materials including recordings of the presentations and panel discussions can be found on the [Commission's website](#).

Table 5: Webinars and community forums

Project	Overview
Webinar 1 - Forest waterways November 2023	This webinar presented two research projects that investigated post-fire debris flows in southeast NSW forests and methods to evaluate the effectiveness of the forest road networks to maintain water quality. Dr Petter Nyman (Alluvium) presented research and was joined by Dr Peter Hairsine (Australian National University) for a Q&A panel following the presentation.
Webinar 2 - Fauna monitoring in NSW state forests December 2023	This webinar presented the design and early roll out of an ambitious fauna monitoring program across NSW state forests. This works builds on baselines established for fauna occupancy that has been recognised as the largest and most significant project of this type in the history of NSW forest management. Dr Brad Law, from the NSW Department of Primary Industries and Chris Slade, Senior Ecologist at FCNSW presented the work-to-date, and were joined by Professor Phil Gibbons (Australian National University) for a Q&A panel following the presentation.
Webinar 3 - Forest carbon of NSW forests December 2023	This webinar presented analysis on quantifying the carbon balance of NSW. Improved data was used to update previous analysis presented in 2022. Geoff Roberts, from the Mullion Group presented the findings and was joined by Professor Patrick Baker (University of Melbourne) for a Q&A panel following the presentation.

2.4.3 New protocol and monitoring

In February 2024, the EPA announced a change to the Coastal IFOA protocol introducing a site-specific biodiversity condition for greater gliders that requires the retention of additional hollow bearing trees.

The protocol directs the Coastal IFOA program to monitoring the effectiveness of the new conditions. The program has initiated a new monitoring plan to meet this outcome (**Section 2.2.3**).

2.4.4 Program evaluation and public submissions

The program has appointed an independent evaluator to assess the adequacy of the program as required under Protocol 38 of the Coastal IFOA. This is part of the program's broader five yearly review (**Section 3**).

To inform the evaluation, the program called for public submissions on its performance and suggested opportunities to improve. The independent evaluator will review the feedback.

3   Priority next steps

The program is focused on delivering ongoing long-term monitoring programs for fauna species occupancy and forest structure, as well as projects commissioned in 2023-24, as outlined in **above**.

These, and other published findings from previous projects will inform the program's first five-yearly formal review, which is to be delivered in 2024. The five-yearly formal review provides an opportunity to:

- assess detailed results from the program, including key findings, insights and trends
- recommend opportunities for improvement for the monitoring program and Coastal IFOA (if any).

The Commission team will work with the Steering Committee and Technical Working Groups in delivering the five-yearly review. The outcomes of this review process will inform the formal five-yearly review of the Coastal IFOA in 2025, led by the EPA.