NSW GOVERNMENT

Natural Resources Commission

NSW Coastal Integrated Forestry Operations Approval Monitoring Program

Fauna occupancy survey design

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Forestry Corporation

PRIMARY INDUSTRIES Forest Science

NSW GOVERNMENT

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.

List of acronyms

CIFOA - Coastal Integrated Forestry Operations Approval
DPI - NSW Department of Primary Industries
IFOAs - Integrated Forestry Operations Approvals
SMP - Species Management Plan

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Cover photo: L-R Song Meter Mini Bat, Albert's Lyrebird

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1 Background

Biodiversity monitoring is an important aspect of forest management. The Coastal Integrated Forestry Operations Approval (CIFOA) specifies that a monitoring program is to be designed and implemented under the guidance of a steering committee.

The NSW Forest Monitoring and Improvement Steering Committee (the Steering Committee) was established consisting of representatives from various agencies and is independently chaired by the Natural Resources Commission (the Commission).

The program described hereafter is for state forests under the management of the Forestry Corporation of NSW.

The monitoring being undertaken within state forests is aiming to provide data for the following themes:

- Effectiveness monitoring – are the CIFOA conditions effectively meeting its objectives and outcomes?
- Trend monitoring – is the CIFOA having a neutral, positive or negative impact on landscape-scale environmental values or wood supply?
- Compliance monitoring – are forestry operations carried out in accordance with the CIFOA?
- Adaptive management – can CIFOA conditions, forestry operations, forestry management or monitoring be improved to better meet objectives and outcomes?

Adaptive mechanisms are designed to provide triggers for the need for adjustment in management or activities. These are primarily driven by the data arising from the programs and links to the IUCN criteria for species status adjustments 30 percent decline over 10 years. Changes in species occupancy meeting any of the criteria listed above would be used as triggers for further action.

1.1 Multi-scale approach

Monitoring is a term used to describe a variety of programs underway or in development within the state forest estate and is not limited to a single program. A multi-tiered approach is being undertaken to best suit the objectives or needs of a species or specific question:

- Landscape scale, multi-species, long-term occupancy trend
- Species specific occupancy trends
- Targeted question / issue research

The programs vary from long-term ongoing action of greater than 10 years, to short-term projects with a specifically focused question. The landscape-scale program is aiming at a broad sample of a large range of species that can be photographed at a bait lure station and can include small mammals, medium sized mammals, large mammals, some reptile species, and some bird species.

In addition, sound recorders are being used to record the range of species that emit audible identifiable calls along with ultrasonic sound recorders for echo-locating bat species. Not all species are readily detectable using existing data processing tools, though there is potential to retrospectively establish trends for these species when tools (recognisers) become available.

There is a range of species for which a broad landscape-scaled program will not provide enough data for analysis, therefore requiring a more targeted approach and methods to detect the species. The CIFOA also specifies several species for which a Species Management Plan (SMP) is required to be developed to understand occupancy trends, persistence of viable populations and potential impacts. These include:

- Southern Brown Bandicoot - Eden
- Giant Burrowing Frog – Eden
- Smoky Mouse - Eden
- Yellow-bellied Glider population of the Bago plateau - Tumbarumba
- Eastern Bristle Bird – far northern NSW
- several flora species.

In addition, several other species, not associated with SMP or CIFOA requirements are also being monitored and include:

- Hastings River Mouse – northern tableland forests
- Koala - northern coastal forests
- Greater Glider – all coastal forests, program redesign underway for commencement in 2023
- Large -forest Owls – Eden

Targeted question or issue research is undertaken for specific questions arising or to fill knowledge gaps for a specific issue. Programs such as these have a tighter scope for a specific issue and are best undertaken in a controlled design often at localised scales.

Recent examples on state forests include radio tracking koalas at sites where timber harvesting had occurred within the last 5-10 years to get a better understanding of habitat use in regrowth forests[1] along with the use of arrays of sound recorders to assess changes in density of koalas following timber harvesting[2] and intense wildfires.[3]

[1] ..... Law, B., Slade, C., Gonsalves, L., Brassil, T., Flanagan, C. and Kerr, I. (2022) Tree use by koalas after timber harvesting in a mosaic landscape. *Wildlife Research.*

[2] ..... Law BS, Brassil T, Gonsalves L, Roe P, Truskinger A, McConville A (2018) Passive acoustics and sound recognition provide new insights on status and resilience of an iconic endangered marsupial (koala *Phascolarctos cinereus*) to timber harvesting. *PLoS ONE* 13(10): e0205075.

[3] ..... Law B. S, Gonsalves, L., Burgar, J., Brassil, T., Kerr, I. and O'Loughlin C. (2022) Fire severity and its local extent are key to assessing impacts of Australian mega-fires on koala (*Phascolarctos cinereus*) density. *Global Ecology and Biogeography* 00:1-13.

2 Landscape Scale Program: Fauna occupancy trends

The Fauna Monitoring Program will be used to evaluate the effectiveness of the CIFOA protections and conditions, particularly the collective multi-scale landscape protections, in maintaining species occupancy and the population status of focal species. To achieve this, the program will estimate the trends in occupancy of focal species, such as koalas and other arboreal mammals, hollow-dependant bats, nectivores, ground-dwelling mammals and forest owls.

2.1 Pilot trial

A pilot trial was undertaken in autumn and spring 2021 to assess the feasibility of remote sampling techniques, detectability of various species, probability of occupancy, site establishment and overall program design. The results of the pilot trial have guided the design of the program which can be adaptively adjusted as required. A minimum of 300 sites were recommended to be sampled to provide enough data to estimate occupancy levels for a variety of species in the monitoring study area.

The pilot trial estimated the probability of detection for a range of species for which data were available. As an example, the Yellow-bellied Glider was detected on 5 of 15 survey locations with a nightly detection probability determined to be 0.22 ± 0.05 at the site level with multiple sound recorders and 0.14 ±0.04 at the sample point level of a single sound recorder. These results suggest that multiple sub-plots per site should be sampled for 10 to 14-nights to have high probability of detection ($p>0.9$) at an occupied site. Assuming an initial occupancy and detection probability as reported for the pilot monitoring grid points, approximately 90 grid points would need to be monitored for 14 nights each year to have 80 percent power for detecting a 30 percent decline in 10 years.

The results of this trial along with other monitoring programs, such as NSW Department of Primary Industries (DPI) acoustic monitoring of koalas in north-east NSW and the DPI forest monitoring feasibility study conducted in 2018, was used to inform the design of the Fauna Monitoring Program.

2.2 Fauna monitoring design

The CIFOA estate is divided into 3 regions, Upper north-east, Lower north-east and Southern. Each of these regions has 100 monitoring sites established to be sampled.

To achieve sampling of the 100 survey sites per region, 50 sites are surveyed annually (hereafter ‘annuals’) with 5 panels of 10 sites surveyed once in every five years. The distribution of annuals and panel sites within each region are spatially balanced to minimise spatial bias for any group of sites sampled in a given year. The schedule is arranged to survey a proportion of these sites in the spring and autumn seasons to allow for seasonal variation in detectability of the species, for example, Powerful Owls are more vocal in autumn and koalas are more vocal in spring.

Given the difference in habitat requirements and preference for some species to use runways (track and trails) or other flyways and others preferring more protected locations away from trails, two subplots are deployed to provide for these differences and enable the program to sample the species using these habitats. As such, at each site an “on-track” and an “off-track” sample point is established.

In summary the final design of the programs is as follows:

- 300 sites across the CIFOA area consisting of 2 subplots - an “on-track” and “off-track”
- 100 sites per region - Upper north-east, Lower north-east, Southern
- Minimum 14-night deployment of survey equipment

Confidence in detectability of various species is important to be able to determine whether trends in occupancy are either stable, increasing or decreasing. Repeat visits are required to be able to determine the probability of detection for each species, which in turn is used to adjust naïve occupancy given detection probability for any method is never perfect.

The costs of repeat measures using manual methods are high and can be biased due to observer skill and can be challenged by weather at the time of survey. There are inherent safety risks and while some species can only be surveyed using these methods, for example the Greater Glider via spotlighting or thermal drone, the opportunity to minimise these aspects has been taken to determine the methods used for the monitoring program.

Remote cameras, remote sound recorder for species emitting audible calls and ultrasonic sound recorders have been chosen as the preferred methods for this program.

The CIFOA *Operational Manual for Fauna Monitoring* provides more detail on how surveys are implemented.

2.2.1 Site selection

The selection of sites used for the monitoring program (**Figures 1** to **3**) has incorporated several long-term programs including sites for koala occupancy monitoring in the north-east hinterland forests of NSW and long-term large forest owl and Southern Brown Bandicoot monitoring sites in the Eden area.

These sites have been chosen as they have a long history of monitoring and data since 2015 for the north coast koala program and the late 1990s for large forest owl and glider monitoring. These sites, along with the remaining sites selected, were chosen to ensure a range of disturbance histories and landscape locations are included to give a broad landscape scale perspective to the occupancy trends of the range of species being sampled. This includes long undisturbed - in areas such as flora reserves - mapped old growth forest patches and areas available for timber harvesting with a range of age classes, including recently harvested and areas to be harvested in the future.

Site access, remoteness and size of the forest were factors considered with areas too remote or too small avoided to ensure the program can be undertaken efficiently without compromising the opportunity to capture reliable data and to sample the range of species.

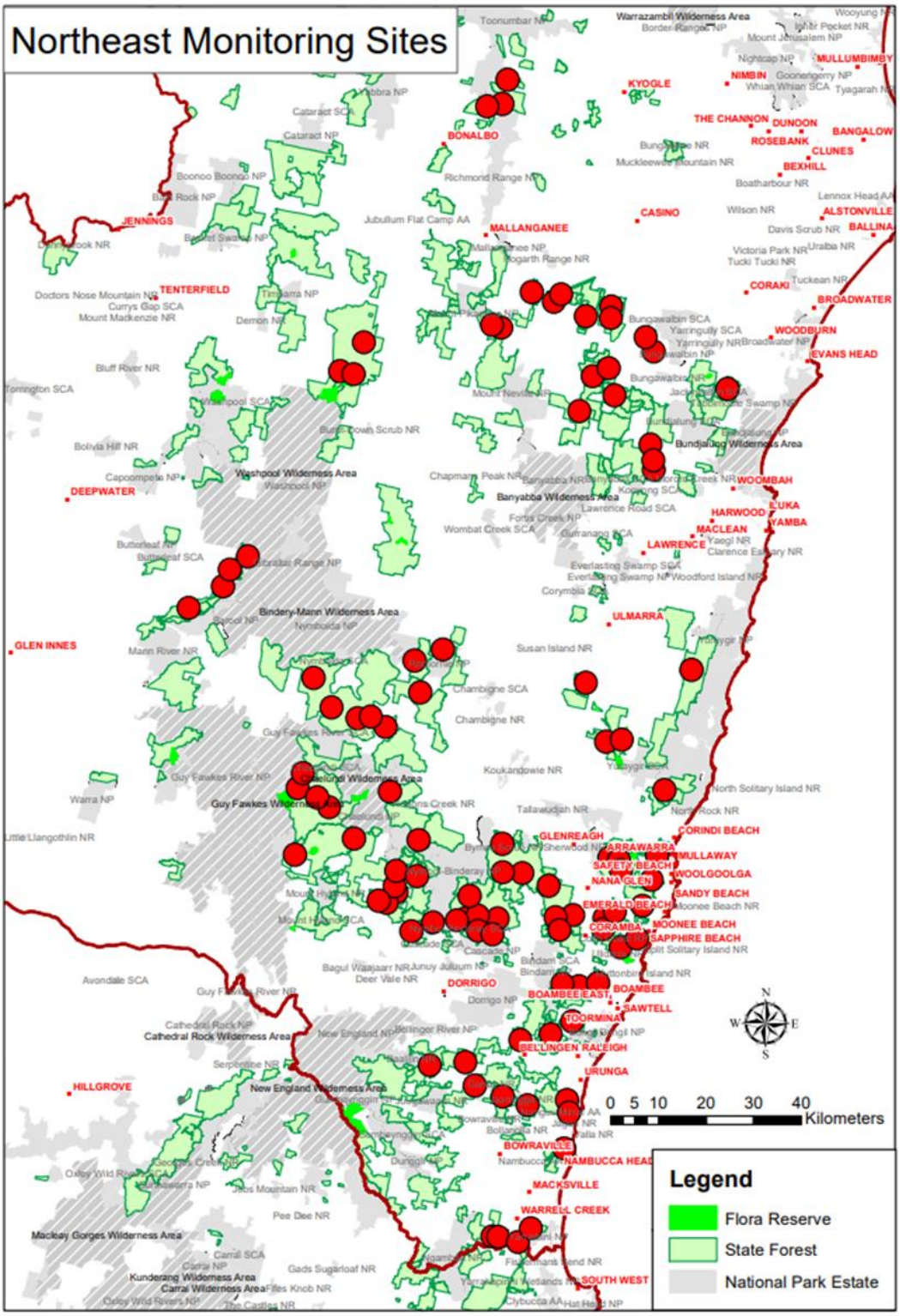

Figure 1: Northeast NSW monitoring site locations - Upper northeast region

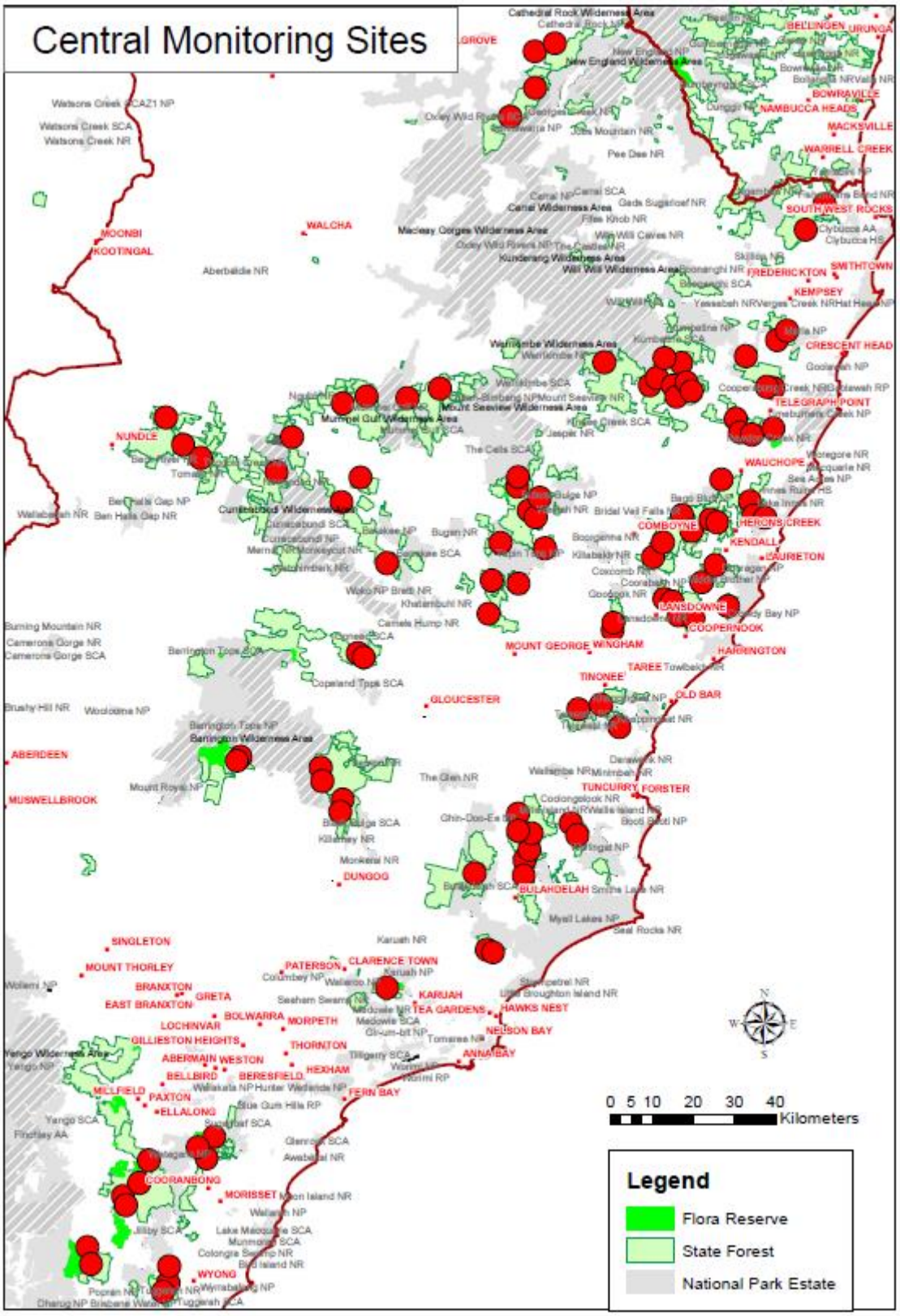

Figure 2: Central NSW monitoring site locations - Lower northeast region

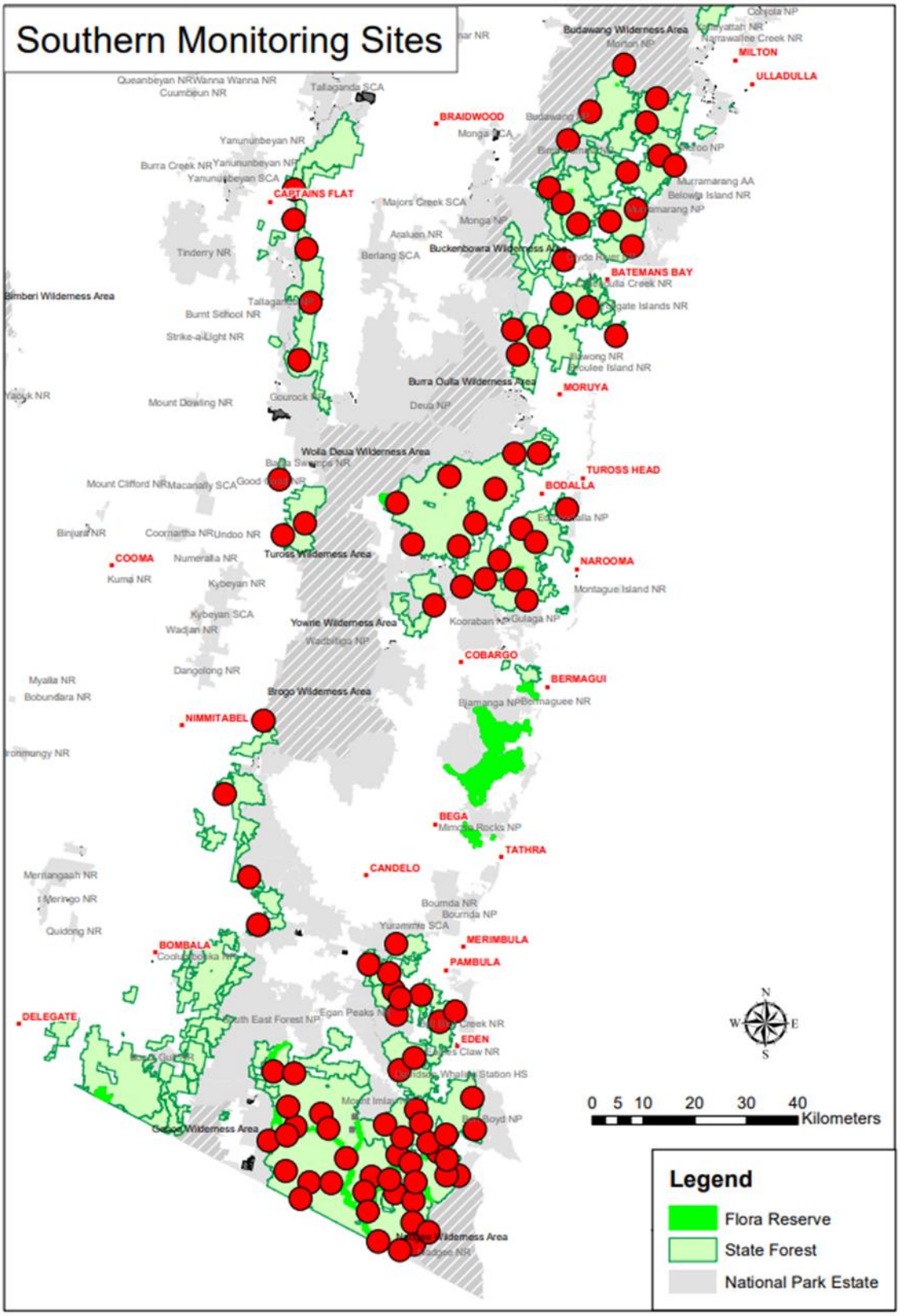

Figure 3: Southern NSW monitoring site locations – South coast region

2.2.2 Data Management

A program of this scale has many challenges associated with managing data. The volume alone is a large factor with approximately 30 TB of data captured per year for the program. The aim is to store the data in a cloud platform to enable access and analysis and to avoid physical transport of hard drive copies. There is a need for a high level of data integrity and metadata management to enable remotely captured data to link to the sites and seasons.

The devices allow for site naming to be established and carried onto the data cards with linkage to the spatial location ensuring that this aspect of the data is consistently recorded. Strict protocols for managing data cards on device retrieval has also been established and described in the equipment instruction sheets. This will ensure consistency and to minimise the risk of data loss and inappropriate filing and storage.

2.3 Data Analysis

2.3.1 Species identification

Images captured by the cameras are run through artificial intelligence programs (e.g., Mega-detector or Marsupial AI) to isolate images with fauna species present to minimise the manual processing of images with false triggers, for example from shadows or foliage movement. Image files are then manually assessed to identify and tag species recorded.

Sound files (both audible and ultrasonic) are run through programs using algorithms (recognisers) for specific species to identify calls of the targeted species. For bats, Anascheme is used to automate identification.[4] For acoustics data, individual species recognisers using CNN algorithms within AviaNZ software are used (https://www.dpi.nsw.gov.au/forestry/science/forest-ecology/fauna-identification-service).

A number of species recognisers are available including the koala, yellow-bellied glider (**Figure 4**) and some forest owls but this is an area of rapid development with more recognisers being developed regularly by NSW DPI. The sound files are archived for future assessment as each new recogniser becomes available providing a valuable opportunity for further use of the data to establish trends retrospectively for these species.

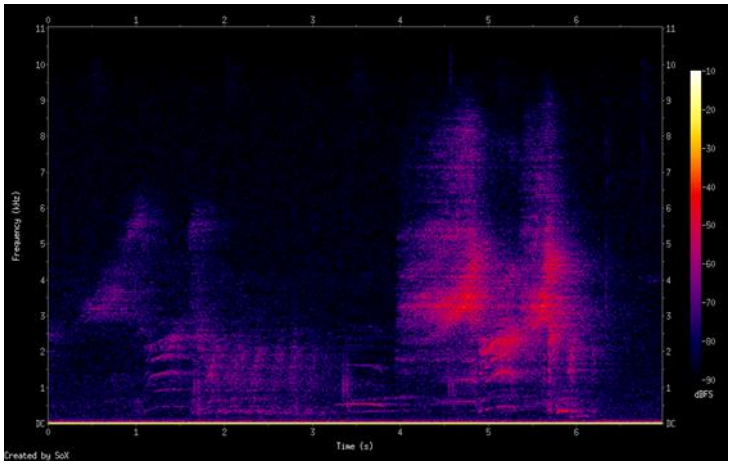

Figure 4: Example spectrogram of a yellow-bellied glider vocalisation

[4] ..... Adams, M., LAW, B., and Gibson, M., (2010). Reliable automation of bat call identification for eastern New South Wales, Australia, using classification trees and Anascheme software. *Acta Chiropterologica* **12**: 231-45.

2.3.2 Occupancy analysis

Occupancy monitoring is built on site-specific surveys repeated over short periods of time to determine the probability for a species to occupy an area and the probability that it would be detected during a survey. When repeated over years, this information allows for changes in occupancy or mapped occurrence to be identified, which can reflect changes in population size.

With occupancy modelling, detection or non-detection data are collected on multiple repeat visits (e.g., multiple nights of survey). For example, a detection history of '00100011000010' would indicate that the species was detected at that site on the 3rd, 7th, 8th and 13th days, but not on the other days (although it may have been present on any of those days, just not detected). This allows probability of detection for a given survey method to be calculated and used to adjust estimates of naïve occupancy that assume perfect detection.

The use of remote survey methods reduces costs and time associated with detailed mark-recapture surveys required for population studies, provides the repeat visit data required for occupancy modelling and yields data for alternative metrics for analysing species trends.[5] For example, ultrasonic detection of bats yields activity levels, which is a more sensitive measure for describing change than species occupancy for many species in that fauna group.[6] Species occupancy will be the default for analysing change, unless other more sensitive metrics can be extracted efficiently from the data.

Site-specific data can be modelled spatially into areas of similar habitat, to account for different management practices using environmental and physical variables by identifying key co-variates that influence the likelihood of both occupancy and detection of a species at a site. Survey-specific data (e.g., temperature or rainfall on day/night of survey) can also be incorporated in models for detection probability. Importantly, occupancy accounts for false absences or imperfect detection, and is therefore useful as no method has 100 percent detection. Occupancy modelled across a species range at points in time helps to visualise where changes are occurring. Sufficient visits are required to be able to estimate the probability of detection and the optimal number will vary by species and method.

Occupancy monitoring is proposed for focal species that may be sensitive to harvesting due to being hollow-dependent or reliant on other landscape habitat resources, and therefore to test the suitability of the multi-scale landscape protections.

Surveys will be completed in areas with different management practices (different zones) and results modelled across the CIFOA regions using co-variates. These co-variates will be GIS-based and would include timber harvesting history and extent, fire history and extent, climatic variables, topographic variables, and others.

Trends in a species occupancy will be modelled every year or two, while changes in spatial extent of a species occupancy would be modelled every five years after all sites are surveyed at least once. Occupancy estimates can also be compared with baseline occupancy models generated across all forests of eastern NSW from the 1990s. A multi-season occupancy approach will allow for colonisation and extinction to be modelled across sites providing further information on potential drivers/correlates (co-variates) of change in a species occupancy level.

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[5] ..... For camera trap and acoustic recorder examples see review paper - Buxton, R. T., Lendrum, P. E., Crooks, K. R., Wittemyer, G. (2018). Pairing camera traps and acoustic recorders to monitor the ecological impact of human disturbance. *Global Ecology and Conservation*, Volume **16**.

[6] ..... Law, B., Gonsalves, L., Tap, P., Penman, T., Chidel, M. (2015). Optimizing ultrasonic sampling effort for monitoring forest bats. *Austral Ecology* **40** (8): 886-897.

Modelling will be used to both monitor the collective success of the conditions (management actions) and to identify downward trends where additional investigation may be needed to improve management (i.e., adaptive monitoring and management). Trends will be analysed over time and compared, where appropriate, to cross-tenure monitoring. Given limited cross tenure monitoring at this point in time, monitoring within areas of mapped old growth on state forest will be important to provide reference conditions for timber harvesting.

2.4 Reporting

Reporting will be undertaken at regular intervals, at least annually following analysis of the previous years' data capture. The results will be presented in multiple formats including score card style summary page, more detailed analysis reports and peer reviewed papers for submission to scientific journals.

Baselines for occupancy metrics for the 1990s have been developed for a subset of species as part of the 'Baselines, drivers and trends in species occupancy and distribution' project.[7] It is anticipated that the first three years of data from the CIFOA monitoring will be used to establish contemporary baselines for the implementation of the species occupancy monitoring plan and can be compared to the 1990s baselines.

2.5 Adaptive Management

The monitoring program will be reviewed regularly to ensure the design, methods and analysis are fit-for-purpose and link to the aims and objectives.

Opportunities to improve all aspects of the program will be assessed with improvements and adjustments implemented as required.

Advancements in the field are happening regularly with additional recognisers, tweaks to occupancy analysis and the equipment. Any new equipment recommended will be assessed alongside the existing equipment in use to enable a correlation between the old and new to ensure detectability and probability of occupancy estimates remain consistent.

Survey method can also be included as a covariate for detection in the analysis to cater for device updates over time.

3 Other documents for the Fauna Monitoring Program

This document describes the design of the Fauna Monitoring Program.

The *Operational Manual for Fauna Monitoring* provides details on the implementation of the monitoring surveys.

[7] ..... Kavanagh, R., Law, B., Drielsma, M., Gonsalves, L., Beaumont, L., Jenkins, R., Wilson, P. D, Binns, D., Thinley, P., Bulovic, N., Lemckert, F., Brassil, T., and Reid, N. (2022). *Project 2: 'Baselines, drivers and trends in species occupancy and distribution'*. NSW Forest Monitoring and Improvement Program Final Report to the Natural Resources Commission of NSW.

Further details on the set-up and programming of equipment are provided in the equipment instruction sheets:

- Reconyx camera instructions
- Song Meter Mini Bat instructions
- Song Meter Mini instructions

Other monitoring information and instructions include:

- Monitoring maps
- Site selection instructions
- Monitoring field sheet
- Monitoring bait station specifications
- Annual equipment check instructions.