Aerial Crossing Monitoring 2020

Frederickton to Eungai Pacific Highway Upgrade

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Cover photograph: Feathertail Glider using western glider pole at site 1 (left), Brushtail Possum using the rope bridge at site 1 (middle) and Sugar Glider using the median glider pole at site 1 (right).

Executive summary

Context

This report documents the results of the autumn 2020 aerial crossing monitoring period. The 2020 monitoring represents an additional 60-day aerial crossing monitoring period as a part of the final of three monitoring cycles required by the Frederickton to Eungai (F2E) Ecological Monitoring Program (EMP, RMS 2016) for aerial crossing monitoring. This autumn 2020 monitoring was required due to equipment theft in autumn 2019 that resulted in the loss of autumn 2019 camera data. Transport for NSW (TfNSW) is required to manage and monitor the effectiveness of biodiversity mitigation measures implemented as part of the Project.

Aims

The aim of this report is to summarise the methods and results of the autumn 2020 monitoring and all previous monitoring events and determine if performance measures have been met, as per the EMP.

Methods

In accordance with the EMP, each of the three aerial crossing zones (Sites 1, 2 and 3) was monitored in autumn 2020 through the use of automated cameras for a period of 60 consecutive days. The final arboreal tree trapping was undertaken in spring 2019 and is presented in the 2019 Aerial Crossing Monitoring Report (Niche 2020).

Key results

- Remote cameras detected two glider species using the aerial crossings; the Feathertail Glider and Sugar Glider.
- Gliders were detected on the median glider poles at two of three sites, indicating assumed complete crossings.
- Two arboreal mammals, the Brushtail Possum and Feathertail Glider, were recorded on the canopy rope crossing at Site 1 and 3, respectively.
- Complete crossings were not detected on canopy rope crossings.
- To date all glider poles have been used by at least two target species on multiple occasions.
- To date rope bridges have been used by glider species and the Brushtail Possum, however complete crossings have not been recorded.

Conclusions

Glider poles: As gliders have been recorded using both eastern and western poles and the median poles at all sites on multiple occasions it is considered that indicators of success in relation to successful complete crossings of the glider poles by glider species have been met, despite the absence of recapture data and quick succession records for a full crossing. Neither sign of unsuccessful mitigation has been met for the glider crossings as gliders have been detected on all median poles and gliders have not been recorded as road kill.

Rope bridges: While arboreal fauna have been recorded on the canopy rope bridges at all sites, successful complete crossings have not been confirmed using remote cameras or recaptures during arboreal trapping. As such, indicators of success have not been met for canopy rope bridges.

Management implications

In relation to the relevant contingency measures and performance indicators that have not been met, a number of recommendations have been made, including:

- Additional plantings of tubestock tall tree species at RB1 east and RB3 west.
- Ongoing downloading of aerial camera data to capture additional crossings by fauna for a period of one year, or less if the canopy rope bridges are deemed successful within the year, to determine success in accordance with the performance measures.

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1. Introduction

1.1 Context

As part of the Frederickton to Eungai (F2E) Pacific Highway Upgrade Project (the Project), Transport for NSW (TfNSW) have implemented an Ecological Monitoring Program in accordance with the Minister for Planning's Condition of Approval (MCoA) No. 3.1. This Ecological Monitoring Program (RMS 2016) (hereafter referred to as the EMP) combines the approval conditions provided within the Ministers Conditions of Approval (MCoA) and Statement of Commitments (SoC), and defines the mitigation and monitoring requirements for threatened species and ecological communities impacted by the Project.

Aerial crossings have been installed to reduce the impacts on fauna, facilitate movement and maintain connectivity for existing glider/arboreal mammal populations (RMS 2016). These structures are to be monitored to assess their effectiveness.

1.2 Monitoring framework

The EMP states the following regarding monitoring:

"It is proposed that monitoring of the glider crossings be undertaken in order to provide long term insights into the mitigation effectiveness once the carriageway becomes operational. With this in mind, monitoring would commence 6 months after the structures have been installed and focus on a 4 week sampling period in autumn and spring in 2017, 2018, and 2019, after which the need for further monitoring would be reviewed in consultation with EPA".

To date, these monitoring events have been undertaken and reported on as follows:

- *Autumn and spring 2017*: Aerial Crossing Monitoring 2017 (Niche 2018a)
- *Autumn and spring 2018*: Aerial Crossing Monitoring 2018 (Niche 2019a)
- *Autumn and spring 2019*: Aerial Crossing Monitoring 2019 (Niche 2020).
- *Autumn 2020*: Aerial Crossing Monitoring 2020 (current report)

The 2020 monitoring represents an additional 60-day aerial camera monitoring period as a part of the final of three monitoring cycles required by the EMP for aerial crossing monitoring. This autumn 2020 monitoring was required due to equipment theft in autumn 2019 that resulted in the loss of autumn 2019 camera data. In consultation with TfNSW, the Department of Planning Industry and Environment (DPIE) and the NSW Environment Protection Authority (EPA), it was determined that an additional 60-day aerial camera monitoring period would be conducted in autumn 2020 and data was to be reported in a separate report.

1.3 Baseline data

The EMP provides the following background information:

"Table A3 provides results of surveys in the vicinity of the three nominated aerial crossing locations. Yellow-bellied Glider has been recorded at or near each of the three crossing locations as have Brush-tailed Phascogale and other common arboreal fauna including Common Brushtail Possum, Sugar Gliders and Feathertail Glider".

Table A3 is provided in the original EMP (Lewis 2013) and presents the results of systematic surveys for the Kempsey to Eungai Environmental Assessment (Lewis 2005).

1.4 Purpose of this report

This report complies with the monitoring requirements described within the EMP and details the findings of the additional camera monitoring period as part of the third monitoring event.

The aims of this report are to summarise the methods and results of the autumn 2020 monitoring and previous monitoring events and determine if performance measures have been met, as per the EMP.

1.5 Performance measures

The EMP specifies the performance indicators for the aerial crossing structures as follows:

***Indicators of success for the glider poles would include one or more of the following**:*

- *Evidence of use by any glider species using the median pole.*
- *Photographic evidence of a glider using both the eastern and western poles.*
- *One or more gliders with left ear tag/notch occurring on the western side of the carriageway and fauna with right ear tag/notch occurring on the eastern side of the carriageway*.

Signs of the glider poles being unsuccessful will be based on the:

- *Absence of gliders being recorded using the median pole or other evidence of complete crossings.*
- *Unacceptable levels of road strike (presence of deceased individuals during each sampling period for either year). For example, recording one or more gliders as road strike in both monitoring seasons would be considered as unsuccessful and require contingency measures.*

Indicators of success for the rope canopy bridges would include one or more of the following:

- *Photographic evidence of any arboreal species using both sides of the rope ladder to indicate a successful passage.*
- *One or more arboreal species with left ear tag/notch occurring on the western side of the carriageway and arboreal fauna with right ear tag/notch occurring on the eastern side of the carriageway.*

Signs of the canopy rope bridges being unsuccessful will be based on:

- *No photographic evidence of arboreal fauna successfully crossing the rope bridge or other evidence of complete crossings (i.e. ear tags, notches).*
- *Unacceptable levels of road strike (presence of deceased individuals during each sampling period for either year). For example, recording one or more gliders as road strike in both the winter and spring would be considered as unsuccessful and require contingency measures.*

Note, PIT tagging of captured animals was used in place of ear notching as an alternative (and ethically more sound) approach to identifying individual animals during the mark-recapture component of the monitoring. This change in methodology was undertaken in consultation with TfNSW, DPIE and the EPA.

1.6 Monitoring timing

As per the EMP, monitoring was undertaken in autumn and spring of 2017, 2018 and 2019, with an additional 60-day aerial crossing monitoring period in autumn 2020.

1.7 Reporting

As per the EMP, annual reporting of monitoring results includes:

- A description of the monitoring methodology employed
- Results, including field data, of the monitoring surveys
- A discussion of the results, including how the results compare against key performance criteria
- General recommendations including the need for any corrective actions/contingency measures.

All reports prepared under the EMP will be submitted to NSW DPIE and the NSW EPA.

1.8 Limitations

The following limitations to the monitoring procedure were encountered:

- The camera detection system is designed to maximise the likelihood that any animal using the structures is photographed, i.e. the cameras are fitted with motion detectors triggered to take photographs as animals pass by and the glider poles have collars to direct the animals through a single gap where the camera is trained. However, the highly mobile nature of gliders may result in their arrival on the structures at a variety of locations, all of which cannot be captured by the cameras. As a result complete passage across the structure/road may not always be captured. This limitation applies to both glider poles and rope bridges.

2. Survey Methods

2.1 Survey sites

Three aerial crossing zones (hereafter Sites 1, 2 and 3) are specified in the EMP. Site 1 and 2 each have a single canopy rope bridge and a set of glider poles consisting of a pole on each opposing road verge and a single median pole. Site 3 has a single canopy rope bridge and a single glider pole crossing, consisting of two median poles and one road verge pole (east), due to existing suitable trees to glide from/to on the opposing (western) road verge. The location of each crossing structure is provided in Figure 1.

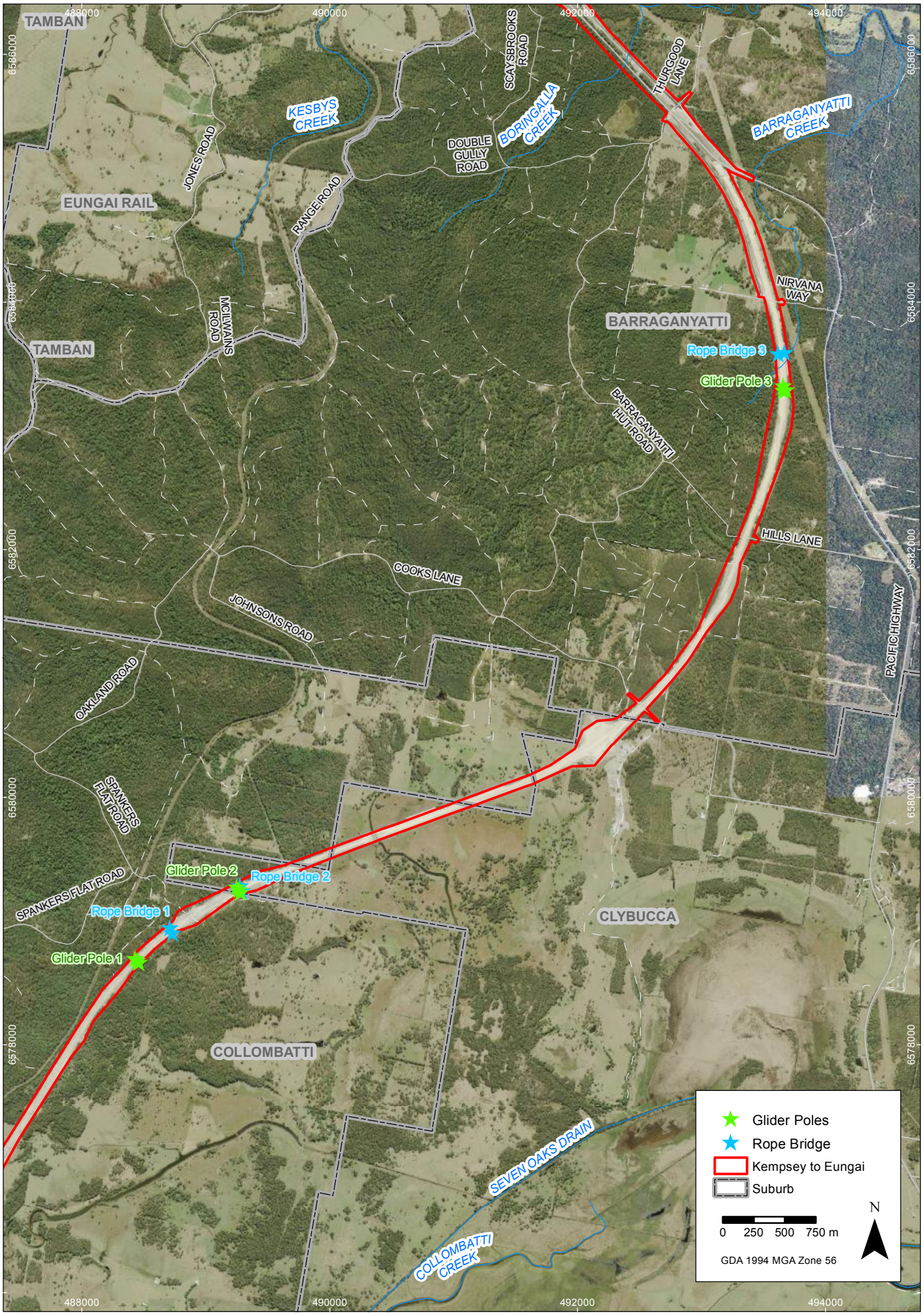
2.2 Survey method

2.2.1 Remote cameras

Automated cameras were installed at the top of each crossing structure pole. A single camera was installed on each glider pole and a single camera was installed at each end of the canopy rope bridges. Customised surveillance systems were installed at glider crossings and canopy rope bridges using BuckEye Cam X7D Covert IR wireless surveillance cameras (minimum response time 200 milliseconds) and standard antennae. Cameras were mounted on a customised adjustable camera mount or strut. Power is provided via a solar panel and extension power cable connected to a battery housing near ground level, which is mounted on each pole. Each glider pole was fitted with a collar to direct animals toward the camera in order to capture their image. Rope bridges were fitted with an external dual active infrared sensor to trigger cameras. All cameras were calibrated for short focus and reduced infrared output to maximise species identification. Images were downloaded wirelessly to ground level via X-Manager software installed on a laptop.

2.2.2 Arboreal trapping

The final trapping survey was undertaken in spring 2019 with detailed methods and results presented in the Aerial Crossing Monitoring Report 2019 (Niche 2020). A summary of all trapping survey results is provided in this report.



Drawn by: RJ Project Manager: CMcE Project Number: 1702 6.5 Date: 28/09/2018

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Location of Aerial Crossings

Frederickton to Eungai Pacific Highway Upgrade

FIGURE 1

Imagery: (c) LPI 2014-09-18

3. Results

Detailed remote camera data for the 2020 autumn monitoring are presented in Annex 1.

3.1 Remote cameras

The sixty-day autumn monitoring period was 23 March – 23 May 2020. However, given cameras function continuously outside of this period, fauna records obtained before and after the nominated 60-day monitoring period (6 December 2019- 2020) were included in the results as they are considered as value adding data. All cameras were functioning for the entire monitoring period.

3.1.1 Data summary

A total of 87 fauna records were analysed, of which 8 (9.2%) were within the 60-day monitoring period. Two target arboreal fauna were recorded within and outside of the 60-day monitoring period, including the Feathertail Glider (*Acrobates pygmaeus*) and Sugar Glider (*Petaurus breviceps*). The Brushtail Possum (*Trichosurus vulpecula*) was recorded outside of the 60-day monitoring period. Of the six Sugar Glider records from three sites, only one was within the 60-day monitoring period (site 1) and of the 76 Feathertail Glider records from three sites, only four records were within the 60-day monitoring period from one site (site 1). The inclusion of additional data has therefore identified use of two additional crossing zones by these species for this monitoring period.

3.1.2 Glider crossings

In accordance with the performance indicators of the EMP, a successful crossing is considered to have occurred if an individual animal is detected using the median pole. Photographic data was also analysed for the detection of the same species in rapid succession on both the western and eastern road verge poles at Sites 1 and 2 as an indication of a successful crossing.

Sugar Gliders were recorded at all three sites and were noted as using the median glider poles on one occasion at both Site 1 and Site 3. The Feathertail Glider was observed frequently using the road verge poles and was detected on the median poles at Site 1 and 3. The results of the glider pole use by various glider species is summarised below and in Table 1.

Site 1

- Feathertail Gliders were detected using the median pole, eastern and western road verge poles.
- Sugar Gliders were detected using the median pole and western road verge pole.
- There were no quick succession records between any of the poles.

Site 2

- Feathertail Gliders were detected using the eastern and western road verge poles.
- One Sugar Glider was detected using the western road verge pole.
- There were no median pole records.
- There were no quick succession records between the any of the poles.

Site 3

- Feathertail and Sugar Gliders were detected using the second median pole.
- Feathertail Gliders were detected using the eastern verge pole (no western pole).
- There were no quick succession records between the any of the poles.

Table 1: Fauna use of glider crossings during autumn 2020

Species	Site 1			Site 2			Site 3		
	Eastern	Median	Western	Eastern	Median	Western	Eastern	Median1	Median2
Feathertail Glider	Y (2)	Y (1)	Y (7)	Y (1)		Y (3)	Y (10)		Y (6)
Sugar Glider		Y (1)	Y (3)			Y (1)			Y (1)
Yellow-bellied Glider									

(n) = number of separate occasion the species was detected, Y = yes detected.

3.1.3 Canopy rope bridges

As for the glider crossings, photographic data was analysed for the detection of the same species in rapid succession at both the western and eastern ends of the crossing as an indication of a successful crossing.

Two arboreal mammal species, the Brushtail Possum and Feathertail Glider, were detected using the canopy rope bridges. The Brushtail Possum was recorded on two occasions during the same night at rope bridge 1, western side only. The species was recorded travelling in both directions approximately 17 minutes apart. This implies that either an individual entered onto the rope bridge but did not complete a crossing before returning, or that the eastern camera did not detect one or more individuals leaving and/or entering the rope bridge. The Feathertail Glider was recorded at rope bridge 3, eastern and western sides on 20 and 26 occasions, respectively.

3.1.4 Site summary

Table 2, Table 3 and Table 4 provide a summary of the records from each site for autumn 2020. Detection frequency was much higher on glider crossings with only one target species recorded using the canopy rope bridges.

Table 2: Site 1 remote camera records autumn 2020

Camera	Species (occasions detected)	Detection frequency (mammals)
GP1 East	Feathertail Glider (2)	2
GP1 Med	Feathertail Glider (1) Sugar Glider (1)	2
GP1 West	Feathertail Glider (7) Sugar Glider (3)	10
RB1 East	No fauna	0
RB1 West	Brushtail Possum (2) Raven (3)	2

Table 3: Site 2 remote camera records autumn 2020

Camera	Species (occasions detected)	Detection frequency (mammals)
GP2 East	Feathertail Glider (1)	1
GP2 Med	No fauna	0
GP2 West	Feathertail Glider (3) Sugar Glider (1)	4
RB2 East	No fauna	0
RB2 West	No fauna	0

Table 4: Site 3 remote camera records autumn 2020

Camera	Species (occasions detected)	Detection frequency (mammals)
GP3 East	Feathertail Glider (10)	10
GP3 Med	No fauna	0
GP3 Med2	Feathertail Glider (6) Sugar Glider (1)	7
RB3 East	Feathertail Glider (20)	20
RB3 West	Feathertail Glider (26)	26

3.2 Road kill

Road kill monitoring results are presented in the Frederickton to Eungai Fauna Underpass and Associated Fauna Fencing Monitoring report 2018/2019 (Niche 2018b, Niche 2019b). While road strike monitoring was not part of aerial crossing monitoring, the EMP requires specific reporting on the presence of road strike gliders at or in vicinity of aerial crossings. Data presented within Niche (2018b, 2019b) did not report any records of road kill glider species.

3.3 Cumulative analysis

3.3.1 Glider poles

In some cases, it was not possible to definitively distinguish between the threatened Squirrel Glider (*Petaurus norfolcensis*) and the Sugar Glider due to partial or blurred images. Glider images where a Squirrel Glider identification was considered possible but not definite, are referred to as Sugar/Squirrel Glider records.

To date, the outcome of the glider pole use by various glider species over the course of the three year monitoring period is provided in Table 5 and can be summarised as follows:

Site 1

- Feathertail and Sugar Gliders have been detected using the median, eastern and western road verge poles.
- There has been one quick succession record from the western road verge to median pole by a Feathertail Glider in 2019 (Niche 2020).
- The median pole has a much lower detection frequency than the eastern and western verge poles (7 *cf* 22 and 51 respectively).
- The threatened Yellow-bellied Glider has been recorded on the western pole.

Site 2

- Feathertail, Sugar and Yellow-bellied Gliders have been detected using the median, eastern and western road verge poles.
- There have been three occurrences of quick succession records; one from the eastern to western road verge poles in 2017 by a Feathertail Glider (Niche 2018a) and two from the median pole to western road verge pole by a Yellow-bellied Glider (Niche 2020).
- The median pole has a similar detection frequency to the eastern and western verge poles (30 *cf* 24 and 44 respectively).
- The threatened Yellow-bellied Glider has been recorded on all three glider poles.
- The threatened Brush-tailed Phascogale (*Phascogale tapoatafa*) has been recorded on the eastern verge pole.

Site 3

- Feathertail and Sugar Gliders have been detected using both median poles, however median pole 2 has a much lower detection frequency (35 *cf* 15).
- Feathertail and Sugar Gliders have been detected using the eastern verge pole (no western pole).
- Median pole 1 has a lower detection frequency than the eastern verge pole (35 *cf* 85).

Table 5: Cumulative glider pole records for the entire three-year monitoring period

Species	Site 1			Site 2			Site 3		
	Eastern	Median	Western	Eastern	Median	Western	Eastern	Median1	Median2
Feathertail Glider	✓ (14)	✓ (5)	✓ (40)	✓ (12)	✓ (12)	✓ (29)	✓ (83)	✓ (30)	✓ (13)
Sugar Glider	✓ (5)	✓ (2)	✓ (7)	✓ (5)	✓ (9)	✓ (7)	✓ (1)		✓ (2)
Sugar/Squirrel Glider	✓ (3)				✓ (5)	✓ (5)	✓ (1)	✓ (4)	
Yellow-bellied Glider			✓ (3)	✓ (4)	✓ (3)	✓ (3)			
Unknown mammal			✓ (1)	✓ (2)	✓ (1)			✓ (1)	
Brush-tailed Phascogale				✓ (1)					

(n) = number of separate occasions the species was detected.

3.3.2 Canopy rope bridges

To date, the outcome of the canopy rope bridge use by arboreal species is provided in Table 6 and can be summarised as follows:

Site 1

- Arboreal species have not been detected at **both** the eastern and western ends.
- There have been no quick succession records between the eastern and western ends.
- Feathertail Gliders and Brushtail Possums have been detected at the western end.

Site 2

- Arboreal species have not been detected at **both** the eastern and western ends.
- There have been no quick succession records between the eastern and western ends.
- Sugar and Feathertail Gliders have been detected at the western end.

Site 3

- Sugar and Feathertail Gliders have been detected at both the eastern and western ends.
- There have been no quick succession records between the eastern and western ends.
- Brushtail Possums have been detected at the eastern end.

Table 6: Cumulative canopy rope bridge records for the entire three-year monitoring period

Species	Site 1		Site 2		Site 3	
	Eastern	Western	Eastern	Western	Eastern	Western
Feathertail Glider		✓ (27)		✓ (29)	✓ (38)	✓ (43)
Sugar Glider				✓ (1)	✓ (2)	✓ (2)
Brushtail Possum		✓ (2)			✓ (2)	
Australian Magpie			✓ (1)	✓ (1)		
Corvus spp.	✓ (55)	✓ (21)	✓ (18)	✓ (54)		
Laughing Kookaburra				✓ (10)		
Small bird				✓ (1)		
Butcher Bird				✓ (2)		
Kite/bird of prey				✓ (1)		

(n) = number of separate occasion the species was detected.

3.3.3 Arboreal trapping summary

The final arboreal trapping surveys were undertaken in spring 2019, with results present in the Aerial Crossing Monitoring 2019 Report (Niche 2020). A total of eight species and 37 individuals have been captured over the monitoring program, including the Sugar Glider, Common Brushtail Possum (*Trichosurus vulpecula*), *Melomys* sp., Black Rat (*Rattus rattus*), Bush Rat (*Rattus fuscipes*), *Rattus* sp., *Antechinus* sp. and Brown Antechinus (*Antechinus stuartii*). Table 7 summarises the species captured at each site during the three year monitoring program. No individuals were recaptured on opposite sides of the carriageway.

Table 7: Cumulative arboreal trapping records for the entire three-year monitoring program

Species	Site 1	Site 2	Site 3
Sugar Glider	Y (3)	Y (5)	
Common Brushtail Possum	Y (1)	Y (3)	Y (2)
Melomys sp.			Y (3)
Black Rat	Y (1)	Y (1)	
Bush Rat	Y (1)		
Rattus sp.		Y (1)	Y (2)
Brown Antechinus	Y (4)	Y (2)	Y (5)
Antechinus sp.	Y (2)	Y (1)	

(n) = number of captures, Y = yes.

3.4 Comparison with baseline data

Baseline surveys in adjacent bushland detected a number of arboreal and scansorial mammal species near some or all aerial crossing locations, including: Brush-tailed Phascogale, Yellow-bellied Glider, Sugar Glider, Greater Glider (*Petauroides volans*), Feathertail Glider, Common Ringtail Possum (*Pseudocheirus peregrinus*), Common Brushtail Possum, Mountain Brushtail Possum (*Trichosurus cunninghami*), Bush Rat (*Rattus fuscipes*), and Brown Antechinus. Of these 10 species, four (the Yellow-bellied Glider, Sugar Glider, Feathertail Glider and Brushtail Possum) have been observed using the aerial crossing structures and another two (the Brown Antechinus and Brush-tailed Phascogale) have been recorded in the vicinity of the crossings. Three of the four glider species previously recorded (with the exception of the Greater Glider) have been detected on the glider crossings and canopy rope bridges. There were a number of possible, but not definite, Squirrel Glider records.

4. Discussion

4.1 Performance measures

A summary of the current (autumn 2020 camera records), and the cumulative results in relation to the performance indicators is provided in Table 8 to Table 11. As stated in the EMP, indicators of success for the glider poles and rope bridges include one or more of the performance indicators.

Table 8: Indicators of success for the glider poles

Indicators of success	Discussion
Evidence of use by any glider species using the median pole.	**This performance indicator of success has been met for all sites.** Cumulative results show the median glider poles at Sites 1 and 3 have been used by Feathertail and Sugar Gliders. The median pole at Site 2 has been used by Feathertail, Sugar and Yellow-bellied Gliders.
Photographic evidence of a glider using both the eastern and western poles.	**This performance indicator of success has been met at site 2.** There has been one occurrence of quick succession records from the east to west road verge poles in 2017 by a Feathertail Glider (Niche 2018a).
One or more gliders with left ear tag/notch occurring on the western side of the carriageway and fauna with right ear tag/notch occurring on the eastern side of the carriageway.	**This performance indicator of success has not been met.** Implantation of PIT microchips was implemented (in consultation with TfNSW, DPIE and the EPA) as an alternative method to ear notching to identify individual animals. There have been no captures of individually marked animals on both sides of the road.

Table 9: Signs of the glider poles being unsuccessful

Signs of the glider poles being unsuccessful	Discussion
Absence of gliders being recorded using the median pole or other evidence of complete crossings.	**This sign of unsuccessful mitigation has not been met.** The median glider poles at all sites have been used by at least one glider species.
Unacceptable levels of road strike (presence of deceased individuals during each sampling period for either year). For example, recording one or more gliders as road strike in both monitoring seasons would be considered as unsuccessful and require contingency measures.	**This sign of unsuccessful mitigation has not been met.** There have been no records of road kill glider species from the road kill monitoring results.

Table 10: Indicators of success for the canopy rope bridges

Indicators of success	Discussion
Photographic evidence of any arboreal species using both sides of the rope ladder to indicate a successful passage.	**This performance indicator of success has not been met.** No individual has been recorded using both sides of a crossing in rapid succession.
One or more arboreal species with left ear tag/notch occurring on the western side of the carriageway and arboreal fauna with right ear tag/notch occurring on the eastern side of the carriageway.	**This performance indicator of success has not been met.** Implantation of PIT microchips was implemented (in consultation with TfNSW, DPIE and the EPA) as an alternative method to ear notching to identify individual animals. There were no captures of individually marked animals on both sides of the road.

Table 11: Signs of the rope bridges being unsuccessful

Signs of the rope bridges being unsuccessful	Discussion
No photographic evidence of arboreal fauna successfully crossing the rope bridge or other evidence of complete crossings (i.e. ear tags, notches).	**This sign of unsuccessful mitigation has been met.** No individual has been recorded using both sides of a crossing in rapid succession.
Unacceptable levels of road strike (presence of deceased individuals during each sampling period for either year). For example, recording one or more gliders as road strike in both the winter and spring would be considered as unsuccessful and require contingency measures.	**This sign of unsuccessful mitigation has not been met.** There have been no records of road kill glider species from the road kill monitoring results.

5. Recommendations

5.1 Contingency measures

The EMP lists potential problems and contingency measures for various components of the monitoring program. Those that are considered to be relevant to the aerial crossing monitoring program are listed and discussed in Table 12.

Table 12: Contingency measures

Potential problem	Contingency measure proposed in EMP	Discussion of proposed measure
No fauna recorded using the poles or rope ladder canopy bridges No evidence or marked/tagged gliders crossing the carriageway.	• Review other monitoring data. • Review planting schedules/status of vegetation bordering the poles and/or rope ladder canopy bridges. • Review monitoring program and make necessary adjustments. • Consider placing lead/lure ropes from neighbouring trees to the poles and/or rope ladder canopy bridges.	***Glider poles***: In accordance with the EMP, use of the median pole of glider crossings is considered to represent a successful crossing, despite the absence of recapture data and quick succession records. Glider species have been recorded using median poles at all sites and it is considered likely that resident Yellow-bellied Gliders are using the glider poles to move between habitat and denning sites on either side of the highway. **These contingency measures are therefore not considered relevant for glider pole crossings.** ***Rope bridges***: Successful crossings of canopy rope bridges have not been confirmed. However, the majority of fauna detected using the canopy rope bridges are glider species. As gliders may arrive and depart from the rope bridge at an undefined point, they may do so without triggering the second camera. The absence of scansorial fauna and few records of non-gliding arboreal mammals is however noted. **These contingency measures are therefore considered relevant for canopy rope bridges.**
Unacceptable levels of road strike for gliders (>1 during each monitoring event for Year 1, Year 2, Year 3)	• Review current information of glider pole plane angles. • Consider design adjustment that could improve the usability of the poles and/or rope ladder canopy bridges. • Review the extent of vegetation in the median.	**These contingency measures are not considered relevant.** There have been no road kill records of glider species.

5.2 Recommendations

In relation to the relevant contingency measures noted above (Table 12), and performance indicators that have not been met, a number of recommendations have been made. These are detailed in Table 13 below.

Table 13: Recommendations

Problem identified during monitoring	Relevant contingency measures	Discussion of contingency measure/recommendation
Successful crossings of canopy rope bridges have not been confirmed.	• Review other monitoring data. • Review planting schedules/status of vegetation bordering the poles and/or rope ladder canopy bridges. • Review monitoring program and make necessary adjustments. • Consider placing lead/lure ropes from neighbouring trees to the poles and/or rope ladder canopy bridges.	**Review of other monitoring data** Baseline surveys indicate the presence of arboreal fauna at all three crossing zones that might be expected to use canopy rope bridges. Trapping data has confirmed presence of arboreal species the Sugar Glider and Common Brushtail Possum at Sites 1 and 2. Further, *Antechinus* spp. have been detected at all three sites whilst *Melomys* sp. (Site 3) and the Bush Rat (Site 1) were detected at one site. In addition, nest box data (Niche 2019c) shows records of the Sugar Glider and Brushtail Possum occupying nest boxes adjacent to rope bridge 1; the Sugar Glider, Yellow-bellied Glider and Brushtail Possum occupying nest boxes adjacent to rope bridge 2; the Brushtail Possum and Common Ringtail Possum occupying nest boxes adjacent to rope bridge 3. These additional data confirm the presence of arboreal fauna in habitat adjacent to the crossing zones. **Review of vegetation bordering the aerial crossings** A review of the vegetation status immediately adjacent to the canopy rope bridges was undertaken by TfNSW in September 2020 and can be summarised as follows: • All locations were planted with additional advanced size trees and tubestock during construction at the request of EPA. • Advanced size plantings have now reached the height of the lead ropes while the tubestock plantings are now approximately 2-3 metres tall. • At the request of the Project Verifier (Ben Lewis for Jacobs) during the landscape maintenance period, a second program of additional plantings was agreed to during the first year of maintenance. Tubestock tree species were planted in all available gaps. • RB1 east (Plate 1): Space exists between the pole and the current plantings for additional planting. • RB1 west (Plate 2): The presence of a concrete drainage channel at this location precludes additional plantings. • RB2 east (Plate 3): There is limited space for additional plantings beyond the required fauna exclusion fence maintenance zone. • RB2 west (Plate 4): Existing planting enveloping the pole, additional planting not necessary. • RB3 east (Plate 5): There is limited space for additional plantings beyond the required fauna exclusion fence maintenance zone. • RB3 west (Plate 6): Space exists between the pole and adjacent canopy for additional planting **Review of monitoring program** The monitoring program as required by the EMP is now complete. As the cameras have been installed and are designed to function continually throughout the year, consideration should be given to ongoing downloading of camera images in an effort to capture additional crossings by fauna. Seasonal downloads could be undertaken, and all photographic records retained, as opposed to defined monitoring periods **Review of lead ropes** A review of the lead rope connectivity of the canopy rope bridges was undertaken by TfNSW in September 2020. All poles were originally installed as per the design, with three lead ropes. An additional lead rope was installed at the request of EPA during construction. It is considered that additional lead ropes are unlikely to increase the use of the canopy rope bridges.

<table>
<tr><th>Problem identified during monitoring</th><th>Relevant contingency measures</th><th>Discussion of contingency measure/recommendation</th></tr>
<tr><td></td><td></td><td>Recommendations
Based on the above information, recommendations and actions are outlined below.<table><tr><th>Recommendation</th><th>TfNSW response</th></tr><tr><td>The above review data should be discussed with EPA to provide opportunity to incorporate findings of other Pacific Highway Upgrade project outcomes</td><td>A meeting with EPA to discuss the outcomes and further actions occurred on 24 November 2020. The actions below were discussed with and endorsed by EPA.</td></tr><tr><td>Additional plantings of tubestock tall tree species at RB1 east and RB3 west</td><td>TfNSW will undertake plantings as recommended.</td></tr><tr><td>Ongoing downloading of aerial camera data to capture additional crossings by fauna for a period of one year, or less if the canopy rope bridges are deemed successful within the year, to determine success in accordance with the performance measure: Photographic evidence of any arboreal species using both sides of the rope ladder to indicate a successful passage.
Success for all three rope canopy crossings should be considered where at least one of the canopy rope bridges record a successful passage. This success is considered to be an inferred success based on the similarity of the structures, i.e. same crossing lengths and canopy heights, i.e. it takes into account variability in fauna density/movement and acknowledges that where one structure has been shown to be suitable for fauna crossings, the remaining structure may also be considered suitable.</td><td>Ongoing monitoring will be undertaken at all three canopy rope bridge sites over a period of one year, or less if the canopy rope bridges are deemed successful within the year.
If success for at least one of the canopy rope bridges is not confirmed within the year, further discussions with EPA would be undertaken.</td></tr></table></td></tr>
<tr><td>Recaptures of tagged fauna have not been made on either side of the road, therefore there is no evidence of tagged fauna crossing the carriageway.</td><td></td><td>Due to low capture rate of fauna combined with the limited trapping effort, it is considered that this means of identifying successful crossings is unlikely to result in positive outcomes. It is likely that a substantial increase in trapping effort would be required to obtain the necessary micro chipping numbers to provide results based on mark-recapture surveys.
Further trapping is not recommended as a means of determining successful crossing of the rope bridges as it is unlikely to provide additional useful data.</td></tr>
</table>

Plate 1: RB1 east

Plate 2: RB1 west

Plate 3: RB2 east

Plate 4: RB2 west

Plate 5: RB3 east

Plate 6: RB3 west

6. References

Lewis, B.D. (2013). Ecological Monitoring Report: Frederickton to Eungai Upgrade. Report prepared for Roads and Maritime Services by Lewis Ecological Surveys.

Lewis, B.D. (2005). Kempsey to Eungai Pacific Highway Upgrade: Fauna Survey. Report prepared by Lewis Ecological Services for Parsons Brinckerhoff-Sydney.

Niche (2020). Aerial Crossing Monitoring 2019. Prepared for Transport for NSW.

Niche (2019a). Aerial Crossing Monitoring 2018. Prepared for NSW Roads and Maritime Services.

Niche (2019b). Fauna Underpasses and Associated Fauna Fence Monitoring Report 2018/2019. Prepared for NSW Roads and Maritime Services.

Niche (2019c). Nest Box Monitoring 2018/2019. Prepared for NSW Roads and Maritime Services.

Niche (2018a). Aerial Crossing Monitoring 2017. Prepared for NSW Roads and Maritime Services.

Niche (2018b). Fauna Underpasses and Associated Fauna Fence Monitoring Report 2017/2018. Prepared for NSW Roads and Maritime Services.

RMS (2016). Frederickton to Eungai Pacific Highway Upgrade Ecological Monitoring Program. Roads and Maritime Update to report prepared by Lewis Ecological Surveys, May 2016.

Annex 1 – Remote camera results

Table 14: Remote camera records - autumn 2020

Records occurring within the 60-day monitoring period are highlighted in bold and results are sorted by site and date.

Monitoring period	Site	Season	Pole	Camera	Date	Time	Species
Autumn	1	Summer	GP1 east	1	28/12/2019	2:59:41	Feathertail Glider
Autumn	**1**	**Autumn**	**GP1 east**	**1**	**31/03/2020**	**22:20:19**	**Feathertail Glider**
Autumn	1	Summer	GP1 mid	2	26/12/2019	2:52:02	Feathertail Glider
Autumn	1	Winter	GP1 mid	2	24/06/2020	3:39:08	Sugar Glider
Autumn	1	Summer	GP1 west	3	26/01/2020	4:02:28	Feathertail Glider
Autumn	1	Summer	GP1 west	3	27/01/2020	0:24:12	Sugar Glider
Autumn	1	Summer	GP1 west	3	30/01/2020	3:45:26	Feathertail Glider
Autumn	1	Summer	GP1 west	3	2/02/2020	0:09:14	Sugar Glider
Autumn	1	Summer	GP1 west	3	4/02/2020	23:09:59	Feathertail Glider
Autumn	1	Summer	GP1 west	3	6/02/2020	0:19:53	Feathertail Glider
Autumn	**1**	**Autumn**	**GP1 west**	**3**	**26/03/2020**	**23:16:08**	**Feathertail Glider**
Autumn	**1**	**Autumn**	**GP1 west**	**3**	**27/04/2020**	**1:03:32**	**Feathertail Glider**
Autumn	**1**	**Autumn**	**GP1 west**	**3**	**12/05/2020**	**20:03:35**	**Sugar Glider**
Autumn	**1**	**Autumn**	**GP1 west**	**3**	**23/05/2020**	**22:21:31**	**Feathertail Glider**
Autumn	1	Summer	RB1 west	5	18/01/2020	1:08:16	Brushtail Possum
Autumn	1	Summer	RB1 west	5	18/01/2020	1:25:10	Brushtail Possum
Autumn	**1**	**Autumn**	**RB1 west**	**5**	**21/04/2020**	**9:34:41**	**Raven**
Autumn	**1**	**Autumn**	**RB1 west**	**5**	**2/05/2020**	**4:54:43**	**Raven**
Autumn	**1**	**Autumn**	**RB1 west**	**5**	**14/05/2020**	**7:40:50**	**Raven**
Autumn	2	Summer	GP2 east	8	26/01/2020	4:01:05	Feathertail Glider
Autumn	2	Summer	GP2 west	10	1/01/2020	21:51:45	Feathertail Glider
Autumn	2	Summer	GP2 west	10	14/01/2020	23:05:08	Feathertail Glider
Autumn	2	Summer	GP2 west	10	26/01/2020	1:34:56	Sugar Glider
Autumn	2	Summer	GP2 west	10	16/02/2020	21:44:07	Feathertail Glider
Autumn	3	Summer	GP3 east	11	9/12/2019	1:12:37	Feathertail Glider
Autumn	3	Summer	GP3 east	11	14/12/2019	21:58:10	Feathertail Glider
Autumn	3	Summer	GP3 east	11	15/12/2019	22:53:07	Feathertail Glider
Autumn	3	Summer	GP3 east	11	17/12/2019	22:45:23	Feathertail Glider
Autumn	3	Summer	GP3 east	11	17/12/2019	23:16:35	Feathertail Glider
Autumn	3	Summer	GP3 east	11	19/12/2019	0:32:00	Feathertail Glider
Autumn	3	Summer	GP3 east	11	19/12/2019	0:55:55	Feathertail Glider
Autumn	3	Summer	GP3 east	11	19/12/2019	22:41:17	Feathertail Glider
Autumn	3	Summer	GP3 east	11	20/12/2019	0:38:50	Feathertail Glider
Autumn	3	Summer	GP3 east	11	20/12/2019	3:41:14	Feathertail Glider
Autumn	3	Summer	GP3 mid2	13	21/12/2019	2:34:00	Feathertail Glider
Autumn	3	Summer	GP3 mid2	13	27/12/2019	23:25:41	Sugar Glider
Autumn	3	Summer	GP3 mid2	13	28/12/2019	4:35:35	Feathertail Glider
Autumn	3	Summer	GP3 mid2	13	3/01/2020	1:09:29	Feathertail Glider

Monitoring period	Site	Season	Pole	Camera	Date	Time	Species
Autumn	3	Summer	GP3 mid2	13	7/01/2020	0:47:42	Feathertail Glider
Autumn	3	Summer	GP3 mid2	13	17/02/2020	23:23:47	Feathertail Glider
Autumn	3	Summer	GP3 mid2	13	19/02/2020	2:10:22	Feathertail Glider
Autumn	3	Summer	RB3 east	14	6/12/2019	1:36:31	Feathertail Glider
Autumn	3	Summer	RB3 east	14	6/12/2019	4:36:10	Feathertail Glider
Autumn	3	Summer	RB3 east	14	7/12/2019	1:19:56	Feathertail Glider
Autumn	3	Summer	RB3 east	14	10/12/2019	3:50:00	Feathertail Glider
Autumn	3	Summer	RB3 east	14	10/12/2019	4:30:56	Feathertail Glider
Autumn	3	Summer	RB3 east	14	10/12/2019	22:48:50	Feathertail Glider
Autumn	3	Summer	RB3 east	14	11/12/2019	4:38:04	Feathertail Glider
Autumn	3	Summer	RB3 east	14	12/12/2019	3:14:33	Feathertail Glider
Autumn	3	Summer	RB3 east	14	12/12/2019	4:43:55	Feathertail Glider
Autumn	3	Summer	RB3 east	14	13/12/2019	20:43:45	Feathertail Glider
Autumn	3	Summer	RB3 east	14	13/12/2019	23:29:01	Feathertail Glider
Autumn	3	Summer	RB3 east	14	17/12/2019	1:47:20	Feathertail Glider
Autumn	3	Summer	RB3 east	14	17/12/2019	3:00:24	Feathertail Glider
Autumn	3	Summer	RB3 east	14	18/12/2019	4:38:21	Feathertail Glider
Autumn	3	Summer	RB3 east	14	19/12/2019	1:40:38	Feathertail Glider
Autumn	3	Summer	RB3 east	14	19/12/2019	23:49:04	Feathertail Glider
Autumn	3	Summer	RB3 east	14	20/12/2019	1:19:35	Feathertail Glider
Autumn	3	Summer	RB3 east	14	20/12/2019	1:22:29	Feathertail Glider
Autumn	3	Summer	RB3 east	14	20/12/2019	1:38:24	Feathertail Glider
Autumn	3	Summer	RB3 east	14	20/12/2019	2:33:56	Feathertail Glider
Autumn	3	Summer	RB3 west	15	6/12/2019	1:46:20	Feathertail Glider
Autumn	3	Summer	RB3 west	15	6/12/2019	3:43:41	Feathertail Glider
Autumn	3	Summer	RB3 west	15	8/12/2019	3:19:44	Feathertail Glider
Autumn	3	Summer	RB3 west	15	10/12/2019	22:50:02	Feathertail Glider
Autumn	3	Summer	RB3 west	15	11/12/2019	2:24:37	Feathertail Glider
Autumn	3	Summer	RB3 west	15	12/12/2019	4:19:00	Feathertail Glider
Autumn	3	Summer	RB3 west	15	12/12/2019	4:42:59	Feathertail Glider
Autumn	3	Summer	RB3 west	15	14/12/2019	0:24:48	Feathertail Glider
Autumn	3	Summer	RB3 west	15	17/12/2019	2:59:38	Feathertail Glider
Autumn	3	Summer	RB3 west	15	19/12/2019	23:48:15	Feathertail Glider
Autumn	3	Summer	RB3 west	15	20/12/2019	1:39:40	Feathertail Glider
Autumn	3	Summer	RB3 west	15	21/12/2019	2:01:42	Feathertail Glider
Autumn	3	Summer	RB3 west	15	22/12/2019	0:57:53	Feathertail Glider
Autumn	3	Summer	RB3 west	15	23/12/2019	3:13:40	Feathertail Glider
Autumn	3	Summer	RB3 west	15	24/12/2019	21:52:32	Feathertail Glider
Autumn	3	Summer	RB3 west	15	25/12/2019	23:39:52	Feathertail Glider
Autumn	3	Summer	RB3 west	15	26/12/2019	1:32:50	Feathertail Glider
Autumn	3	Summer	RB3 west	15	26/12/2019	2:24:39	Feathertail Glider
Autumn	3	Summer	RB3 west	15	26/12/2019	3:18:13	Feathertail Glider
Autumn	3	Summer	RB3 west	15	26/12/2019	3:39:28	Feathertail Glider

Monitoring period	Site	Season	Pole	Camera	Date	Time	Species
Autumn	3	Summer	RB3 west	15	26/12/2019	23:27:35	Feathertail Glider
Autumn	3	Summer	RB3 west	15	27/12/2019	3:10:49	Feathertail Glider
Autumn	3	Summer	RB3 west	15	27/12/2019	4:12:09	Feathertail Glider
Autumn	3	Summer	RB3 west	15	27/12/2019	4:35:17	Feathertail Glider
Autumn	3	Summer	RB3 west	15	28/12/2019	1:06:46	Feathertail Glider
Autumn	3	Summer	RB3 west	15	28/12/2019	2:02:46	Feathertail Glider

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