

Appendix 14b

Environmental Radiation Impacts (Non-Human Biota)

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ENVIRONMENTAL RADIATION IMPACTS (NON-HUMAN BIOTA)

COPI PROJECT

RZ RESOURCES

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EXECUTIVE SUMMARY

RZ Resources Pty Ltd (RZR) plans to develop the Copi Mineral Sands Project (the Project), approximately 75 km north-west of Wentworth, New South Wales.

The Project will involve open cut mining of the Copi mineral sands orebody over a 17.2-year period extracting up to 27.1 million tonnes per year (Mtpa). It will supply rutile, zircon and rare earth element bearing minerals to domestic and offshore markets.

There is a requirement to demonstrate that non-human species living in natural habitats are protected against ionising radiation risks from radionuclides released to the environment by human actions such as the Copi Project.

A Tier 2 assessment was undertaken for the Project to identify if an Environmental Reference Level (ERL) was exceeded. Using the ERICA software tool, a site scenario was considered. Namely exposure to biota, in a terrestrial ecosystem within the Project area following 17 years of dust deposition arising from operations. Species of flora and fauna native to the area, and/or referenced in the *Biodiversity Development Assessment Report* for the Project were considered.

The results of the modelling have identified that dose rate values, for all species assessed, are considerably less than ERL values.

It was concluded that even using extremely conservative criteria, the radiological risk on any non-human biota identified in the Project area will be negligible.

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1 INTRODUCTION

1.1 PURPOSE OF THIS REPORT

RZ Resources Pty Ltd (RZR) plans to develop the Copi Mineral Sands Project (the Project), approximately 75 km north-west of Wentworth, New South Wales.

The Project will involve open cut mining of the Copi mineral sands orebody over a 17.2-year period extracting up to 27.1 million tonnes per year (Mtpa). It will supply rutile, zircon and rare earth element bearing minerals to domestic and offshore markets.

This report outlines the radiological impact to the natural environment associated with the proposed mine, and processing plant.

2 REGULATORY REQUIREMENT

2.1 NON-HUMAN BIOTA (NHB)

It is generally accepted that there is a need to demonstrate, rather than assume, that non-human species living in natural habitats are protected against ionising radiation risks from radionuclides released to the environment by human actions. For the uranium and mineral sands industry, protection should be based on world's best practice standards.

One of the principal objectives of the NSW *Protection from Harmful Radiation Act 1990* is to 'secure the protection of persons and the **environment** from exposure to ionising radiation to the maximum extent that is reasonably practicable'.

3 OVERVIEW & SCOPE

Australia's system for managing radiation risks from ionising radiation is closely aligned with international best practice as stipulated by the International Commission on Radiological Protection (ICRP) and the International Atomic Energy Agency (IAEA). Protection of the environment from the harmful effects of radiation is integral to these recognised systems.

It is generally accepted that there is a need to demonstrate, rather than assume, that non-human species living in natural habitats are protected against ionising radiation risks from radionuclides released to the environment by human actions. In Australia, this is recognized through a regulatory guidance document – the *Guide for Radiation Protection of the Environment* (2015) (RPS G-1, 2015). The Guide outlines the framework for protection of the environment from the harmful effects of ionising radiation and the practical aspects of the process through which protection can be demonstrated. The Guide was used as the basis for the Copi Project assessment.

An Australian 'top-tier' radiation protection document, *Fundamentals for Protection Against Ionising Radiation* (RPS F-1 2014) includes environmental considerations as one of the exposure categories. The document defines environmental exposure as:

“the exposure of wildlife to all additional radiation sources resulting from human activities. Wildlife may require protection in order to maintain biological diversity, conservation of species, or the health and status of natural habitats, communities or ecosystems, or anything that may be otherwise required from a conservation point of view in accordance with relevant legislation.”

The protection objective is to ensure maintenance of robust wildlife populations. This involves demonstrating that radiation exposures are of no regulatory concern in relation to the maintenance of biological diversity, the conservation of species, or on the health of natural ecosystems.

This assessment considers the wildlife inhabiting and potentially impacted within the Copi Project mining footprint.

3.1 SCOPE EXCLUSIONS

The assessment excludes consideration of protection of the environment for recreational food gathering, or the protection of livestock. Land within the Copi Project footprint is currently used for low intensity grazing, including sheep and the harvesting of feral goats (EIS Copi, 3.12.2.2).

Technically, wild goats could be considered as ‘livestock’, however due to their abundance, they have been considered as a wildlife species for the purposes of this assessment.

Potential radiological impacts relating to human exposures are considered elsewhere (DBH 2025).

4 ENVIRONMENT PROTECTION CONCEPTS

4.1 DOSIMETRIC QUANTITIES FOR WILDLIFE PROTECTION

The fundamental dosimetric quantity is the absorbed dose, i.e. the energy absorbed per unit mass of the material with which the radiation interacts. Absorbed dose is measured in the unit ‘gray’ (Gy).

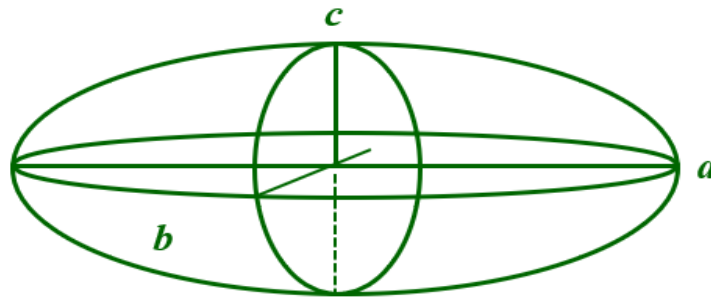
It is relevant to relate the likelihood of occurrence of radiation effects on wildlife to the absorbed ‘dose rate’ resulting from long-term chronic exposures in units of ‘microgray per hour’ ($\mu\text{Gy}\cdot\text{h}^{-1}$).

4.2 REFERENCE ORGANISMS

Among the organisms that inhabit a particular environment where radiation exposures are elevated, it is practical to identify representative organisms, which are typical of that environment or necessary for the structural or functional integrity of an ecosystem exposed to radiation.

As an approximation, and to facilitate assessments with a reasonable degree of confidence, the assessment and decision-making can be built around reference organisms. These are hypothetical representations of wildlife using a simplified (ellipsoid) geometry (Figure 1), and broadly representative of a group of wildlife.

Figure 1: An ellipsoid geometry representative of an assessed organism.



4.3 ENVIRONMENTAL REFERENCE LEVELS

Environmental reference levels (ERLs) are dose rates (in $\mu\text{Gy}\cdot\text{h}^{-1}$) to wildlife, in addition to those incurred from exposure to 'background' radiation, at which a more considered evaluation of the situation and the potential detriment to wildlife might be reasonable, and which should be considered in the overall optimisation process. Calculated dose rates from the assessment are compared to these levels.

Chosen ERLs are defined with different considerations. ICRP considers Derived Consideration Reference Level (DCRL) values, in which stipulated dose rates are a band of dose rates within which there is likely to be some chance of deleterious effect of ionising radiation to individuals of an organism type (ICRP, 2009). IAEA and UNSCEAR instead stipulate dose rates which apply to an organisation population as a whole (IAEA, 1992 and UNSCEAR, 2011).

These ERL's are not dose limits, and do not imply that higher dose rates are environmentally damaging but rather considered a dose rate increment to wildlife above the natural and normal background level, which might result in detrimental health effects in the environment.

4.4 CONCENTRATION RATIOS

The whole-organism concentration ratio ($\text{CR}_{\text{WO-media}}$) is an important value used to quantify the equilibrium activity concentration between an environmental medium and the whole living organism.

For terrestrial biota, as considered for this assessment, the $\text{CR}_{\text{WO-media}}$ value is defined as the ratio of activity concentration whole-body ($\text{Bq}\cdot\text{kg}^{-1}$ fresh weight) to activity concentration in soils ($\text{Bq}\cdot\text{kg}^{-1}$ dry weight).

Where values do not exist, it is deemed acceptable to adopt values from comparable species.

4.5 ERICA ASSESSMENT TOOL AND TIERED APPROACH

The RPS G-1 Guide recommends a graded approach to the assessment of the environment. Whilst radiation protection of the environment has to be clearly demonstrated, it is important a graded approach is applied, commensurate with the actual radiation risks from the Project.

The ERICA software is an internationally recognised assessment tool and allows for the estimation of dose rates from both external and internal exposures based on radioactivity concentrations in wildlife and environmental media. The latest version (2.0.228) was used for this assessment.

The software allows for preliminary Tier 1 assessments of an environment, through to more complex Tier 3 assessments if warranted.

- A **Tier 1** assessment is a basic assessment using conservative radioactivity and site deposition assumptions. It enables 'Risk Quotients' to be calculated and enables sites to be screened out where there is a negligible radiological risk of the populations of non-human species being affected by the presence of the ionising radiation.

A screening dose rate of $10 \mu\text{Gy}\cdot\text{h}^{-1}$ is considered – the value at which 95% of the species in an ecosystem are expected to be protected.

- A **Tier 2** assessment is undertaken if results of a Tier 1 indicate it is warranted. A Tier 2 assessment also allows selection of site-specific reference organisms, modification of default input parameters, and allows selection on how contaminants are distributed in the environment.

ERL's are defined as dose rates in which it is proposed that chronic exposure below these values would result in no measurable population effect ($40 \mu\text{Gy}\cdot\text{h}^{-1}$ for terrestrial animals, birds and amphibians, and $400 \mu\text{Gy}\cdot\text{h}^{-1}$ for plants and other organisms).

- A **Tier 3** is a more complex probabilistic risk assessment in which uncertainties associated with the results may be determined using sensitivity analysis. A Tier 3 assessment is likely only warranted on rare occasions.

A Tier 2 assessment was undertaken for the Project as it allows for the consideration of site-specific organisms.

5 PROJECT EXPOSURE SETTINGS

Project specific data use for the assessment was defined as follows.

5.1 NATURAL BACKGROUND

A detailed assessment of natural background radiation levels is currently underway for the site. This includes measurement of terrestrial radiation levels, airborne radioactive dust, ambient radon concentrations, radioactivity in groundwater, and surface waters.

Identification of the radioactive concentrations of surface soils for the Project areas has been completed.

5.2 RADIOACTIVE CONCENTRATIONS IN MEDIA

Radioactivity concentrations of the ore, topsoil/overburden, and tailings are represented in Table 1. The radioactive concentration of each material is discussed in detail within the public impact assessment report (DBH, 2025).

Table 1: Radionuclide content of ore, tailings, rehabilitation materials, Copi project – May 2025.

Description	tph	Concentrations				
		Uranium mass conc. (ppm)	Thorium mass conc. (ppm)	U-238 (Bq·g ⁻¹)	Th-232 (Bq·g ⁻¹)	Total (Bq·g ⁻¹)
Ore	3000	2 - 3	10 - 12	0.031	0.045	0.076
Topsoils, overburden	-	0.6 – 2.3	3.7 – 8.6	0.021	0.020	0.041
Interburden [#]	-	0.10	0.83	0.0012	0.0034	0.0046
WCP co-disposed rejects	2960	0.10	0.83	0.0012	0.0034	0.0046
RECP rejects	2.2	371	2080	4.62	8.44	13.1
Combined tailings	2962	0.38	2.4	0.0047	0.0097	0.014

[#] Interburden values assumed from concentrations of WCP co-disposed rejects.

Radioactivity concentrations of the ore, topsoil/overburden, and tailings are represented in Table 1, and where applicable used for the assessment. (The radioactive concentration of each material is discussed in detail within the public impact assessment report (DBH, 2025)).

Only long-lived progeny associated with the U-238 and Th-232 decay chain require consideration for the assessment. Progeny with physical half-lives less than 10 days are accounted for accordingly within the ERICA modelling if considered to be in equilibrium with the parent nuclide – as is the case for Copi Project material.

For the purpose of the assessment U-235 and its progeny have been excluded from consideration. The ratio of U-238 to U-235 in the natural environment (and thus the ore) is 0.9928 / 0.0072. If a Tier 2 assessment identified an ERL being exceeded, then U-235 contributions to a species would need to be considered further.

5.3 ENVIRONMENTAL TRANSPORT

Two scenarios were considered, that could result in a potential exposure:

- The resuspension of radioactive material from operations, dispersing and depositing outside the Project footprint; and
- Occupancy of organisms on rehabilitated landforms.

Scenario 1 - Resuspension of airborne radioactivity from operations

The parameters used for the assessment, and the justification for their use is as follows:

- **Dust deposition rate of 1 g/m².month, every month.** This dust deposition rate far exceeds the maximum predicted value of '< 0.1' g/m².month identified for any of the Receptors as outlined in the air quality report (Northstar, 2025). This includes Receptor R1, the position of the receptor representative of the 'Critical Group' for the member of the public assessment.

- **Ore contributes 100% of the deposited dust.** Values used are outlined in Table 1.

In reality, Project dust will be composed of a blend of overburden, topsoil, and road dust, or any other material resuspended as a result of operations, all with activity concentrations considerably less than the ore itself. It has been identified that ore and mineral concentrates combined would comprise <0.3% of all dust emissions for the Project (Northstar 2025, Appendix C).

- **The deposited dust is homogenously distributed through the top 2 cm of soil.** Consideration has been made that the dust is mixed homogenously through the top 2 cm of natural soil. Mixing could occur as the result of cultivation, seepage following rainfall, or an ore deposition event being interspersed by the deposition of windblown localised dust or soil. Conservatively, soil in the top 2 cm layer is assumed to be in direct contact with the applicable root system (which could be to a depth of 20 cm).

Scenario 2 – No environmental transfer, residency on/in rehabilitated landform

Occupancy of an organism on rehabilitated landforms incorporating tailings, including the Off Path Storage Facility will be a likely scenario following rehabilitation. This could include burrowing animals, and vegetation grown on the surface of the landform.

However, this scenario has not been considered further as:

- Tailings are buried at sufficient depth below an overburden cap and are considered inaccessible,
- The tailings have an activity concentration less than the overburden cap; and
- Soil concentrations of the overburden cap are within the range of concentrations identified in topsoils for the area. Surface concentrations will be comparable to identified background levels, and less than that considered as a result of dust deposition considered in Scenario 1.

5.4 TIME SCALES

The assumption is that dust deposition occurs for a 17.2-year period of mining operations.

It is assumed in the first-year dust is deposited and mixed as per the assumptions outlined in 5.3. In the second year, ore is deposited and distributed through the same 2 cm of topsoil, thus contributing to the contamination already deposited in previous years. This process continues for 17 years, essentially resulting in an additive effect to the existing radioactivity present in the soil.

As a result, the activity concentrations assumed for the U-238 decay series radionuclides (including U-238, U-234, Th-234, U-234, Th-230, Ra-226, Pb-210 and Po-210) is $0.210 \text{ Bq}\cdot\text{kg}^{-1}$. For the Th-232 series (Th-232, Ra-228, and Th-228) an activity concentration of $0.304 \text{ Bq}\cdot\text{kg}^{-1}$ is assumed.

Contributions from 'background' radioactivity already present in topsoil are not included, as per the requirements of the assessment.

5.5 ORGANISMS AND PATHWAYS

5.5.1 Reference organisms

Various terrestrial reference organisms in the ERICA software (Table 2) were included in the assessment.

Table 2: ERICA Reference Organisms including default parameters - May 2025.

Reference Organism	Mass (kg)	Default ellipsoid dimensions		
		a (cm)	b (cm)	c (cm)
Amphibian (ICRP Frog)	0.031	8	3	3
Annelid (ICRP Earthworm)	0.0052	10	1	1
Arthropod	0.00017	1.7	0.61	0.31
Bird (ICRP Duck)	1.26	30	10	8
Flying insects (ICRP Bee)	0.00059	2	0.75	0.75
Grasses & Herbs (ICRP Wild grass)	0.0026	5	1	1.0
Lichen & Bryophytes (ICRP Bryophyte)	0.00017	4	0.23	0.23
Mammal - large (ICRP Deer)	245	130	60	60
Mammal - small-burrowing (ICRP Rat)	0.31	20	6	5
Mollusc - gastropod (ICRP Snail)	0.0014	2	1.5	0.9
Reptile	0.75	116	3.5	3.5
Shrub (ICRP Wild grass)	0.0026	5	1	1
Tree (ICRP Pine tree)	471	1000	30	30

NB: Bracketed text relates to the Reference Animal and Plants (RAP) – a suite of organisms recommended as models by ICRP.

5.5.2 Site-specific organisms

The transfer of radionuclides from the environment to non-human biota is dependent on environmental conditions. Often values used are appropriate for a temperate environment (e.g. a European deer) and may not be as applicable in arid Australian conditions. Thus, in addition to Reference organisms, it is important that consideration is given to species unique to the Australian environment.

It is also important to consider any species that may be directly impacted by the Copi Project, or subject to interest from a biodiversity perspective. Potentially impacted species are discussed in the Project *Biodiversity Development Assessment Report* (EIS Copi, Appendix 6).

For the Copi Project, the following additional species were considered:

- Red Kangaroo (*Osphranter rufus*);
- Emu (*Dromaius novaehollandiae*);
- Feral Goat;
- Rainbow bee-eater (*Merops ornatus*) listed under the EPBC Act.

- Mallee birds – listed under the EPBC Act (specifically the Chestnut Quail-thrush (*Cinclosoma castanotum*) and the Splendid Fairy Wren (*Malurus splendens*);
- Pink cockatoo (*Cacatua leadbeateri*);
- Little eagle (*Hieraaetus morphnoides*);
- Spear grass (*Austrostipa nullanulla*); and
- White Cypress Pine (*Callitris columellaris*).

The considered organisms are outlined in Table 3. Concentration ratios used for the assessment are outlined in Appendix A.

Occupancy Factors have been assigned, as it is important that consideration is given to the habitat of the organism which will dictate the dose received.

The two Mallee birds chosen (Chestnut Quail-thrush and the Splendid Fairy Wren) have been chosen based on their differing habitat (the Chestnut Quail-thrush is more ground dwelling while the Splendid Fairy Wren forages in the lower branches of vegetation as well as on open ground near shelter).

The occupancy rate for the emu of 100% in the air does not reflect the species being in-flight, rather, it is considered to have an axial centre 60 cm above ground level.

Table 3: Site specific organisms – Copi Project, May 2025.

Organism	Mass ¹ (kg)	Default ellipsoid dimensions ¹			Occupancy Factor
		a (cm)	b (cm)	c (cm)	
Red Kangaroo (<i>Osphranter rufus</i>)	36	120	40	40	1.0 on soil
Emu (<i>Dromaius novaehollandiae</i>)	40	80	80	50	1.0 in air
Feral Goat	60	100	100	30	1.0 on soil
Rainbow bee-eater (<i>Merops ornatus</i>)	0.027	20	3	3	1.0 in air
Chestnut quail-thrush (<i>Cinclosoma castanotum</i>)	0.075	24	5	5	1.0 on soil
Splendid fairy wren (<i>malurus splendens</i>)	0.01	13	2.5	2.5	0.5 in air, 0.5 on soil
Pink Cockatoo (<i>Cacatua leadbeateri</i>)	0.37	40	10	10	0.5 in air, 0.5 on soil
Little Eagle (<i>Hieraaetus morphnoides</i>)	0.8	50	20	20	1.0 in air
White Cypress Pine (<i>Callitris columellaris</i>)	471	1000	30	30	1.0 on soil
Spear grass (<i>Austrostipa nullanulla</i>)	0.2	50	50	50	1.0 on soil

Note 1: Various on-line sources were utilised to identify representative weights and dimensions.

6 RESULTS

Using the exposure settings as outlined in Section 5, a Tier 2 assessment in ERICA was undertaken. Results are shown in Table 4.

Table 4: ERICA Environmental assessment – Copi Project, May 2025.

Organism	Dose rate per organism ($\mu\text{Gy}\cdot\text{h}^{-1}$)	Tier 1 Screening value ($\mu\text{Gy}\cdot\text{h}^{-1}$)	Tier 2 Environmental Reference Level ¹ ($\mu\text{Gy}\cdot\text{h}^{-1}$)
Fauna			
Amphibian	0.010	10	40
Annelid	0.013	10	40
Arthropod - detritivores	0.014	10	40
Bird	0.0021	10	40
Flying insects	0.0033	10	40
Mammal - large	0.005	10	40
Mammal - small-burrowing	0.0052	10	40
Mollusc - gastropod	0.0030	10	40
Reptile	0.010	10	40
Red Kangaroo (<i>Osphranter rufus</i>)	0.040	10	40
Emu (<i>Dromaius novaehollandiae</i>)	0.0020	10	40
Feral Goat	0.0048	10	40
Rainbow bee-eater (<i>Merops ornatus</i>)	0.0021	10	40
Chestnut quail-thrush (<i>Cinclosoma castanotum</i>)	0.0021	10	40
Splendid fairy wren (<i>malurus splendens</i>)	0.0021	10	40
Pink Cockatoo (<i>Cacatua leadbeateri</i>)	0.0021	10	40
Little Eagle (<i>Hieraaetus morphnoides</i>)	0.0021	10	40
Flora			
Grasses & Herbs	0.023	10	400
Lichen & Bryophytes	0.091	10	400
Shrub	0.026	10	400
Tree	0.0017	10	400
White Cypress Pine (<i>Callitris columellaris</i>)	0.18	10	400
Spear grass (<i>Austrostipa nullanulla</i>)	0.091	10	400

Note 1: Dose rates in which it is proposed that exposure below these values (of chronic exposure), no measurable population effect would occur (IAEA 1992, UNSCEAR 1996).

The results of the modelling have identified that dose rate values are at least two orders of magnitude less than the $10 \mu\text{Gy}\cdot\text{h}^{-1}$ screening value applicable to Tier 1 assessments.

For completeness a Tier 2 assessment was conducted to allow assessment of Project specific species potentially at risk. Estimated dose rates are less than the respective Tier 2 Environmental Reference Level ($40 \mu\text{Gy}\cdot\text{h}^{-1}$ or $400 \mu\text{Gy}\cdot\text{h}^{-1}$) by several orders of magnitude. The highest dose rate was $0.18 \mu\text{Gy}\cdot\text{h}^{-1}$ calculated for the White Cypress Pine.

7 CONCLUSIONS

It can be concluded that even using extremely conservative criteria, the radiological risk on any non-human biota identified in the Copi Project area will be negligible as a result of proposed operations.

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APPENDIX A – CONCENTRATION RATIOS FOR ORGANISMS

Nuclide	Concentration ratio CR ^{wo-soil} (Bq·kg ⁻¹ fw whole organism / Bq·kg ⁻¹ dw soil)					Reference
	U	Th	Ra	Pb	Po	
Amphibian	4.52E-04	5.70E-04	2.00E-01	4.60E-02	8.72E-02	ERICA library
Annelid	3.41E-02	1.12E-02	2.05E-01	4.36E-01	7.63E-02	ERICA library
Arthropod - detritivores	9.55E-02	1.12E-02	2.05E-01	7.02E-01	7.63E-02	ERICA library
Bird	1.46E-03	4.69E-04	3.47E-02	5.92E-02	9.97E-03	ERICA library
Flying insects	5.20E-03	2.96E-03	5.31E-02	1.73E-02	7.63E-02	ERICA library
Grasses & Herbs	1.16E-01	1.50E-01	1.66E-01	1.15E-01	2.76E-01	ERICA library
Lichen & Bryophytes	9.11E-01	3.77E-01	7.10E-01	2.60E+00	2.65E+00	ERICA library
Mammal - large	2.84E-03	1.11E-03	8.93E-02	3.85E-02	8.72E-02	ERICA library
Mammal - small-burrowing	2.84E-03	1.11E-03	8.93E-02	3.85E-02	8.72E-02	ERICA library
Mollusc - gastropod	3.41E-02	1.12E-02	2.74E-02	6.89E-03	7.63E-02	ERICA library
Reptile	3.07E-03	9.55E-04	2.00E-01	4.74E-02	9.85E-02	ERICA library
Shrub	5.99E-02	5.97E-02	3.34E-01	3.29E-01	3.50E-01	ERICA library
Tree	6.47E-03	1.15E-03	1.65E-02	4.95E-02	4.18E-02	ERICA library
Red Kangaroo	2.12E-02	1.11E-03	7.60E-01	2.22E-02	1.06E+00	ARPANSA 2014
Emu	1.46E-03	4.69E-04	3.47E-02	5.92E-02	9.97E-03	ERICA library
Feral goat	2.84E-03	1.11E-03	8.93E-02	3.85E-02	8.72E-02	ERICA library
Rainbow Bee-Eater	1.46E-03	4.69E-04	3.47E-02	5.92E-02	9.97E-03	ERICA library
Chestnut Quail Thrush	1.46E-03	4.69E-04	3.47E-02	5.92E-02	9.97E-03	ERICA library
Splendid Fairy Wren	1.46E-03	4.69E-04	3.47E-02	5.92E-02	9.97E-03	ERICA library
Pink Cockatoo	1.46E-03	4.69E-04	3.47E-02	5.92E-02	9.97E-03	ERICA library
Little Eagle	1.46E-03	4.69E-04	3.47E-02	5.92E-02	9.97E-03	ERICA library
White Cypress Pine	6.47E-03	4.00E-02	1.70E-01	3.90E+01	6.00E-01	Grasses (Hirth et.al 2014)
Spear grass	2.70E-01	2.10E-01	1.30E+00	8.40E-01	4.90E-01	Grasses (Hirth et.al 2014)