INNOVATING ENVIRONMENTAL IMPACT ASSESSMENT: EVIDENCE-BASED APPROACHES TO MANAGING BIODIVERSITY IMPACTS AND CONSERVATION CHALLENGES

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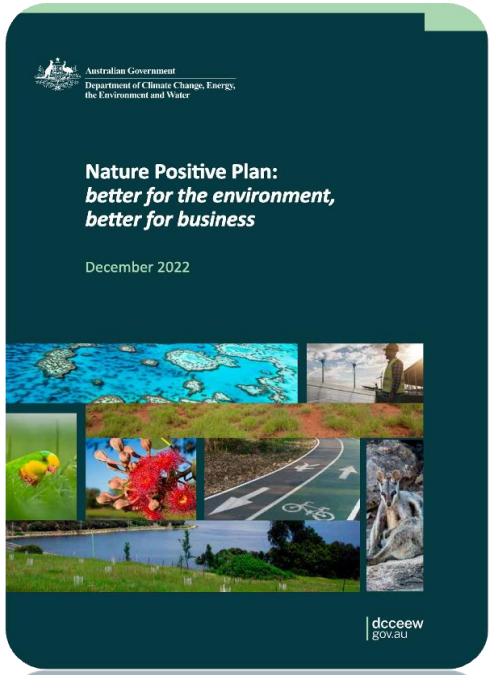
“IN GOD WE TRUST. ALL OTHERS MUST BRING DATA.”

W. EDWARDS DEMING

- Introduce the rationale for an evidence-based approach to Environmental Impact Assessment (EIA).
- How EIA currently navigates uncertainty in the absence of evidence – the precautionary approach and its consequences.
- Constraints to an evidence-based approach:
  - Lack of foundational biological information for most species.
  - Significant knowledge gaps in ecosystem functions and services.
  - Natural (stochastic) variation often obscure true (deterministic/predicted) impacts.
  - Insufficient statistical power.
- Recognising constraints may lead opportunities.
- Guided by structured, collaborative knowledge plans.

"…we show that annual spending on targeted threatened species recovery [in Australia] *is around U.S.$92m (AU$122m) which is around one tenth of that spent by the U.S. endangered species recovery program, and about 15% of what is needed to avoid extinctions and recover threatened species." (Wintle et al. 2019. Conserv. Lett. 12).*

- EIA as a Decision Tool:
  - Informs impact assessment, mitigation design, and monitoring frameworks.
  - Each decision carries financial and ecological cost.
- Costs of Conservation
  - Recovery actions for threatened species are expensive
  - Resources are limited—every dollar must count
- Global and National Expectations
  - Australia is a signatory to the Global Biodiversity Framework
  - Emphasis on a nature-positive future and accountable action
- EIA as a Knowledge Contributor
  - Investment in EIA should enhance biodiversity understanding
  - But only if it's embedded within an evidence-based framework



"The total cost of implementing all strategies to recover threatened species in their in-situ habitat across Australia summed to an estimated AU$583 billion per year..." (Reside et al. 2024. The cost of recovering Australia's threatened species. Nat. Ecol. Evol.)

Australia's National Biodiversity Strategy and Action Plan
(Commonwealth of Australia, 2024)
Goal 3 - Share and Build Knowledge

"Effective management and protection of nature in Australia is best supported by an evidence-based approach built on sound knowledge."

Kunming-Montreal Global Biodiversity Framework 2024; KMGBF
(Convention on Biological Diversity., 2022)

"The implementation of the Framework should be based on scientific evidence and traditional knowledge and practices, recognizing the role of science, technology and innovation."

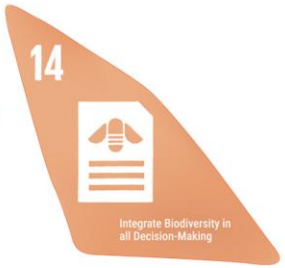
Kunming-Montreal
GLOBAL BIODIVERSITY FRAMEWORK

Kunming - Montreal
GLOBAL BIODIVERSITY FRAMEWORK

GBF HOME // TARGET 14

Target 14

Integrate Biodiversity in Decision-Making at Every Level



Ensure the full integration of biodiversity and its multiple values into policies, regulations, planning and development processes, poverty eradication strategies, strategic environmental assessments, environmental impact assessments and, as appropriate, national accounting, within and across all levels of government and across all sectors, in particular those with significant impacts on biodiversity, progressively aligning all relevant public and private activities, fiscal and financial flows with the goals and targets of this framework.

GBF HOME // TARGET 19

Target 19

Mobilize $200 Billion per Year for Biodiversity From all Sources, Including $30 Billion Through International Finance

MAKING THE EIA DOLLAR COUNT

- **Strategic Opportunity**:
  - Substantial investment in EIA and post-approval monitoring in WA.
  - Resources - public and private - can and should be directed to maximise biodiversity outcomes.
- **The Consultant's Role**:
  - In WA, environmental consultants often see “the lion’s share” of biodiversity funding.
  - We have an opportunity to ensure maximum return on investment for biodiversity.

- EIA must manage uncertainty across:
  - Threatening processes (e.g., habitat clearing, light spill, altered fire regimes).
  - Susceptibility of biodiversity values (species, communities, ecosystem services).
- Outcome uncertainty is widespread due to:
  - Limited understanding of species' biology and ecology.
  - Poorly understood ecosystem functions and services.
- Knowledge gaps impact study design:
  - Difficult to select monitoring approaches aligned with biological/ecological assumptions.
  - Undermines statistical power.
- Monitoring frameworks are often drafted prematurely:
  - Required at assessment stage, commonly developed without pilot studies to test assumptions.

"Ensure that the best available data, information and knowledge, including traditional knowledge, innovations and practices of Indigenous Peoples and local communities with their free, prior and informed consent, are available for policy making, implementation and review of biodiversity-related decisions."

KMGBF Target 21 – Indigenous and Traditional Knowledge

Australia's National Biodiversity Strategy and Action Plan (Commonwealth of Australia, 2024)

"Much of our biodiversity remains undiscovered or poorly known. We need to better understand our biodiversity as a foundation for protecting it."

Kunming-Montreal Global Biodiversity Framework 2024; KMGBF (Convention on Biological Diversity., 2022)

"The absence of reliable data on numerous threatened species severely limits our ability to allocate conservation resources in an informed and effective manner."

Precautionary Approach

Impact assessment embodies a precautionary approach.

Trucker and Treweek (2004)

- Uncertainty carries a cost:
  - Broadly it impedes conservation funding decisions.
  - In EIA, drives the application of the precautionary approach.
- Precautionary Principle is formally recognised:

  National Biodiversity Strategy and Action Plan (2024):

  "…*take actions against likely threats without waiting for full scientific certainty*."
- Legislation:
  - EPBC Act 1999, Section 391(2)
  - WA EP Act 1986, Section 4A
- Projects impacting high biodiversity values with limited data often:
  - Trigger higher levels of assessment.
  - Require broader monitoring and offset measures.

Types of Monitoring

Many existing conservation monitoring programs that focus on broad surveillance without specific hypotheses will often lead to inefficient use of resources and may not effectively inform conservation actions.

From Nichols and Williams 2006

Targeted Monitoring.	*Guided by a conceptual model and by a rigorous design that will typically result in a priori predictions that can be tested.*
Surveillance Monitoring	*Devoid of specified questions or underlying study design and has limited rationale other than curiosity.*
Mandated Monitoring	*Where environmental data are gathered as a stipulated requirement of government legislation or a political directive. The focus is usually to identify trends.*

CENTRAL TENETS OF BIODIVERSITY MONITORING

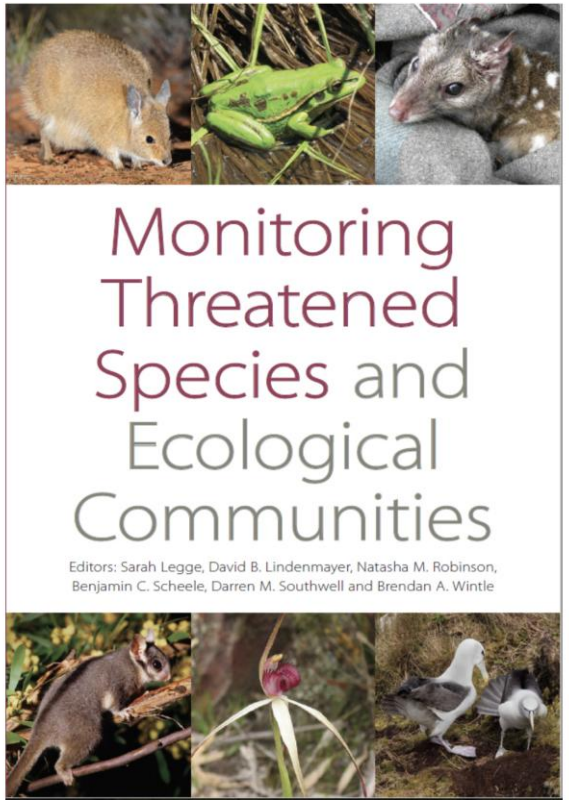
- Clearly Defined Objectives
- Fit-for-Purpose Design
- Detectability
- Measure relevant population attributes
- Statistical Power
- Long-Term Commitment
- Adaptive Management Integration
- Reproducible

Use of monitoring tools often come with assumptions and these need to match target species biology and ecology. We need this foundational knowledge to choose the correct tool.

Distance Sampling
All objects on the line/point are detected with certainty.

SECR
Each animal has a fixed home-range centre during the session.

Home Range Analyses
Animals are range resident.



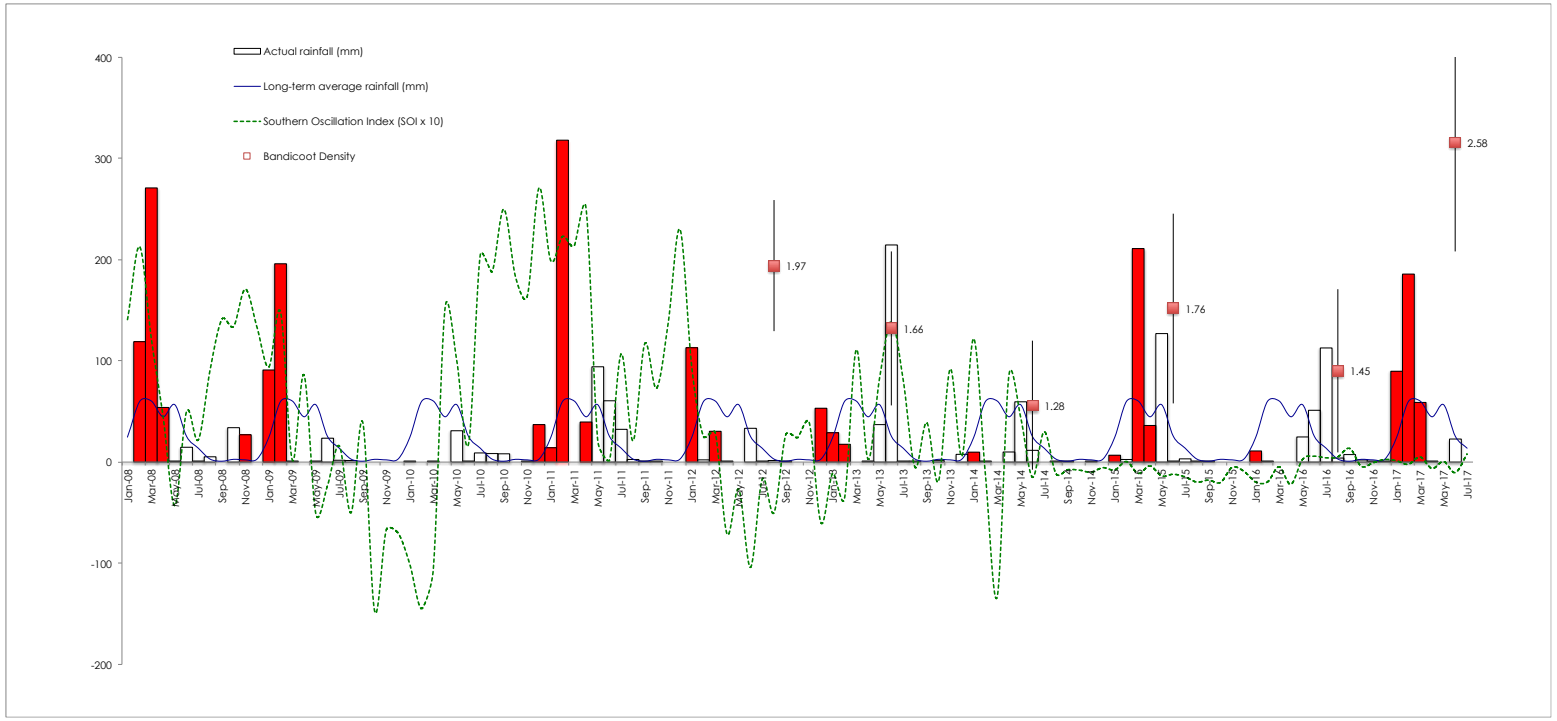
RESTATING THE PROBLEM

- Acknowledged need for evidence-based EIA (global and national commitments).
- Major knowledge gaps persist - even for threatened species (the focus of EIA).
- EIA often defaults to:
  - Inventory-level surveys.
  - Generic impact statements.
- Monitoring remains largely surveillance-based, not targeted.
- Precautionary approach fills the evidence gap (increasing cost?).

Compounding the Problem

"Many Australian ecosystems are shaped by boom-and-bust cycles, with wildlife populations responding dramatically to episodic rainfall events." Dickman et al. (1999).

- WA's biodiversity, particularly terrestrial fauna, often exhibits boom–bust dynamics.
- Climate-driven variability in species abundance and community structure is high.
- Baseline surveys (e.g. 1–2 years) may not reflect typical or long-term conditions.
- Monitoring outcomes confounded when stochastic variation:
  - Swamps deterministic trends (e.g. impact effects).
  - Reduces statistical power and interpretability.



Annual density estimates (ha^{-1}) of Barrow Island golden bandicoots plotted against monthly rainfall and the Southern Oscillation Index (red bars indicate "wet-season" rainfall events).

EFFECT SIZE, STATISTICAL POWER AND THE COMPOUNDING PROBLEM OF RARITY

- Monitoring must detect change - but power is often too low.
- Rare species → too few individuals for statistical tests.
- High stochastic variation obscures real impacts.
- Impacts aren't spatially uniform—but designs often assume they are.
- Movement scale is greater than the impact zone → no measurable effect
  - *Home range vs impact footprint* can be a critical mismatch.

OPPORTUNITIES NOT IMPEDIMENTS

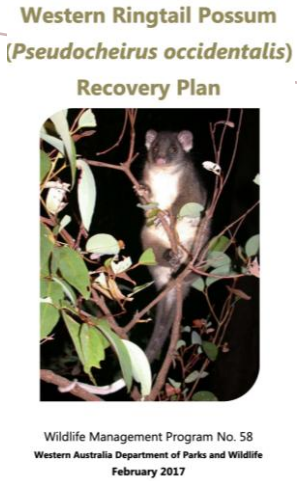
- Impediments aren't universal – in some cases we can:
  - Implement robust monitoring.
  - Ask better, more testable questions.

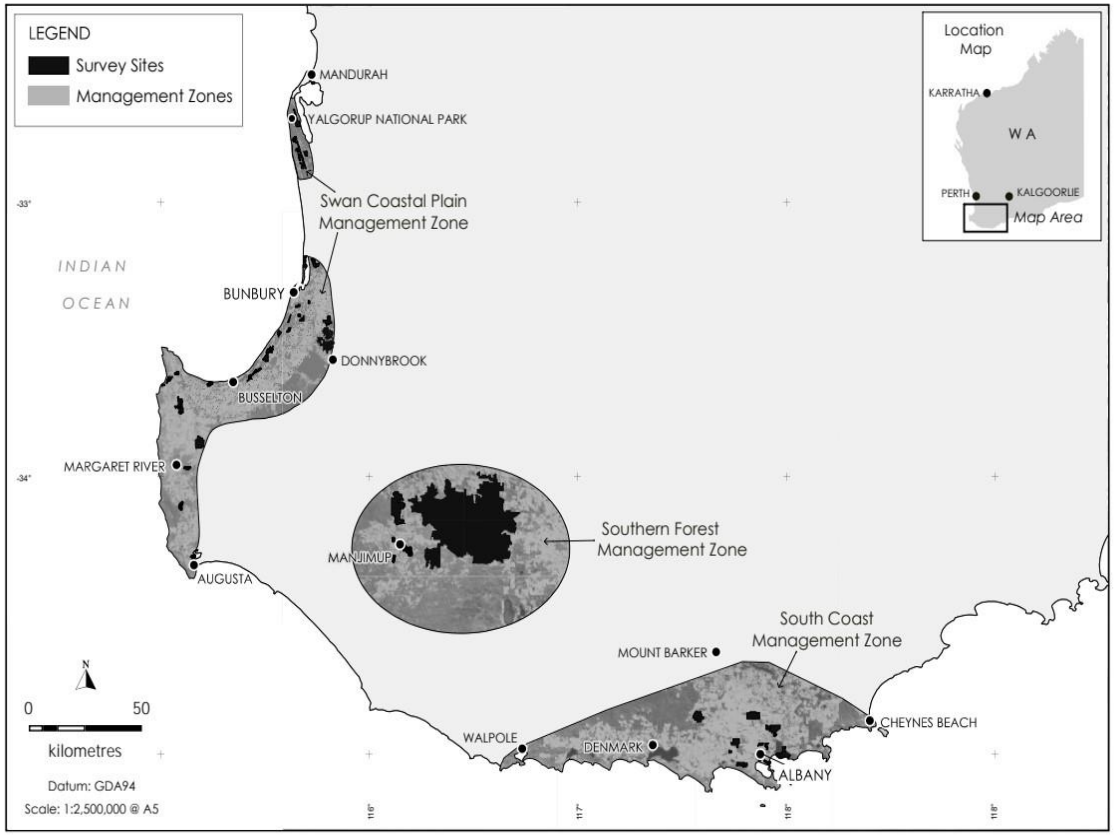
- Example: Road/Rail Duplication.
  - Stratify quadrats by distance to infrastructure.
  - Treat distance as an explanatory variable.
  - Analyse variation in:
    - Threatened species abundance.
    - Functional groups (e.g. fire-sensitive, weed-prone).

- Example: Nullarbor Study
  - Test wombat burrows as ecosystem engineers.
  - Compare faunal diversity near vs away from burrows.

CASE STUDY – WESTERN RINGTAIL POSSUM

- *Pseudocheirus occidentalis* listed as Critically Endangered (IUCN) because of a magnitude of decline of <80%.
- IUCN (2014) inferred 3,400 adults across 3 Management Zones (MZ).
  - A 99% decline inferred in Upper Warren (Southern Forest MZ).
- Assigned 25% extinction risk within 20 years (Geyle et al. 2018).
- The Recovery Plan - "Gaps in Knowledge" identified as a threat and knowledge of abundance remains limited.
- Many unstructured surveys contribute little to knowledge base.





Geyle, H.M., et al., 2018. Quantifying extinction risk and forecasting the number of impending Australian bird and mammal extinctions. *Pacific Conservation Biology* 24, 157–167. https://doi.org/10.1071/PC18006

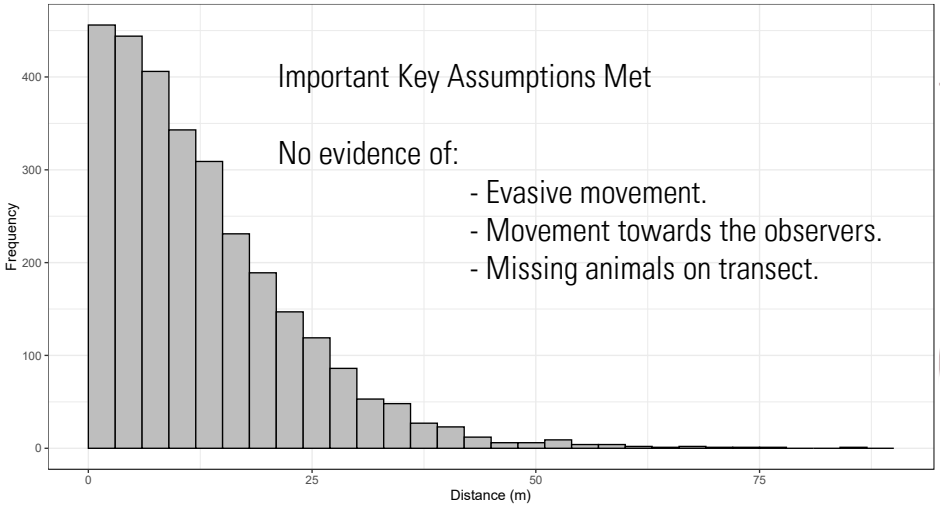
RESULTS – A MARKED DIFFERENCE IN ABUNDANCE

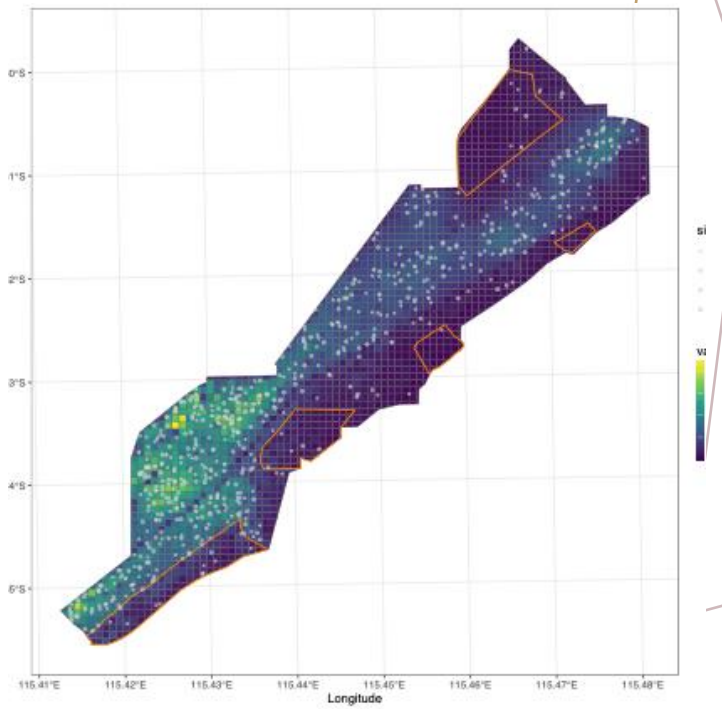
Estimated individuals by management zone
(95% Confidence Intervals)

Zone	Elicited Estimate	Individuals	Detection-Only Estimate
SC	500	3,240 (2,859–3,673)	2,764 (2,450–3,119)
SF*	100	9,205 (6,850–14,086)	8,022 (5,294–12,156)
SSCP	2,500	9,364 (8,620–10,173)	7,236 (6,678–7,841)

* SF is equivalent to Upper Warren

Histogram of perpendicular distances



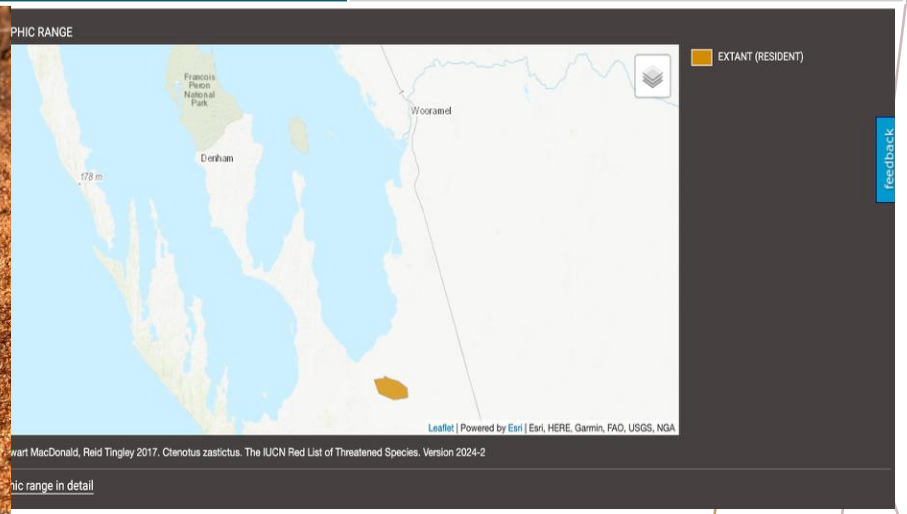


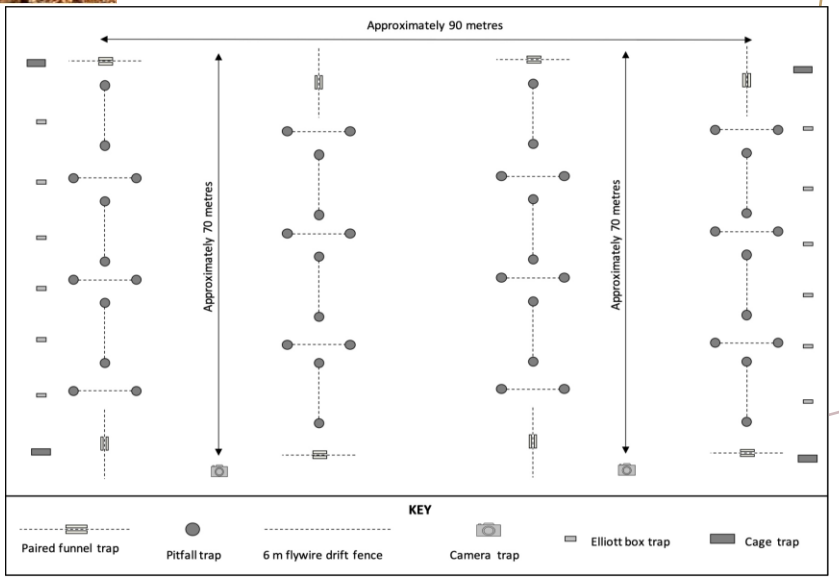
Example density surface

CASE STUDY – HAMELIN SKINK

- *Ctenotus zastictus* listed as Vulnerable.
- Population size was unknown.
- Potentially impact by a haul road through its habitat.
- Monitoring proposed using a mark – recapture approach.

Agency	Status
EPBC Act Listing Status	Listed as Vulnerable
State Listing Status (WA)	Listed as Vulnerable
Non-statutory Listing Status	IUCN: Listed as Near Threatened (Global Status: IUCN Red List of Threatened Species: 2024.2 list) NGO: Listed as Near Threatened (The Action Plan for Australian Lizards and Snakes 2017)





CASE STUDY – HAMELIN SKINK

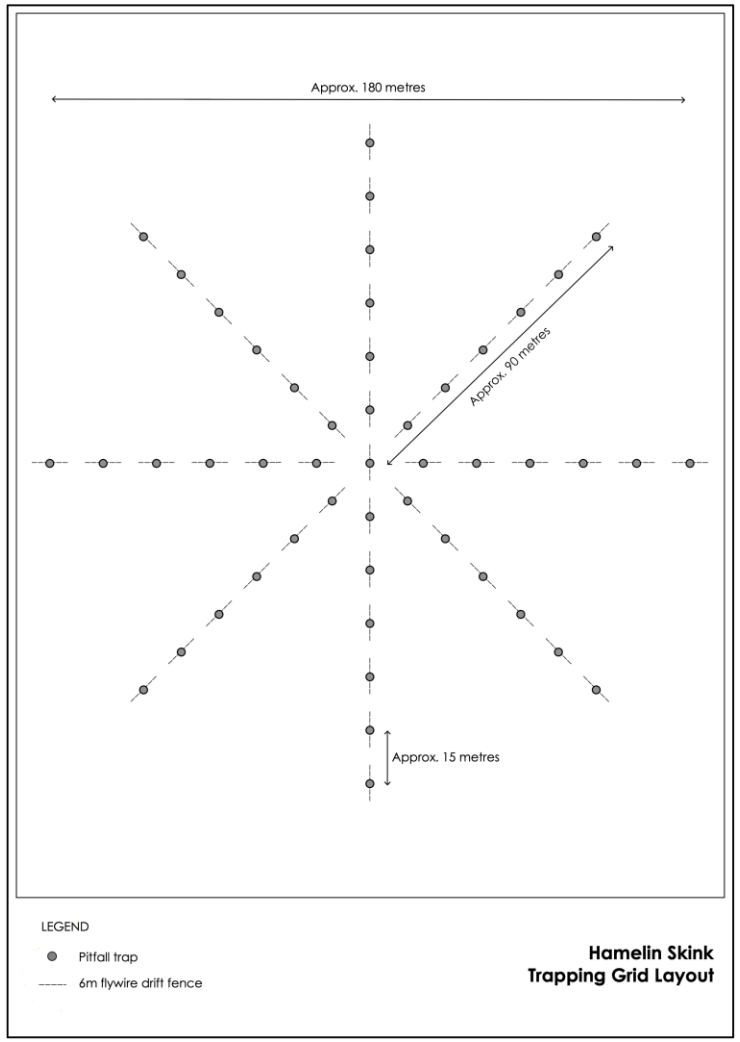
Trapping Webs

Objects at center of web detected with certainty.

Distances are measured accurately.

Recaptures are ignored.

Animals do not range freely across the entire web.



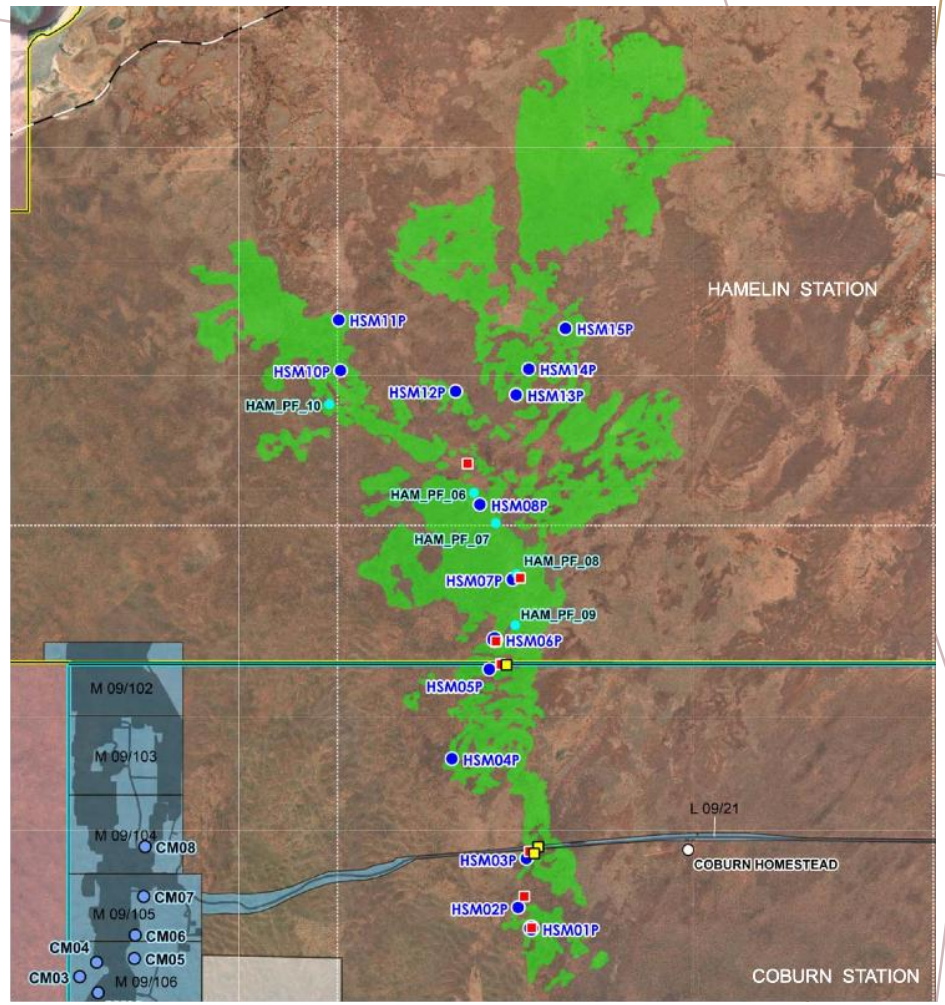


Table 2 **Number of trapping webs sites, detection events and estimated abundance and density for each of the three survey trips. Area represents the mapped extent of the Hamelin Skink habitat = 14,287 Ha.**

Trip	Webs	Detections (individuals)	Abundance Estimate ± se (95% CI)	Density Estimate ± se (95% CI)
1 Autumn 2022	14	48	53,572 ± 11,921 34,076 – 84,222	3.75 ± 0.83 2.38 – 5.90
2 Spring 2022	14	112	125,001 ± 26,261 81,661 – 191,341	8.75 ± 1.84 5.72 – 13.39
3 Spring 2023	14	40	44,643 ± 11,749 26,044 – 76,526	3.25 ± 0.82 1.82 – 5.36

COLLABORATIONS

- Statistical power is a common limitation in project-scale monitoring.
- One solution: Shift from project-specific to collaborative frameworks:
  - Within single proponents (across multiple sites/tenures).
  - Across different proponents (shared species, shared landscapes).
  - Species don't recognise tenement boundaries—why should monitoring?
- Beyond Data Sharing: Collaboration:
  - Data sharing = access to information.
  - Collaboration = shared questions, expertise, and learning.
- Greater capacity to:
  - Increase spatial and temporal scale.
  - Improve inference strength.
  - Generate cumulative ecological understanding.

Helix Molecular Solutions

Biota Environmental Sciences

Fortescue

RioTinto

BHP

HANCOCK PROSPECTING

Murdoch University

Movement ecology, diet and population genetics of the Pilbara Olive Python (Liasis olivaceus barroni)

STRUCTURED KNOWLEDGE PLANS

Case studies

- *Python Knowledge Plan ➜ rapid gains in spatial ecology & habitat use*
- *Western Ringtail Possum ➜ 41 baseline sites now underpin trend analyses*
- *Northern Quoll (no plan) ➜ scattered, under-powered studies*

- EIA conditions ➜ often generic, uncoordinated. ➜ Questionable biodiversity and knowledge gains.
- Existing tools to coordinate monitoring:
  - Recovery plans (now for Priority Species & Places) - but these are conservation driven.

- Knowledge Plan concept:
  - Explicitly states knowledge gaps and statistical power issues.
  - Defines impact / industry relevant questions.
  - Coordinates relevant studies.
  - Promotes collaborations.

- Gains:
  - Eases conditioning: Regulators / Proponents select from a range of pre-defined and relevant knowledge gaps.
  - Builds cumulative knowledge regulators & industry both need.
  - Feedback loop

WHAT DOES EIA REQUIRE?

- Agree that we need to adopt an evidence-based approach.
- Explicitly acknowledge that evidence-based approach is often constrained:
  - Species and biodiversity knowledge gaps.
  - Monitoring programs may be incapable of achieving their stated aims":
    - Species rarity
    - Limited spatial or temporal scale
    - Effect size is too small
    - Background variability is too high

We are all scientists, and we have the lions share of funding to do science. Perhaps a more flexible EIA that explicitly acknowledges these critical limitations can redirect our efforts under relevant guidance to start gathering information and start assessing impacts.

THANK YOU

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