

Trouble in Paradise: Paleoeecology and extinction of island birds

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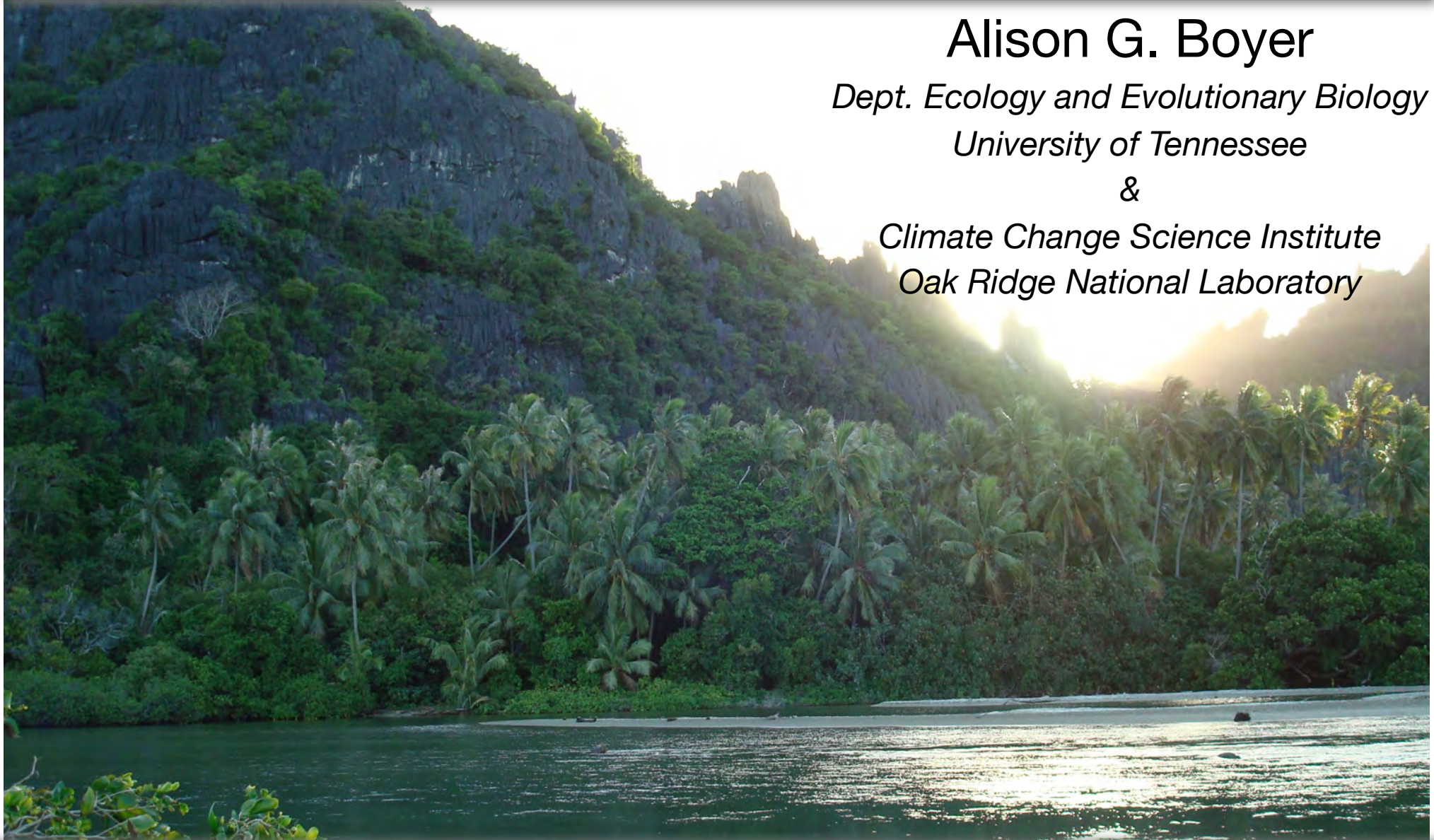
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Oak Ridge National Laboratory



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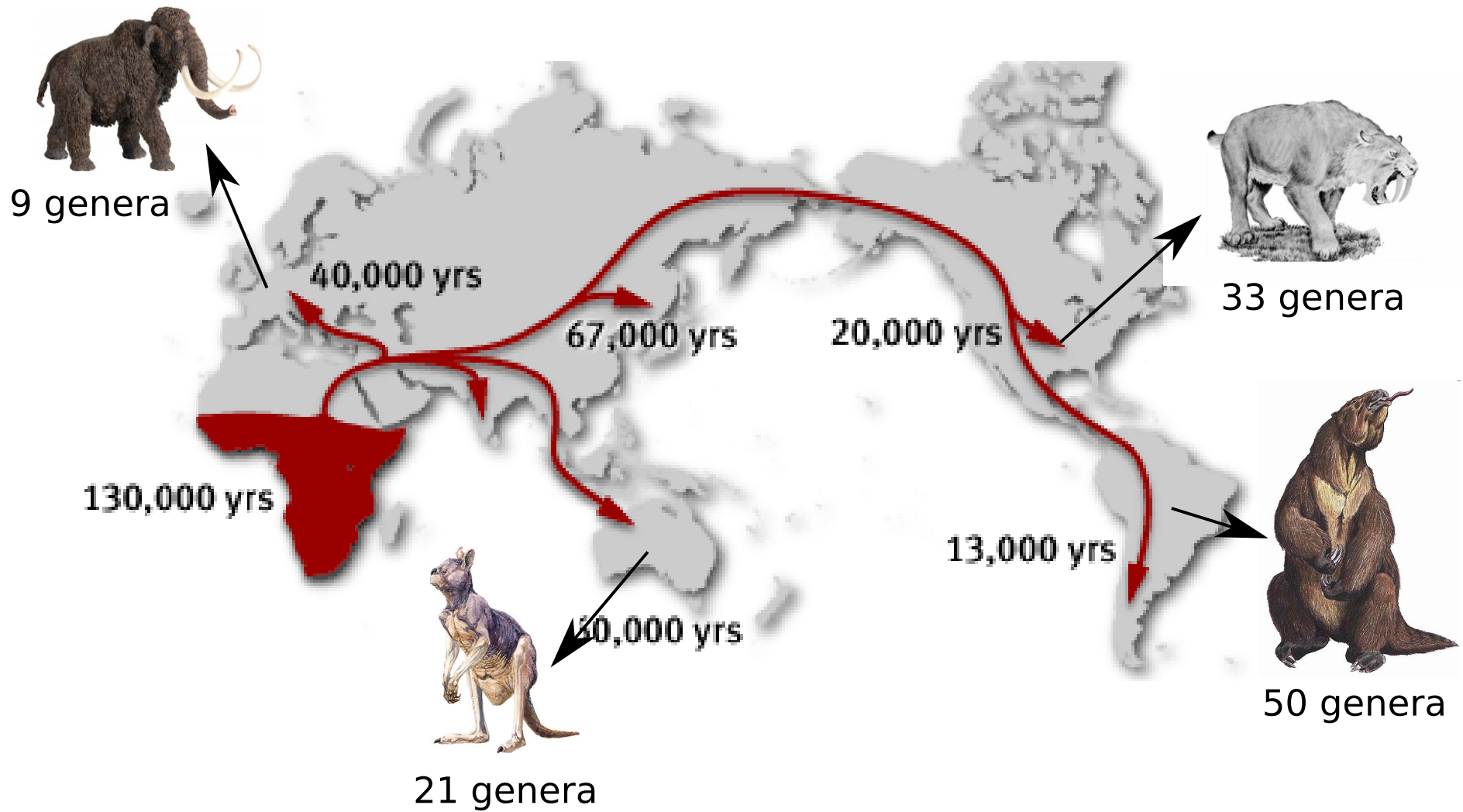




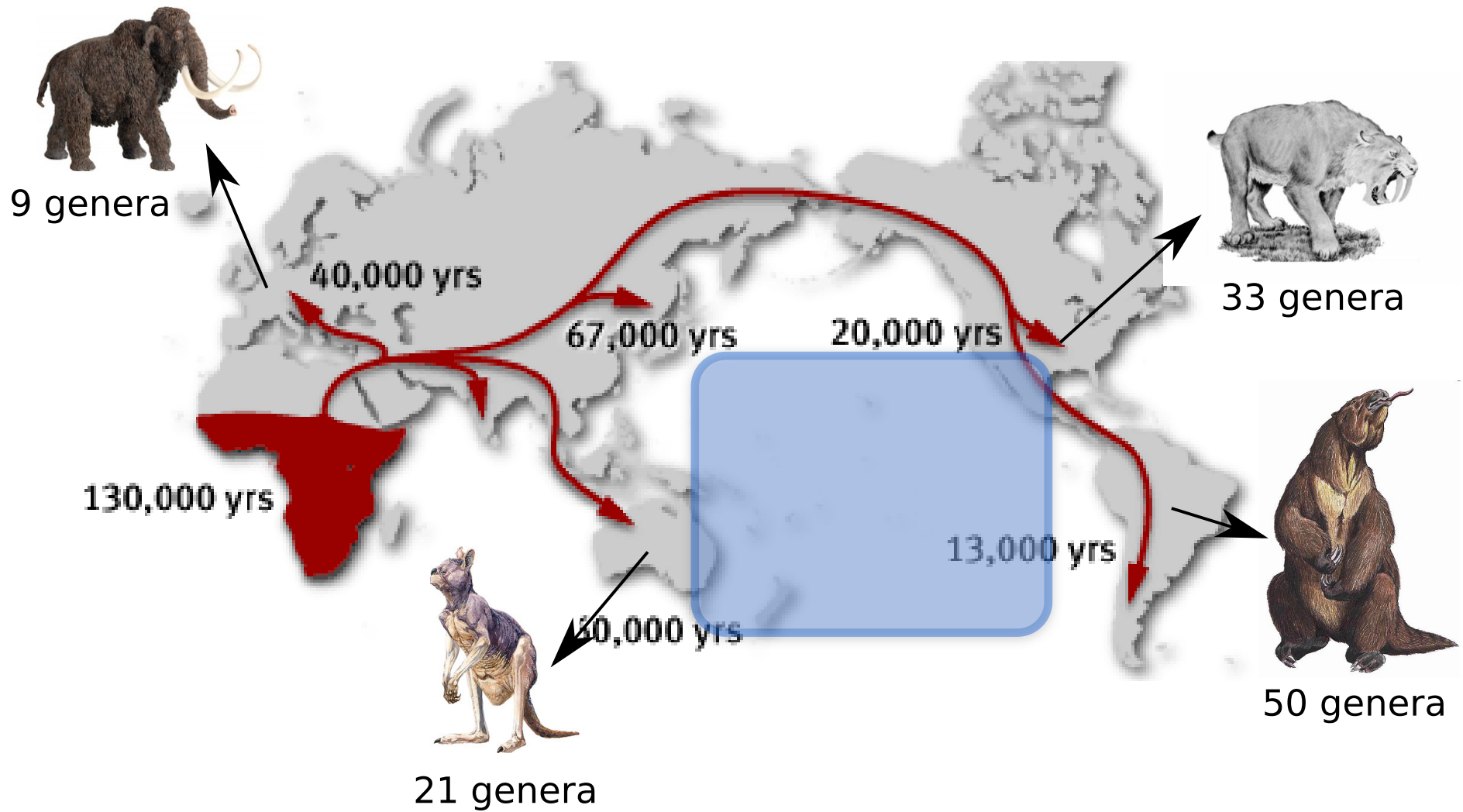
Moorea, French Polynesia

Endangered Pacific island birds



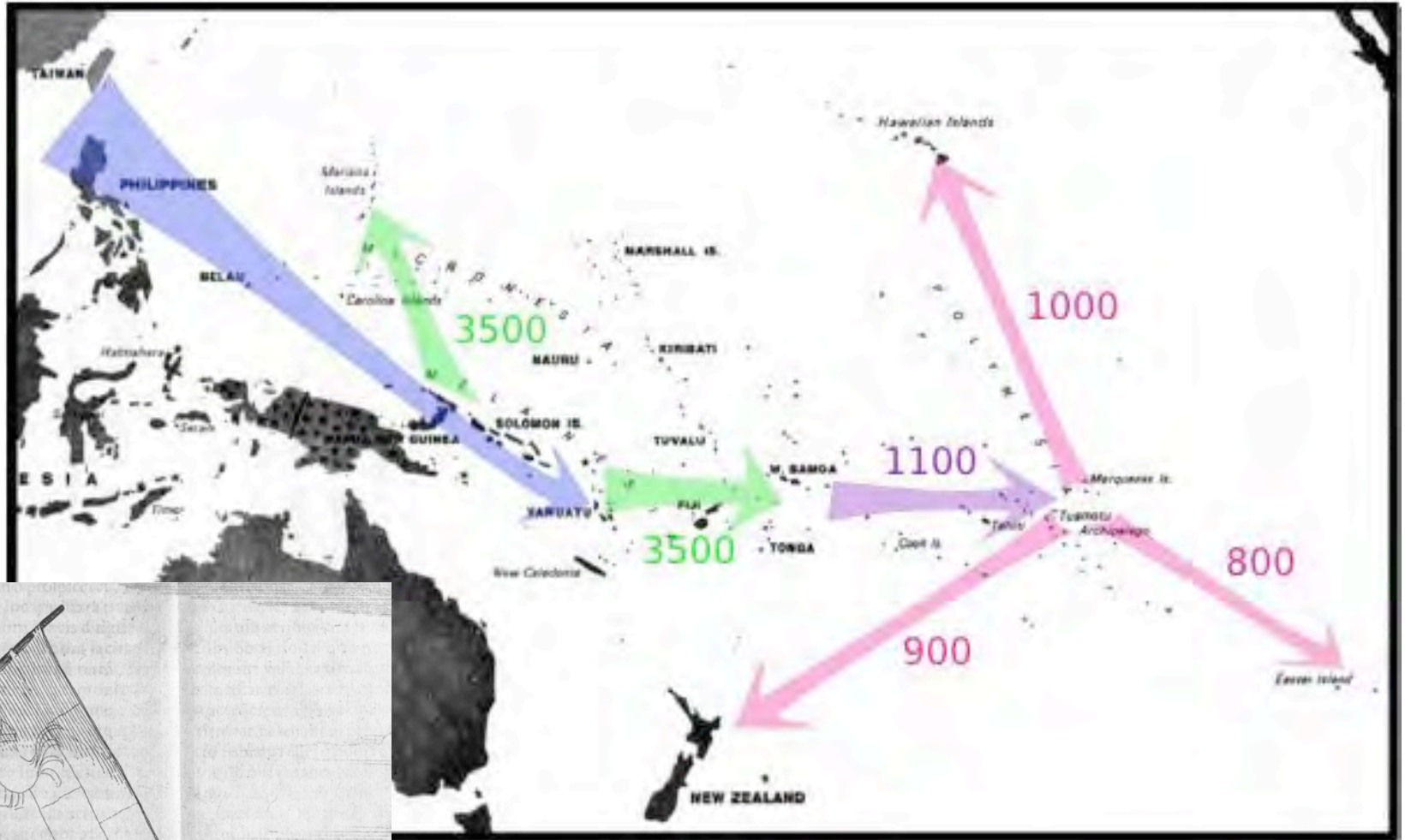


Barnosky et al. 2004, Science

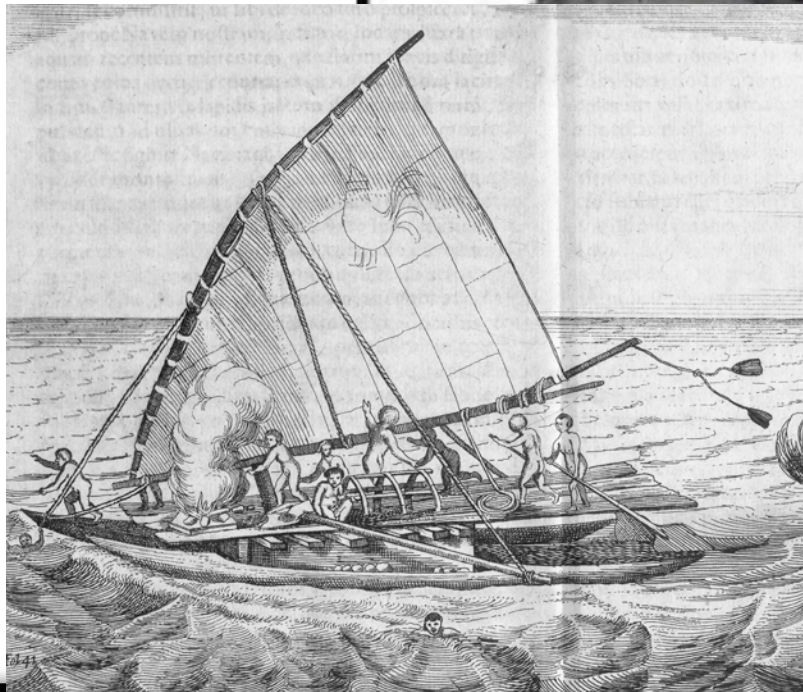


Barnosky et al. 2004, Science

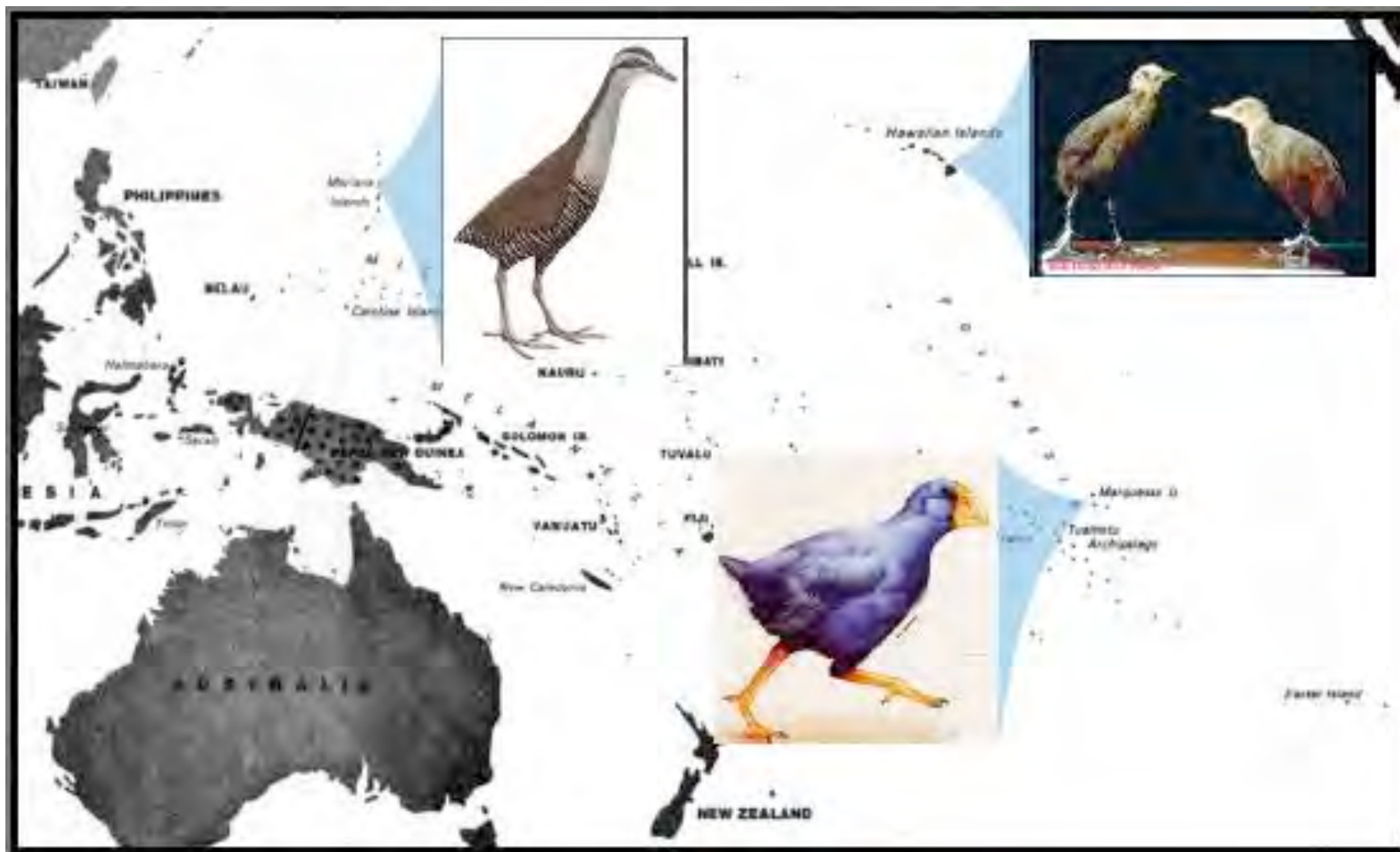
Human colonization of Oceania



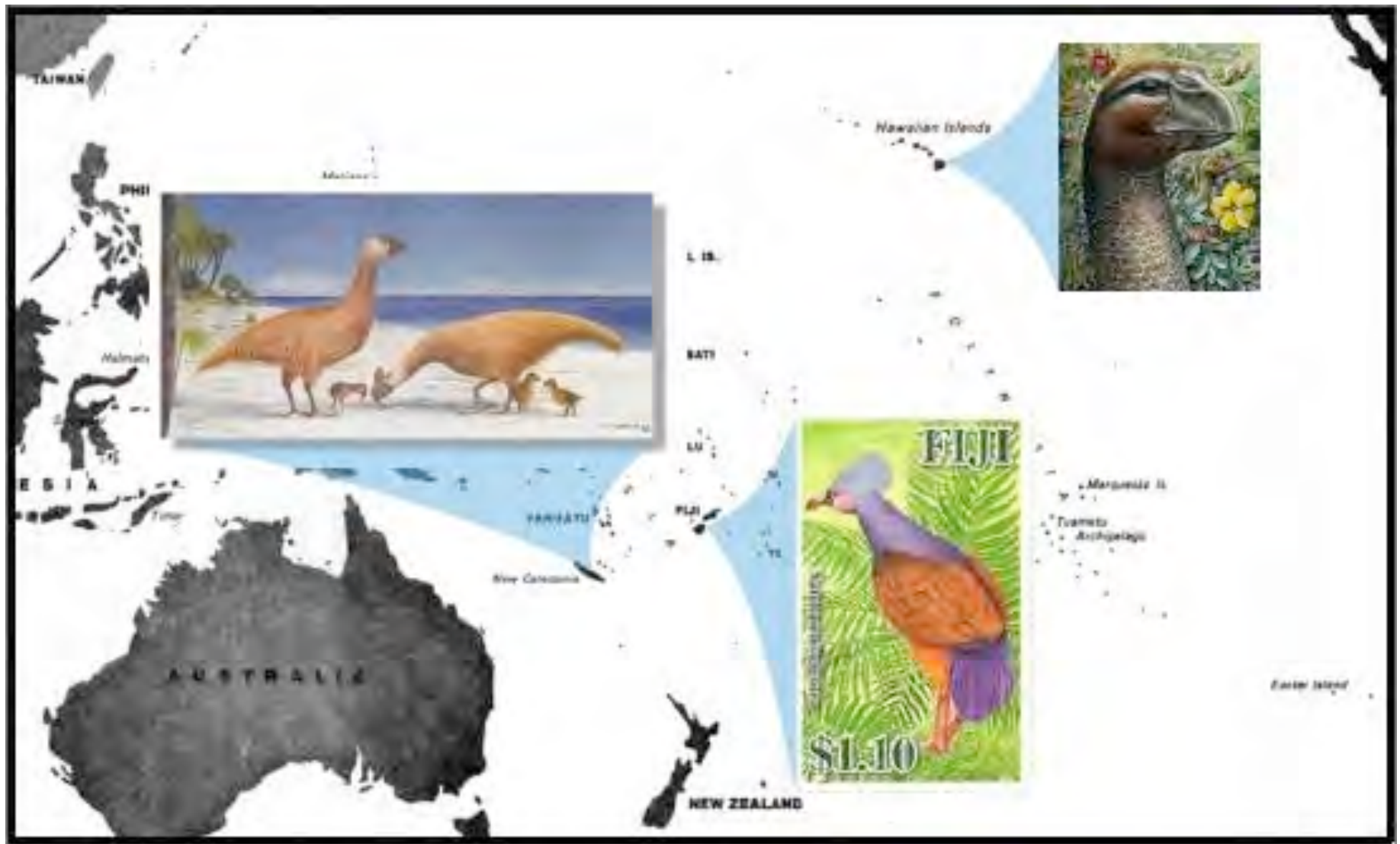
Based on Kirch 2002, *On the Road of the Winds*



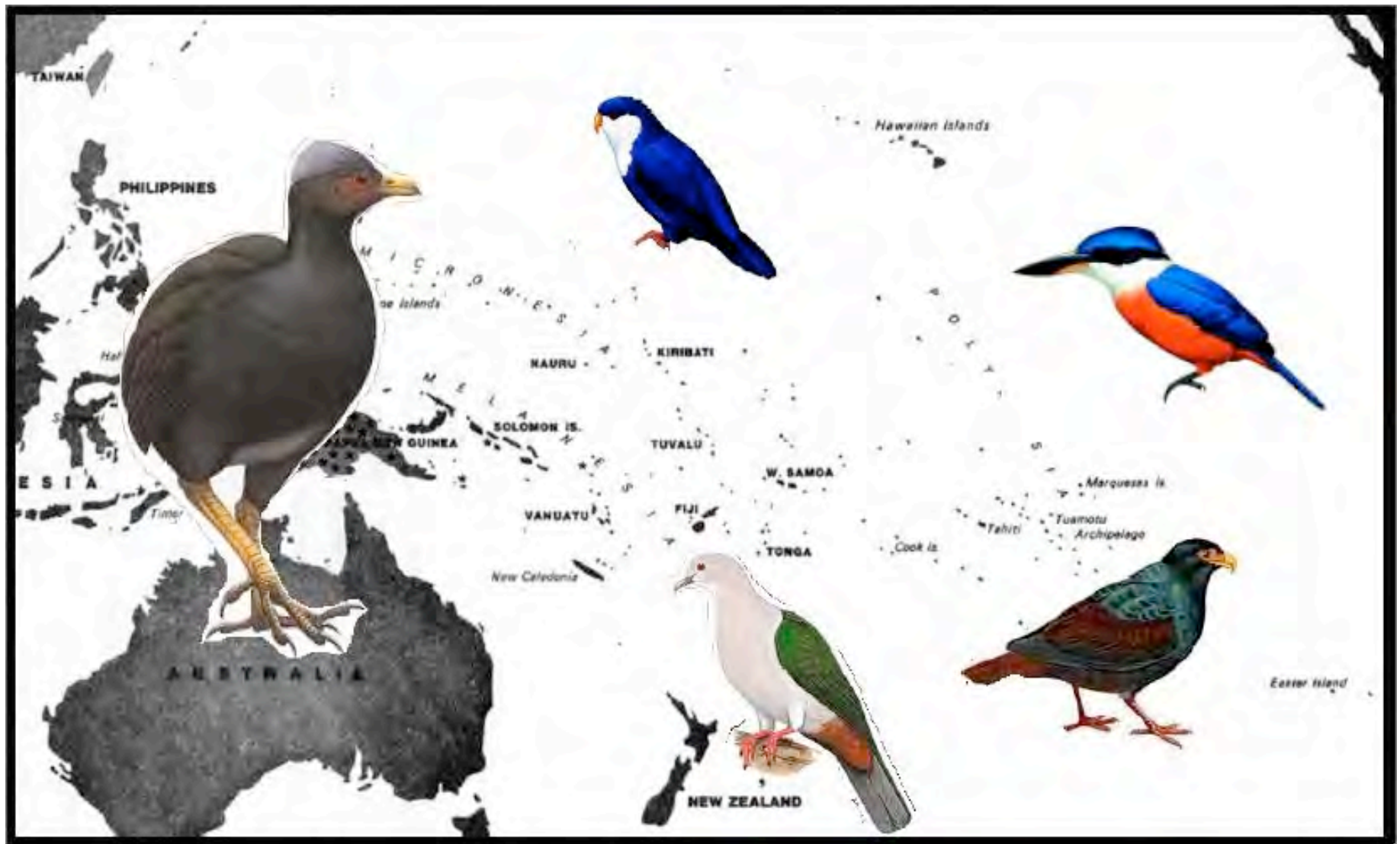
Bird extinctions in Oceania



Bird extinctions in Oceania



Bird extinctions in Oceania



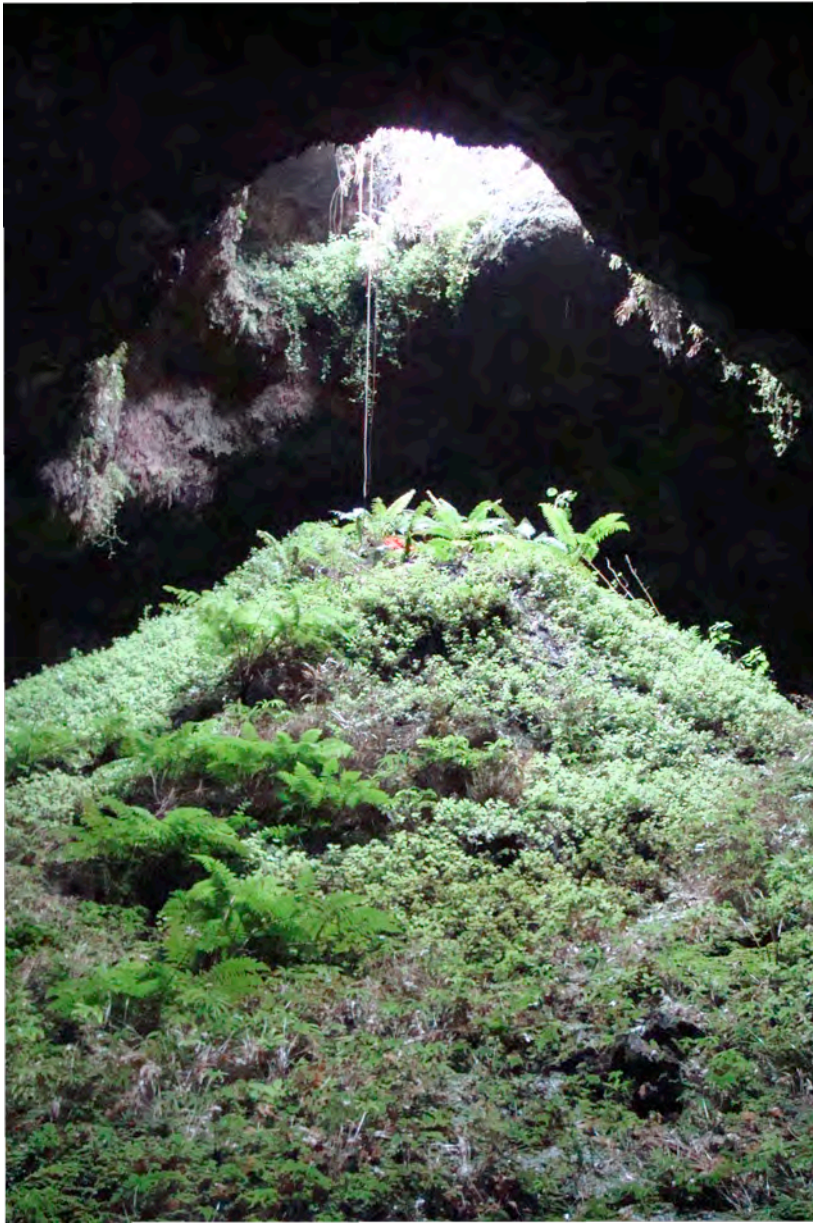
Holocene paleorecord of Pacific islands



Makauwahi Cave, Kauai

Fossil vertebrate localities:
archaeological sites

Holocene paleorecord of Pacific islands



Puu Makua Cave, Maui

Fossil vertebrate localities:

archaeological sites

natural traps

Holocene paleorecord of Pacific islands



Me Aure Cave, New Caledonia

Fossil vertebrate localities:

archaeological sites

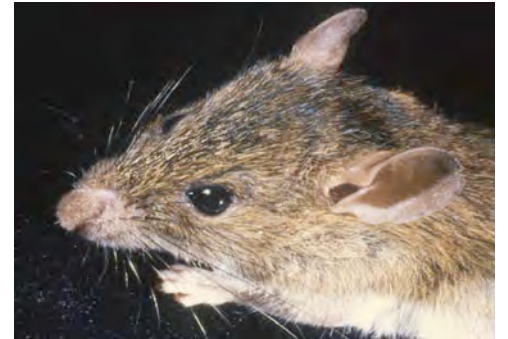
natural traps

bone accumulations by
predators



Extinction Mechanisms

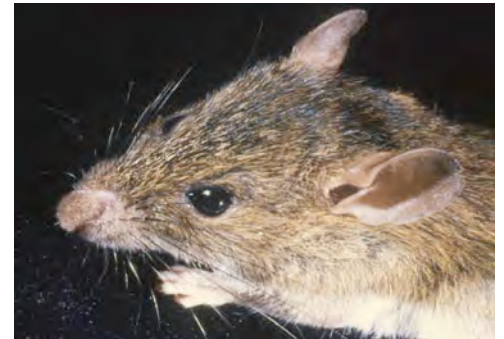
- overexploitation of populations
- introduction of exotic predators and diseases
- habitat destruction



Extinction Mechanisms

- overexploitation of populations
- introduction of exotic predators and diseases
- habitat destruction

These processes remain primary drivers of modern extinctions



Island bird extinctions

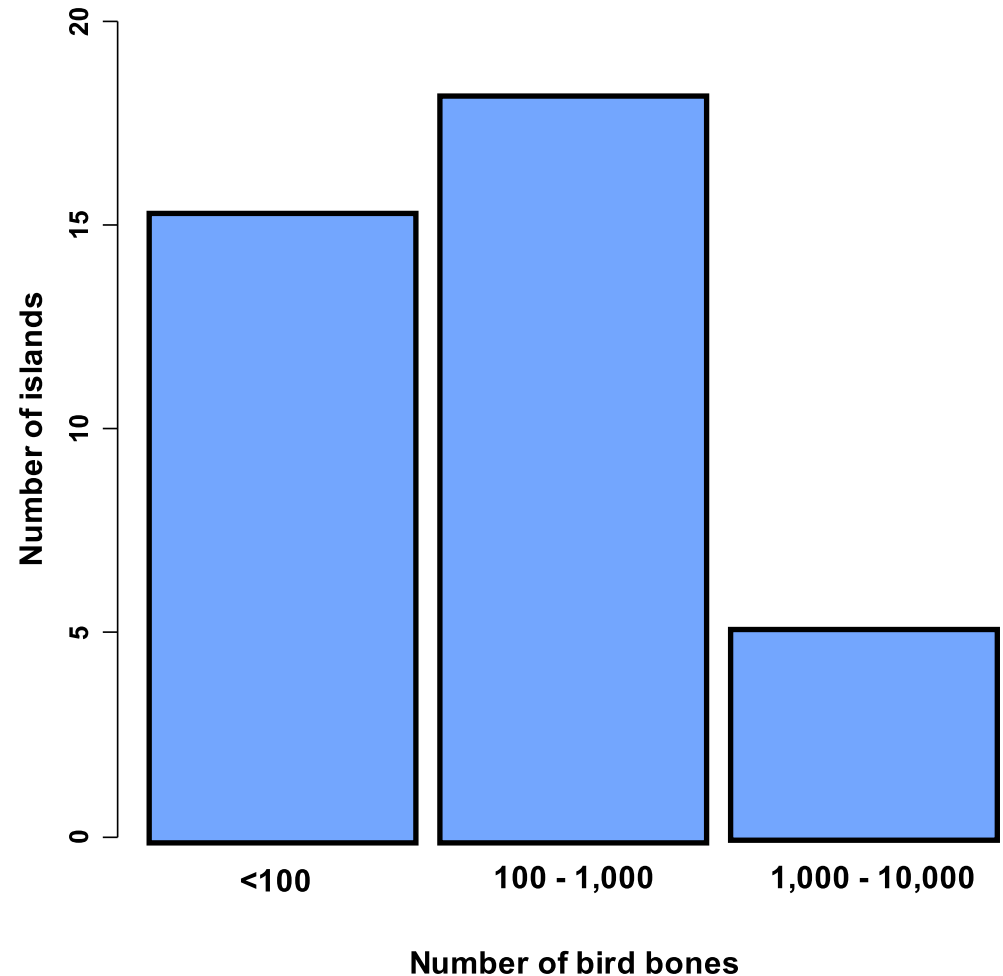
- How many species were lost?
- Which species went extinct?
- How did they change ecological communities?
- How can they be prevented?

How many species were lost?

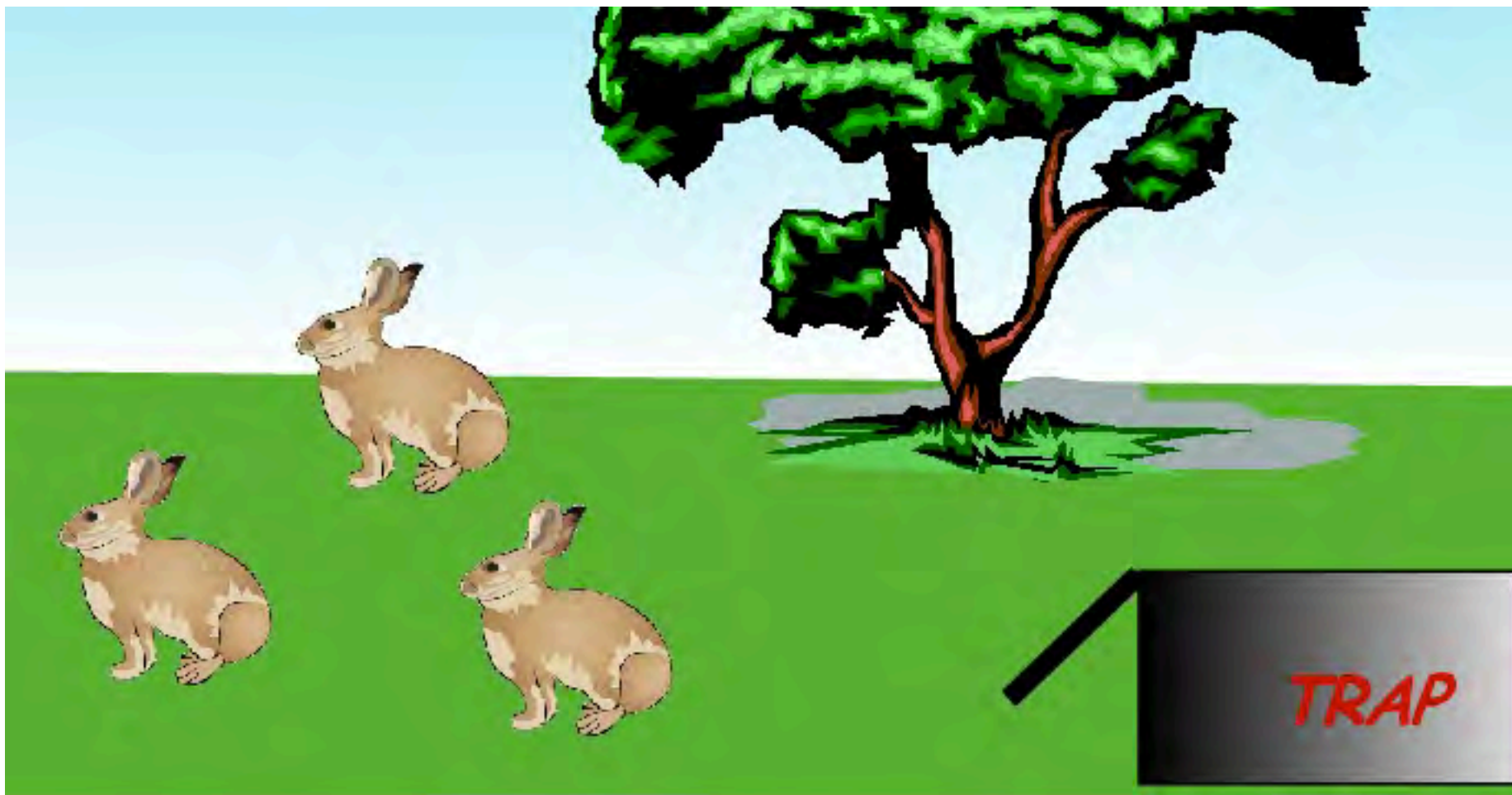
Islands differ in:

- collection effort
- number of sites
- taphonomy of sites
- traits and characteristics of species

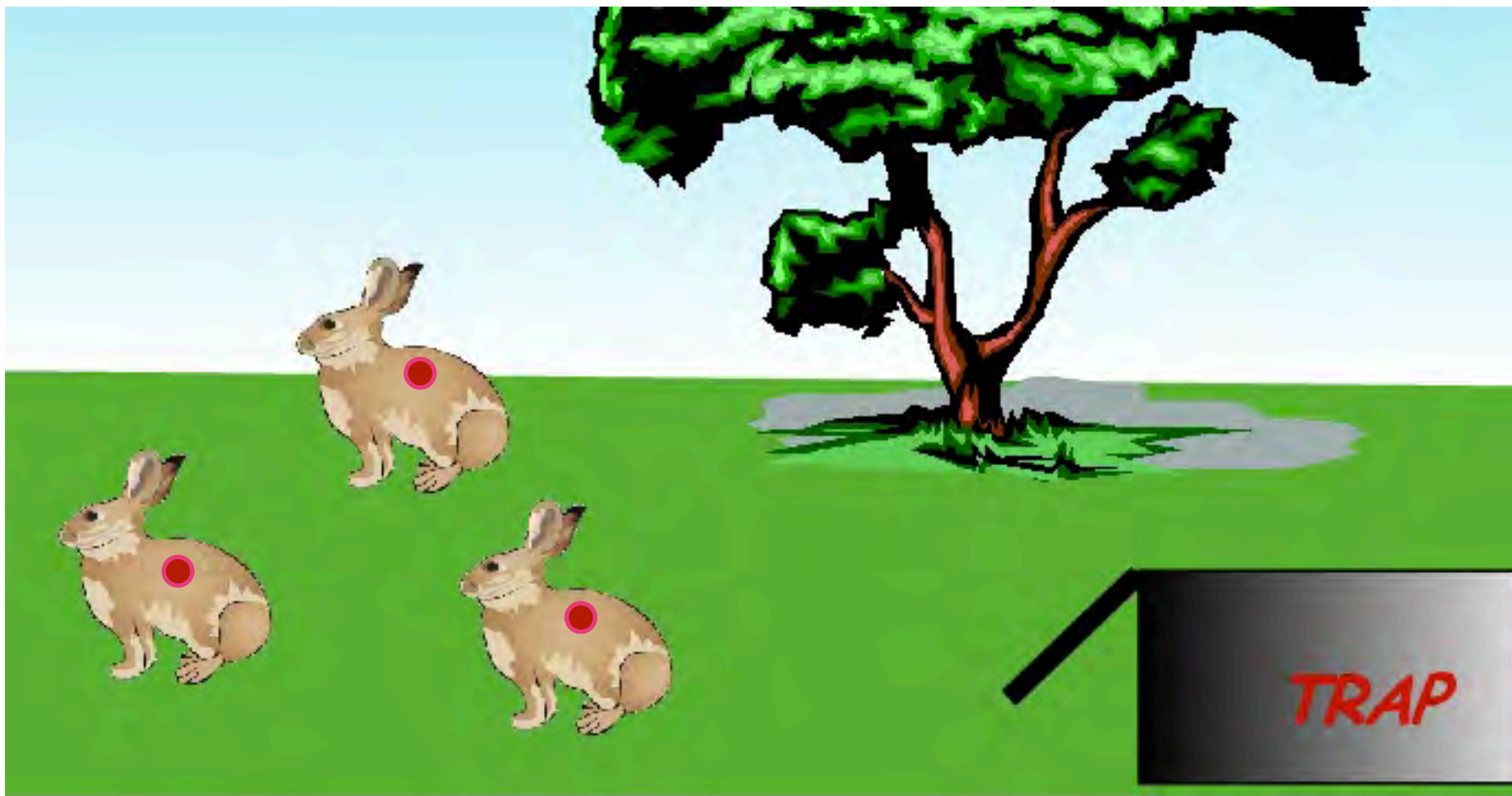
Low collection rate means
many extinct species
may remain to be
discovered



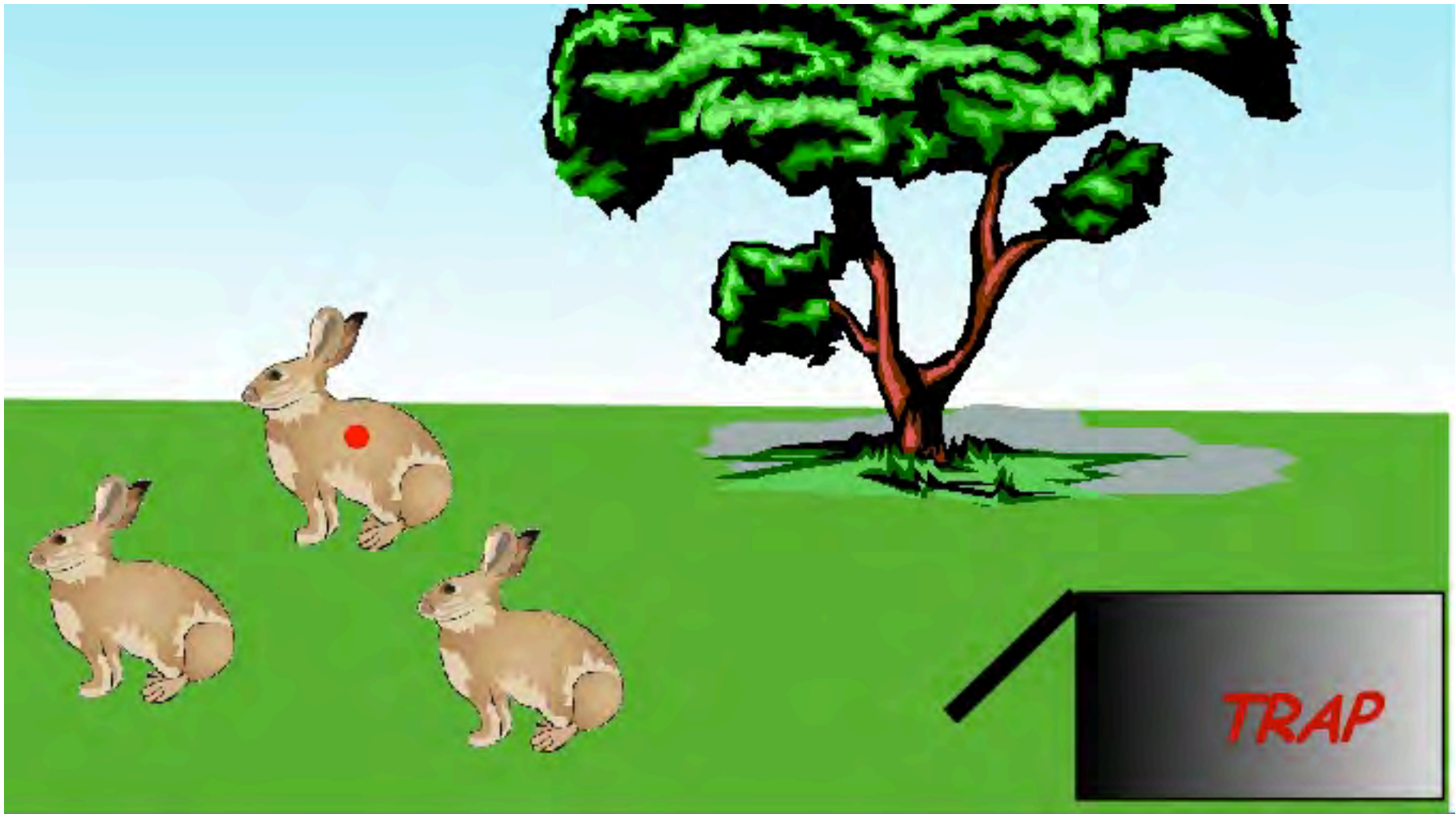
Classic Mark-recapture estimates



Classic Mark-recapture estimates



Classic Mark-recapture estimates



$$N = (M * T) / R = (3 * 3) / 1 = 9$$

Mark-recapture for fossils

Marked



Living species



Historically observed

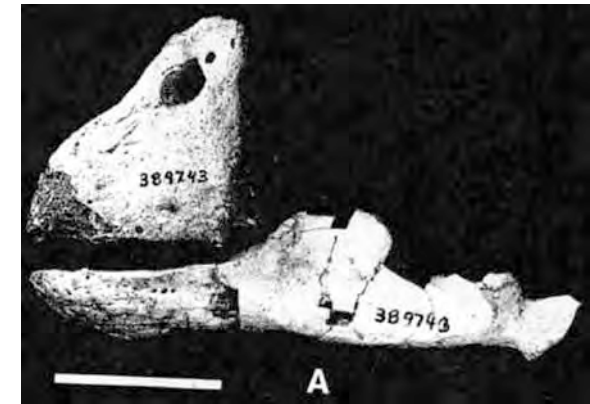
Recaptured



Living species



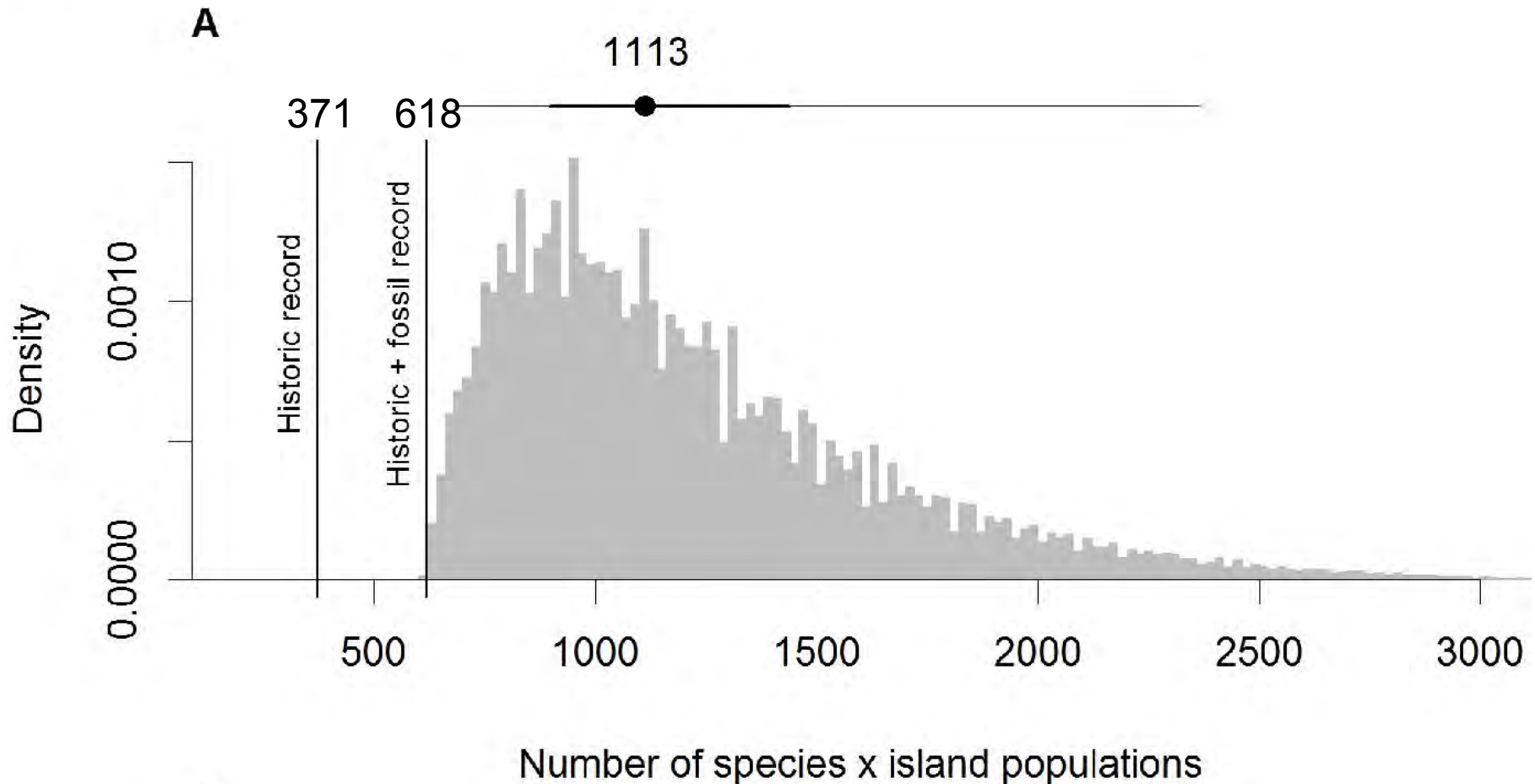
Historically observed



Known only from fossils

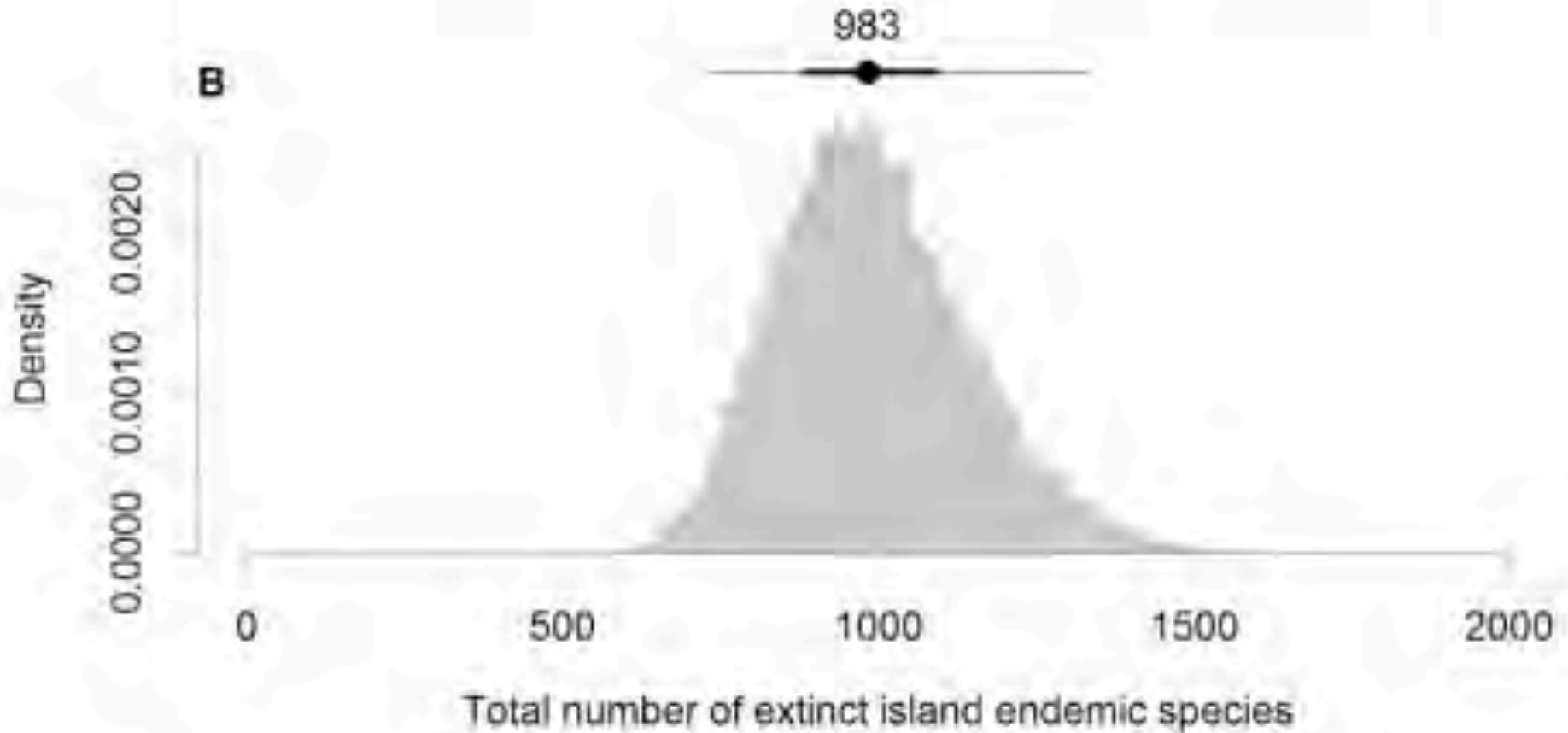
Number of extinctions

Bayesian hierarchical mark-recapture model



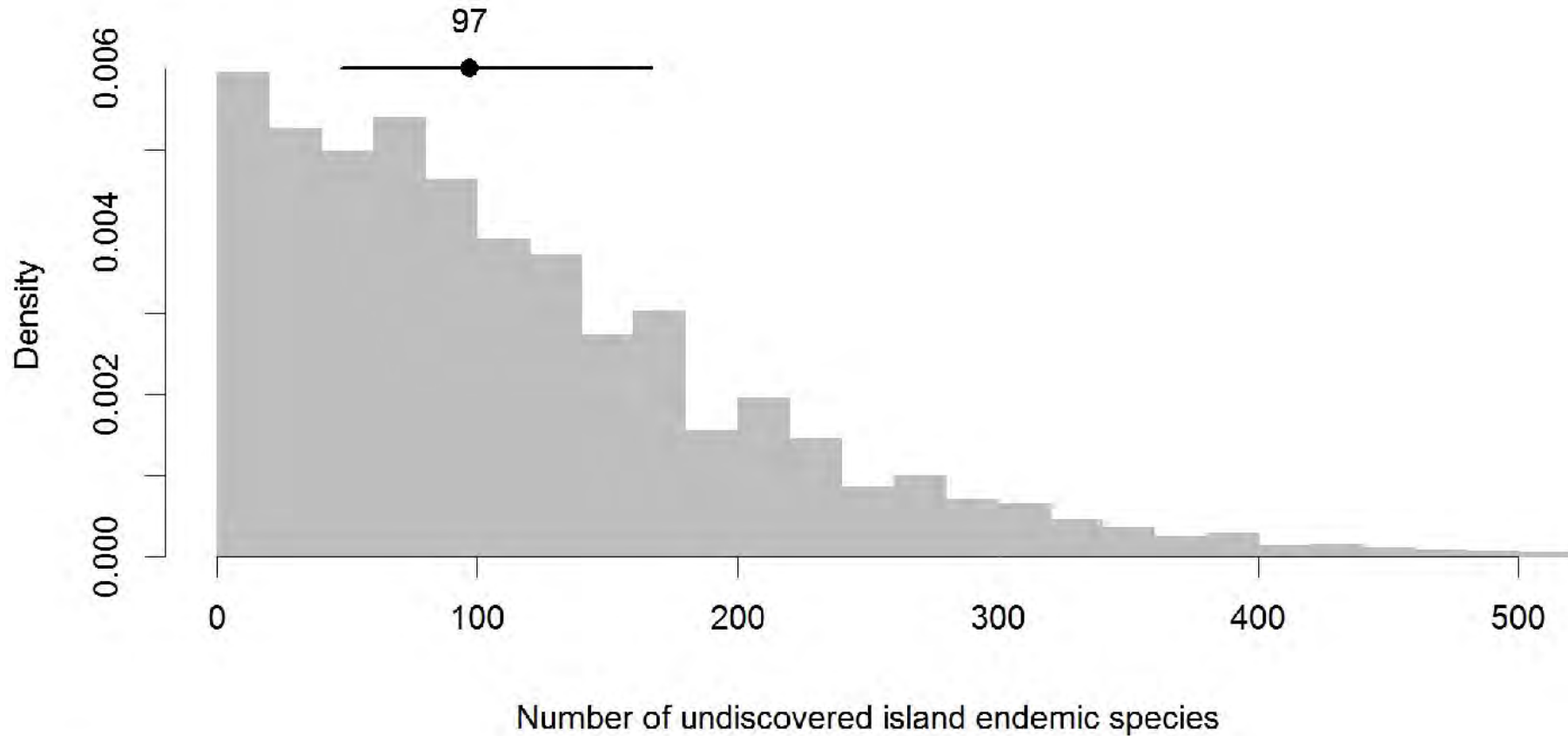
Number of extinctions

Bayesian hierarchical mark-recapture model



Duncan, Boyer & Blackburn, 2013, PNAS

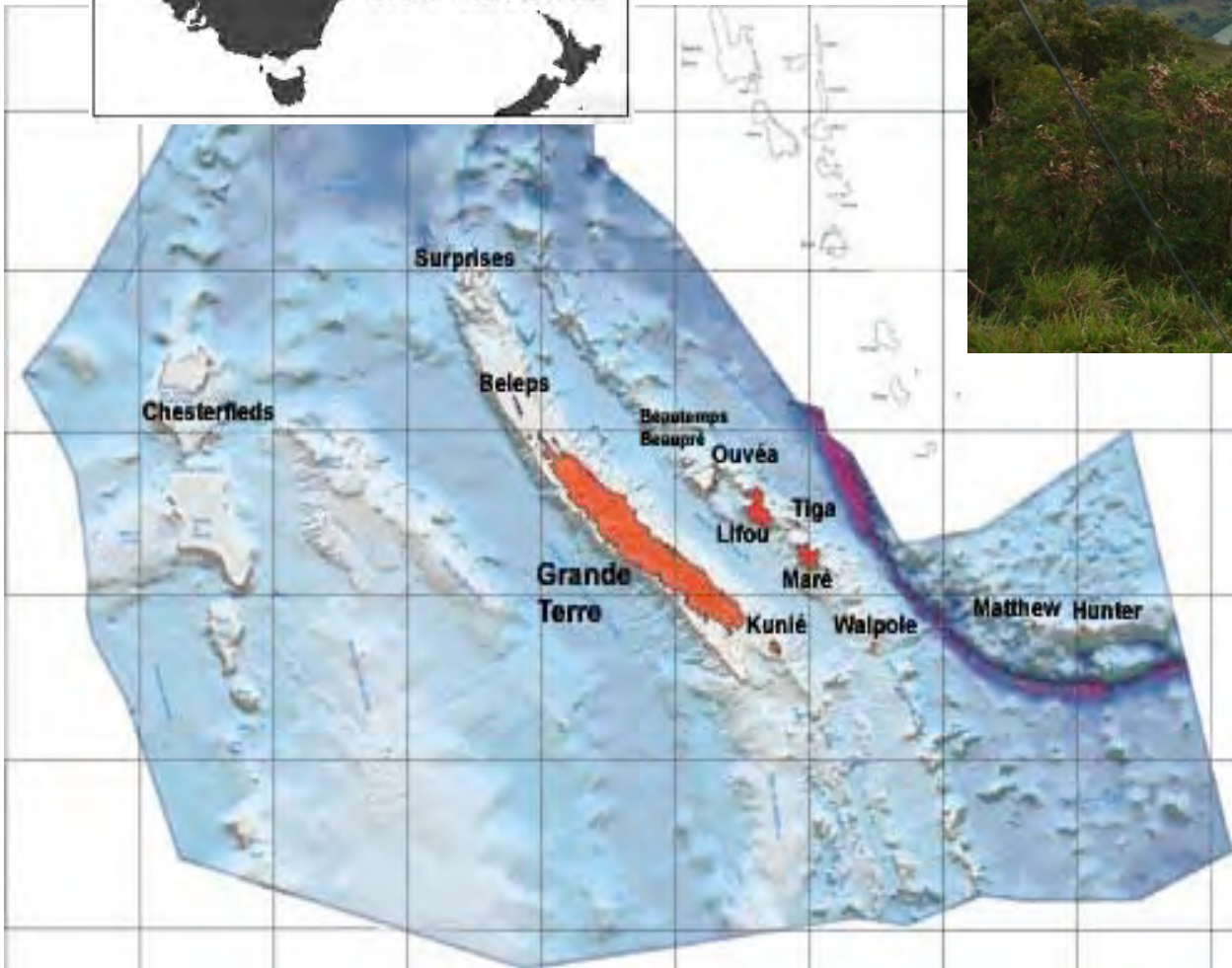
Number of undiscovered species



Island bird extinctions

- How many species were lost?
- **Which species went extinct?**
- How did they change ecological communities?
- How can they be prevented?

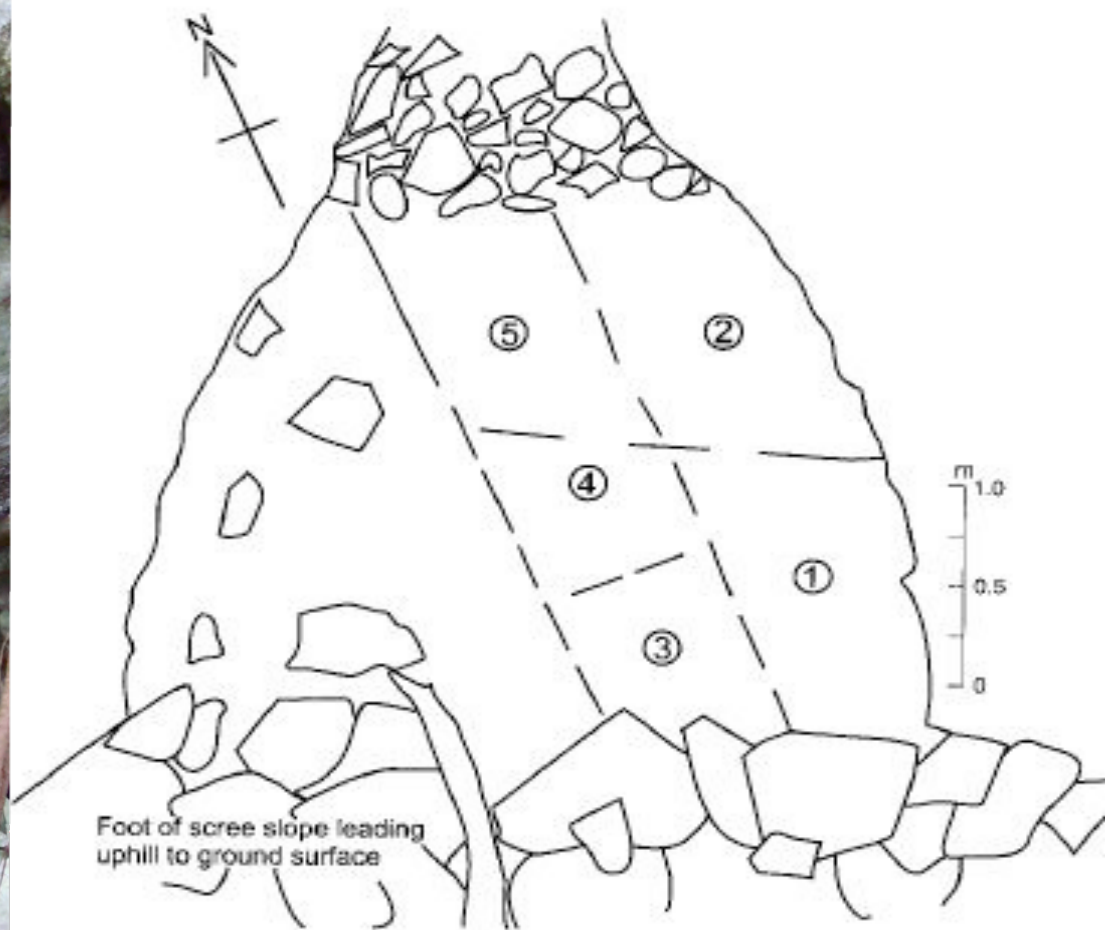
New Caledonia



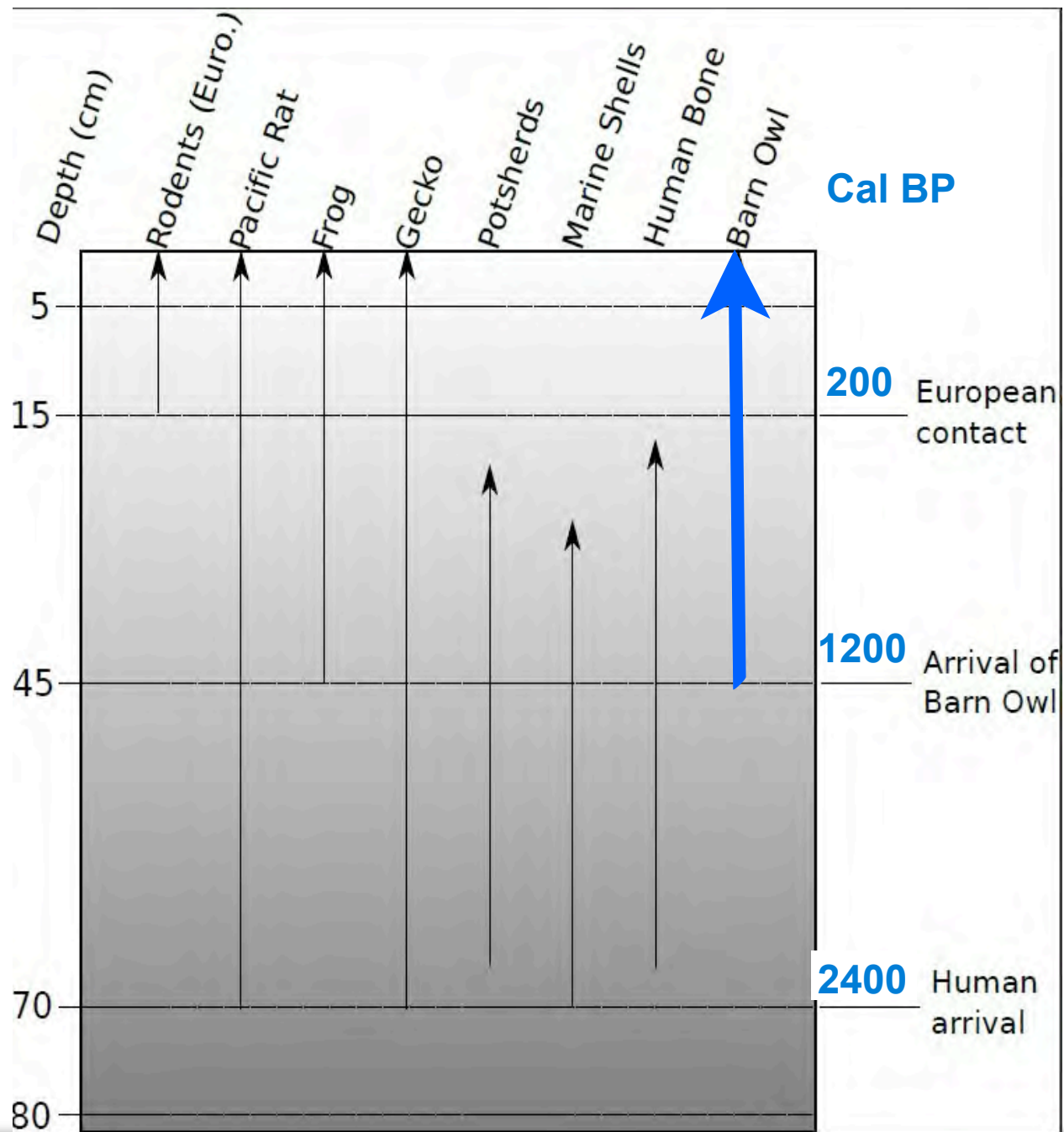
Mé Auré Cave site



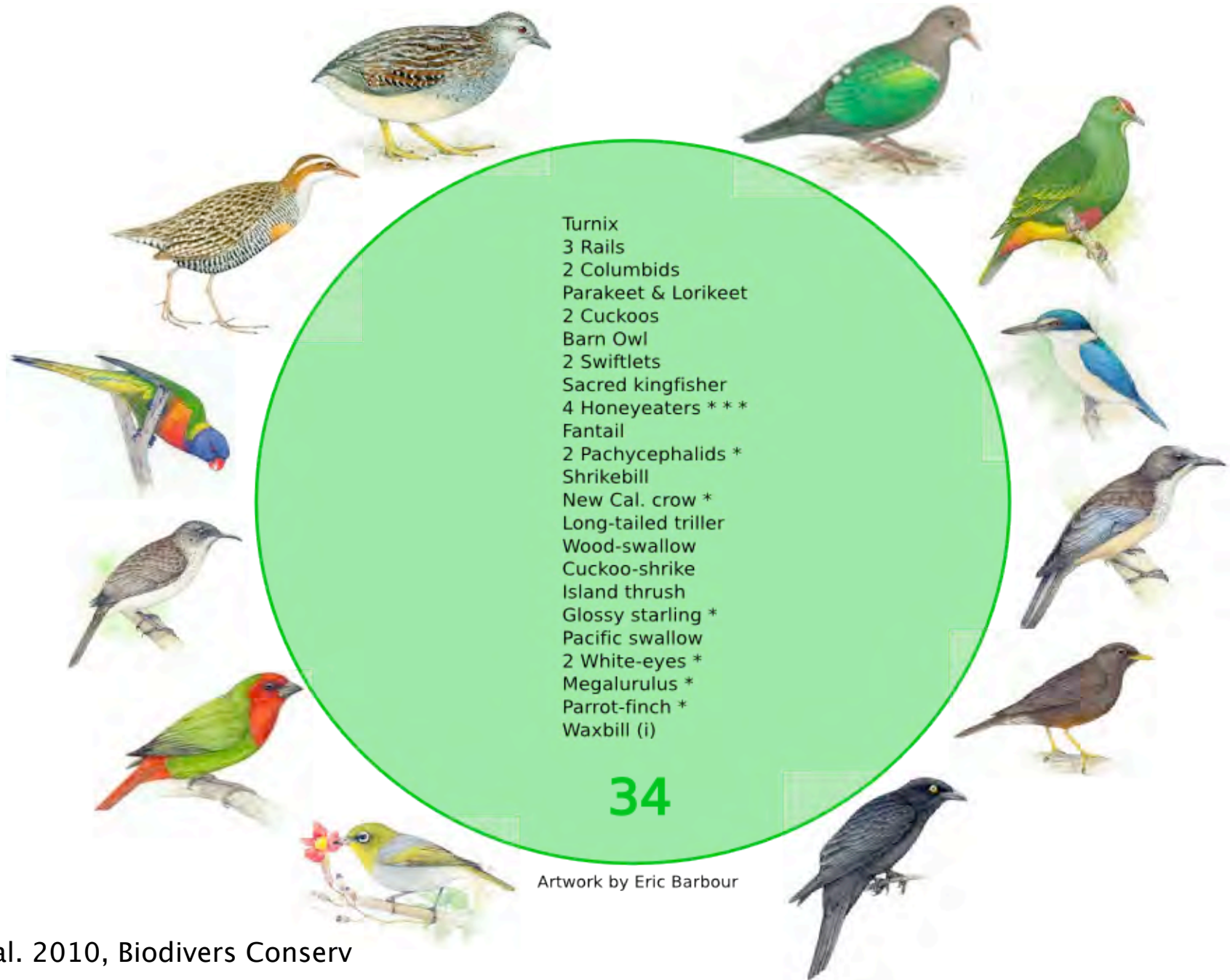
Me Aure Cave, New Caledonia



Mé Auré Cave record



Mé Auré Cave Birds

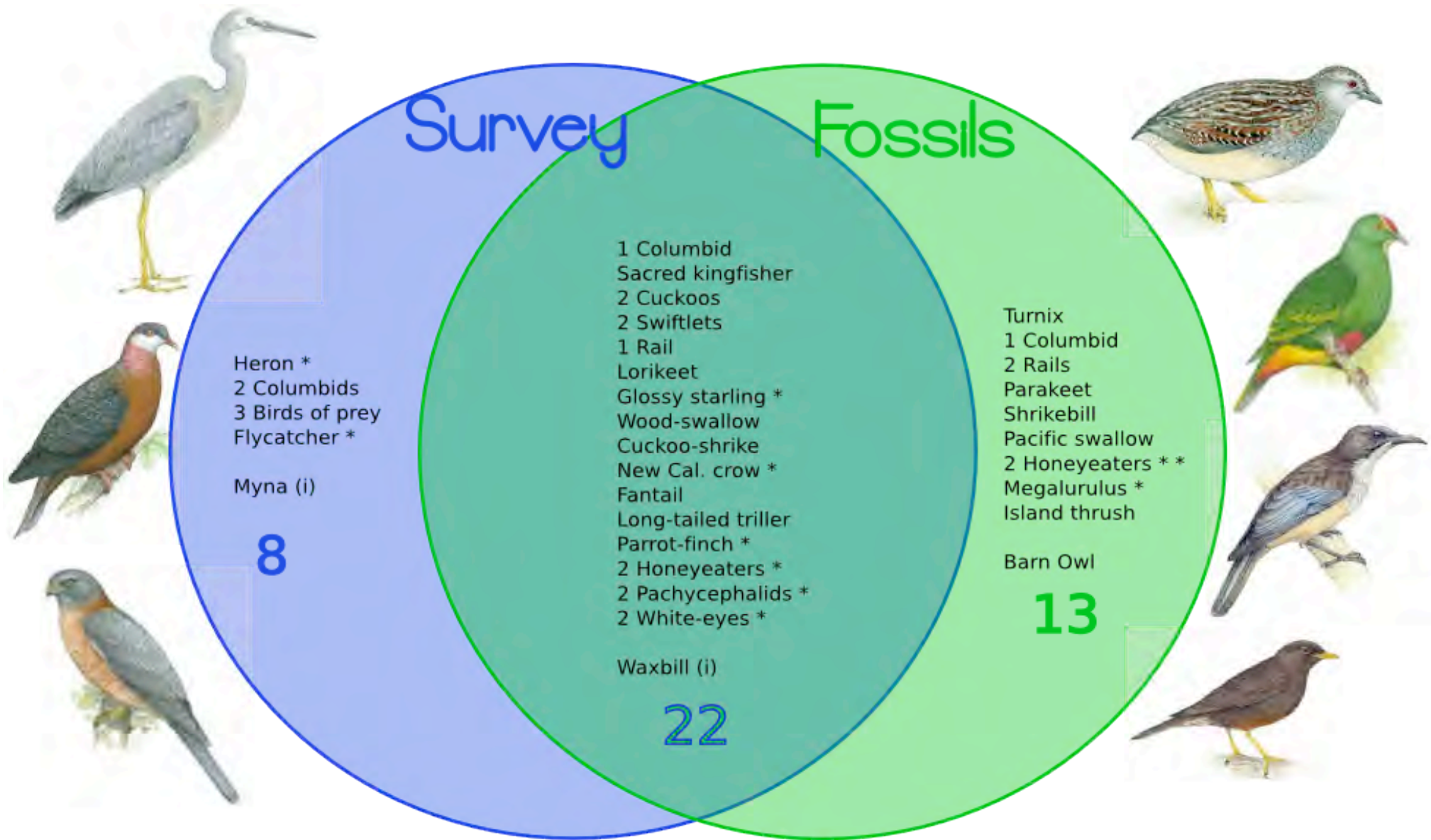


Turnix
3 Rails
2 Columbids
Parakeet & Lorikeet
2 Cuckoos
Barn Owl
2 Swiftlets
Sacred kingfisher
4 Honeyeaters * * *
Fantail
2 Pachycephalids *
Shrikebill
New Cal. crow *
Long-tailed triller
Wood-swallow
Cuckoo-shrike
Island thrush
Glossy starling *
Pacific swallow
2 White-eyes *
Megalurulus *
Parrot-finch *
Waxbill (i)

34

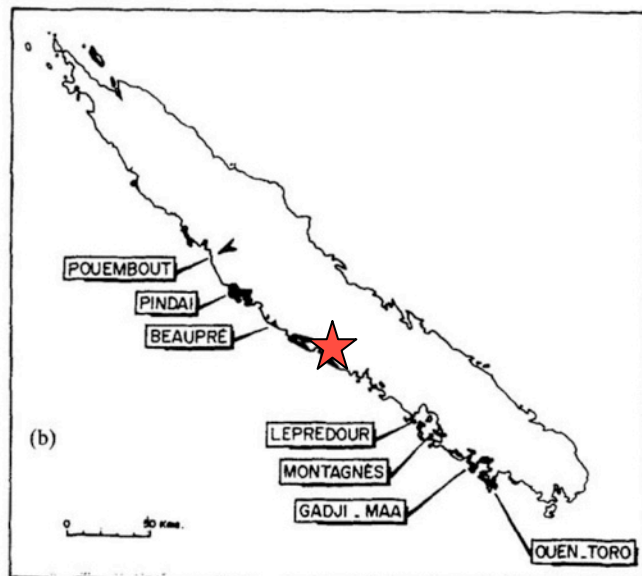
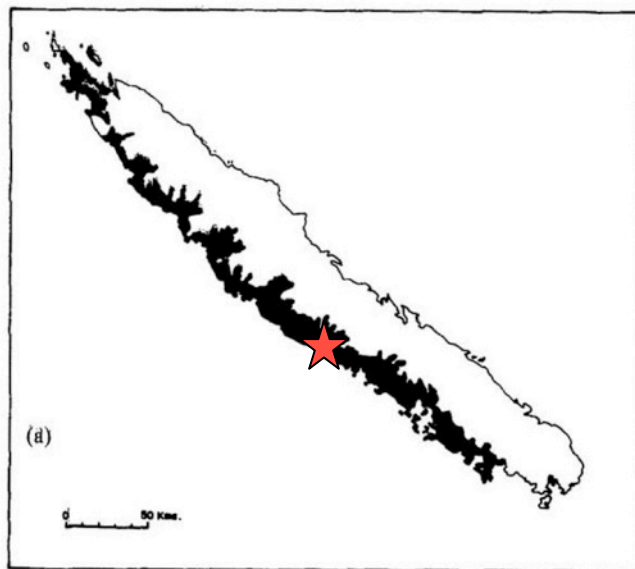
Artwork by Eric Barbour

Mé Auré Cave Birds



Artwork by Eric Barbour

New Caledonia's dry forest



Bouchet et al 1995



“The most threatened
tropical dry forest in the world.”
-Conservation International

Boa Cave site

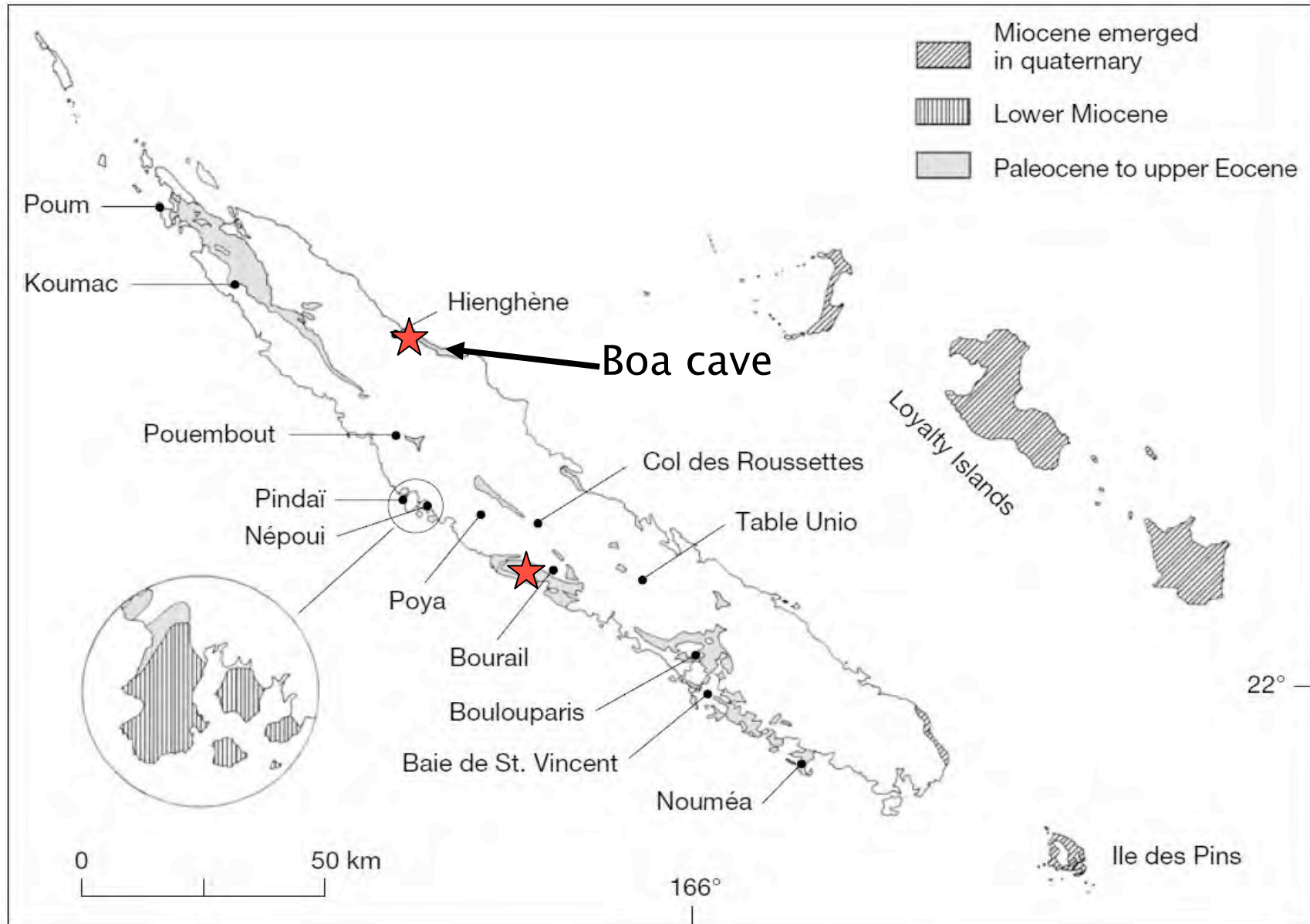


Fig. 1. — Limestone substrate in New Caledonia (adapted from PARIS 1981).

Boa Cave excavations 2011



Boa Cave excavations 2011



Boa Cave excavations 2011



Boa Cave excavations 2011



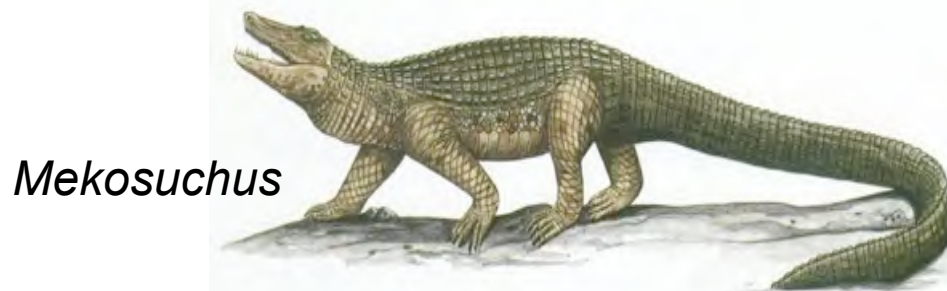
A giant extinct bird



Sylvionis



Known extinctions in New Caledonia



Which species went extinct?

Me Aure Cave:

interior forest spp. declined and
second-growth generalists increased

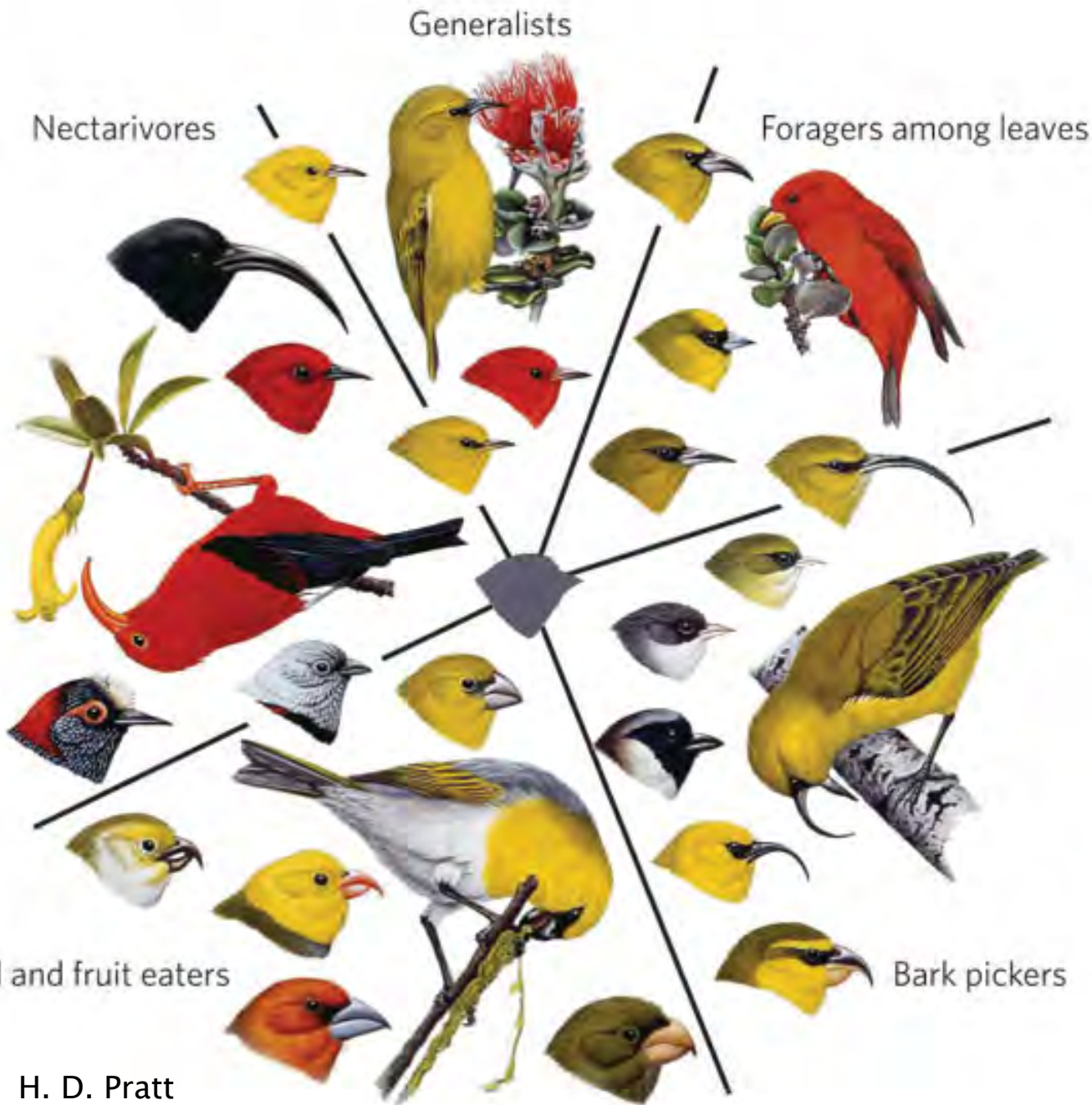
Boa Cave:

the largest vertebrate species
disappeared

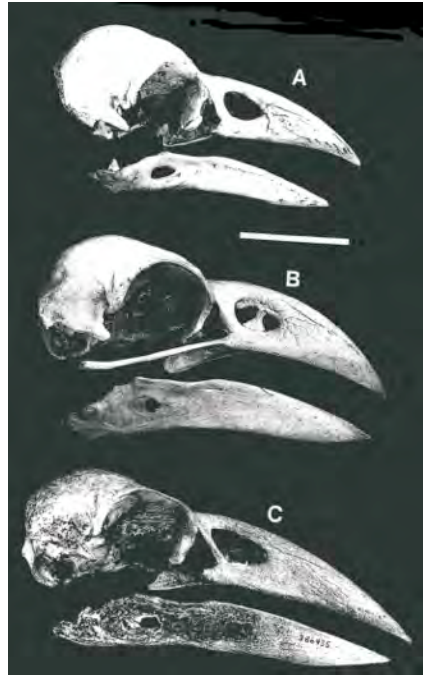


Forest remains intact only on steep ridges

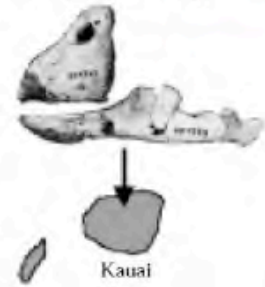
The Hawaiian islands



The Hawaiian islands



Chelychelynechen quassus



Thambetochen xanion



Ptauchen pau



Oahu

Molokai



Lanai

Maui

Hawaii



Anas wyvilliana
Hawaiian Duck



Thambetochen chaulioides

The Hawaiian islands



Extinction selectivity

Why are some species more likely to be threatened with extinction than others?

External threats

- hunting, predators, disease, habitat loss

Intrinsic susceptibility

- body size, endemism, flightlessness, trophic guild

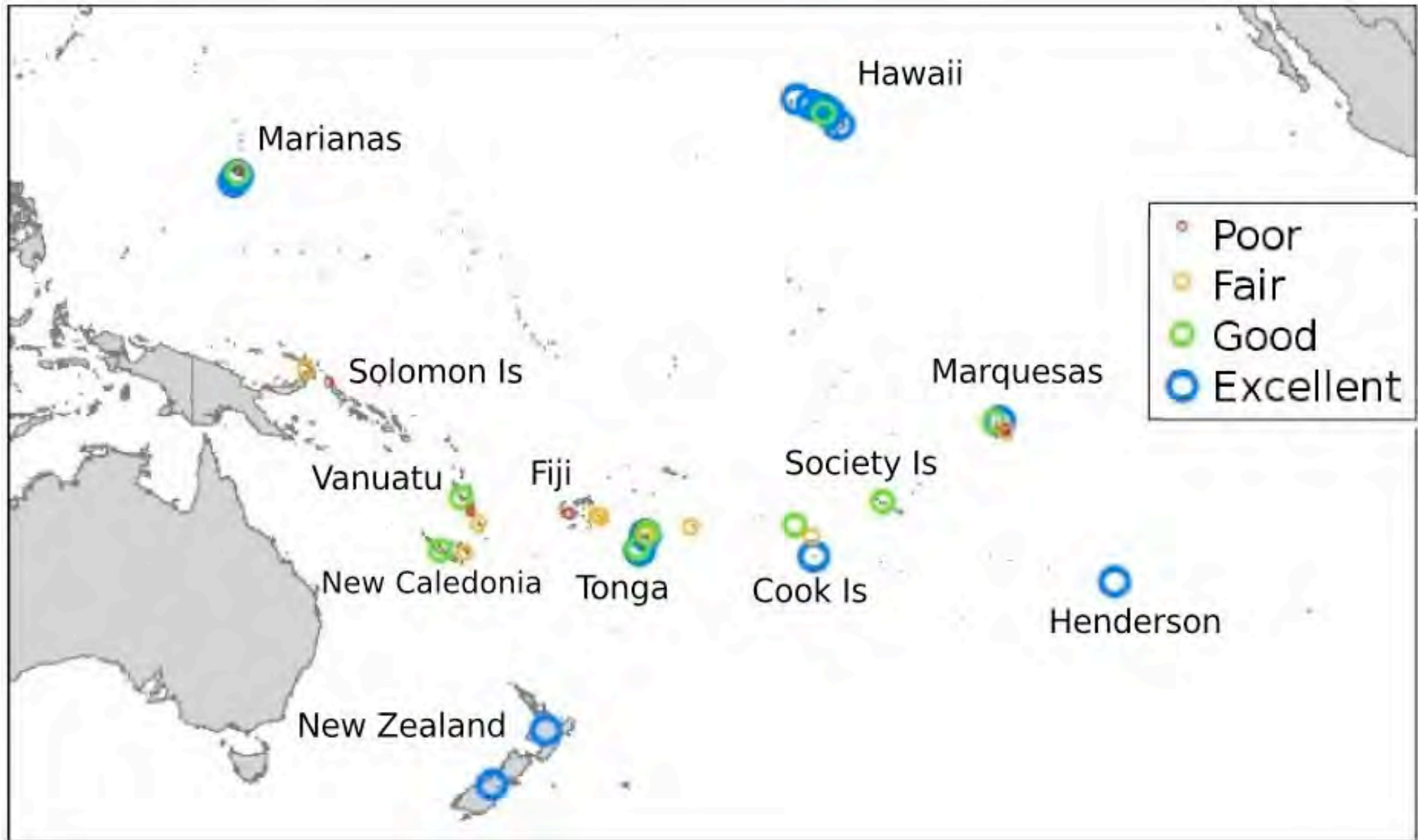
Environmental correlates

- island area, isolation, climate



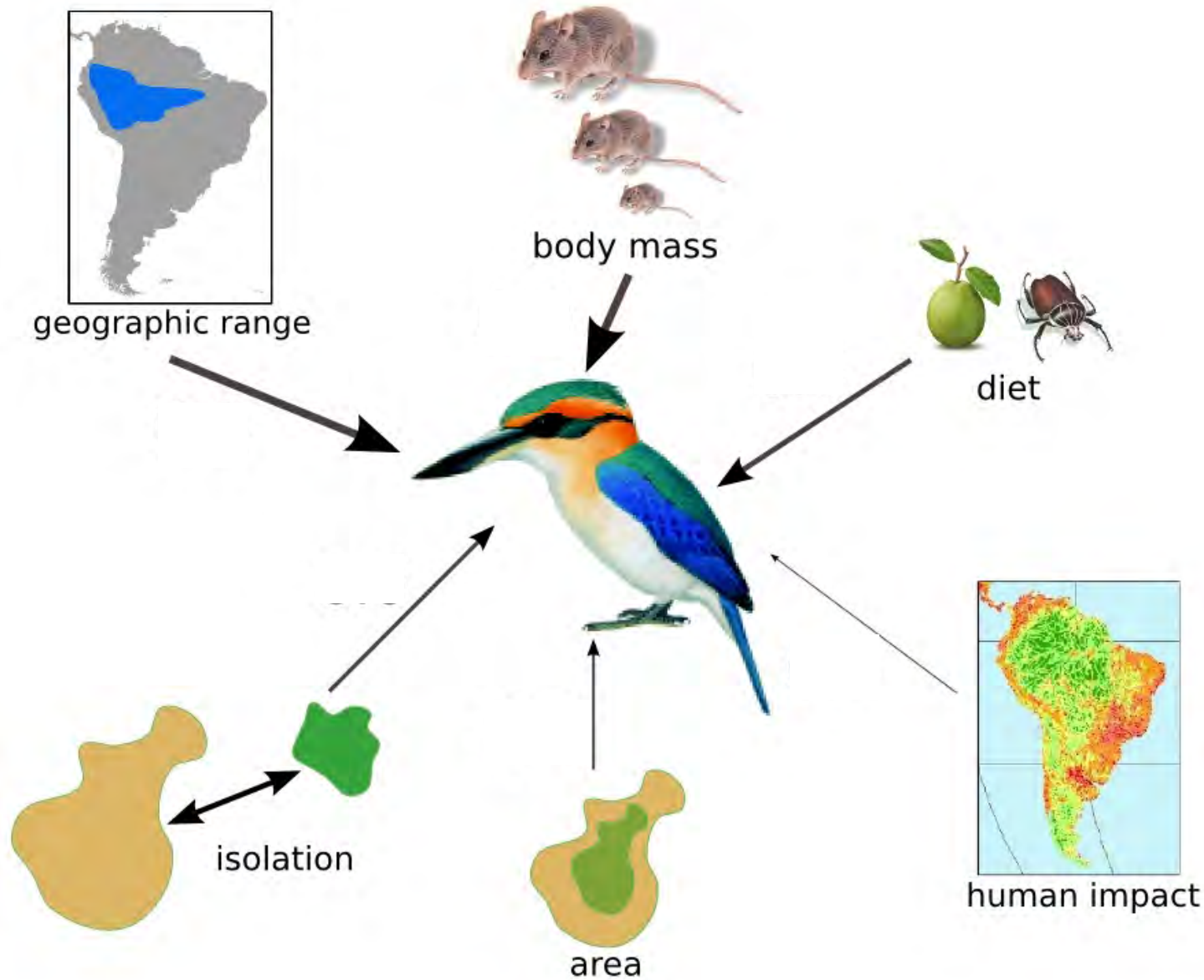
James & Olson 2003, Auk

Holocene paleorecord of Pacific islands



Extinctions 3500 ybp – present

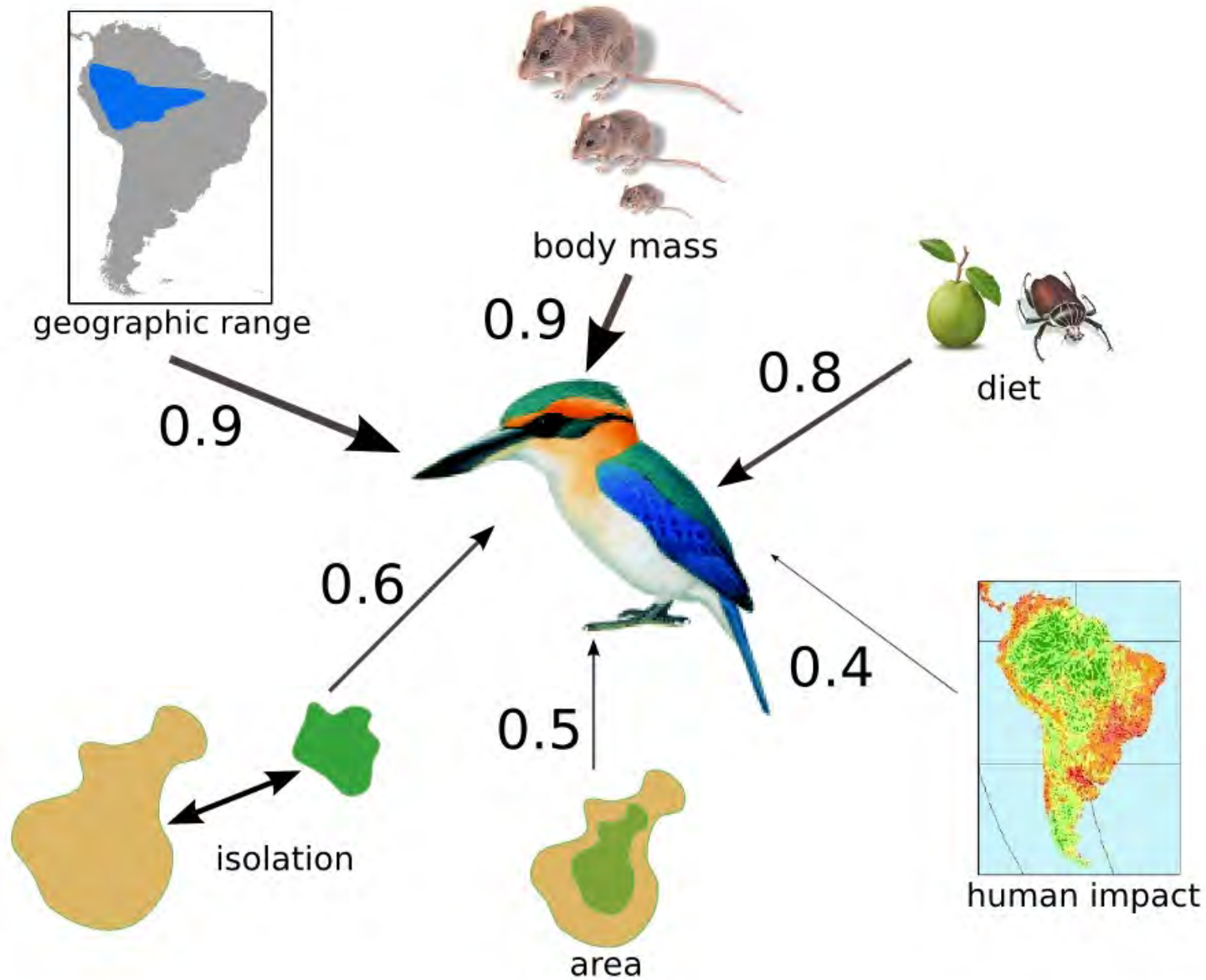
Random forest model



Relative Importance of Predictors

Boyer 2010, *Conservation Biology*

Extinctions 3500 ybp – present

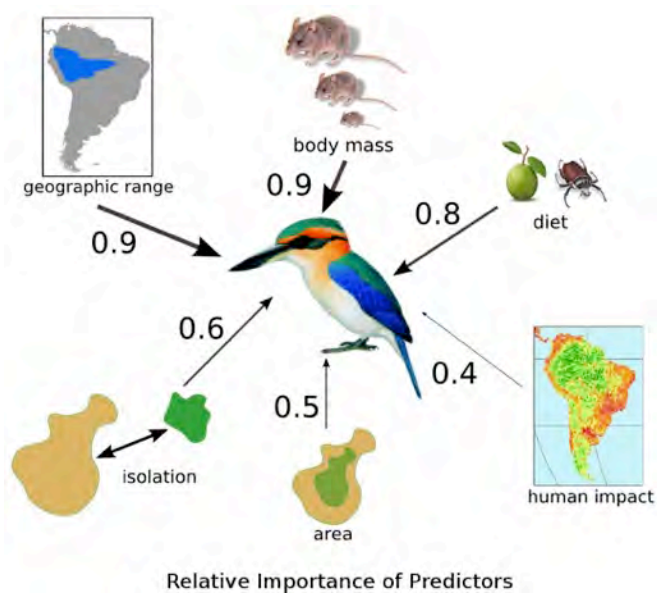


Relative Importance of Predictors

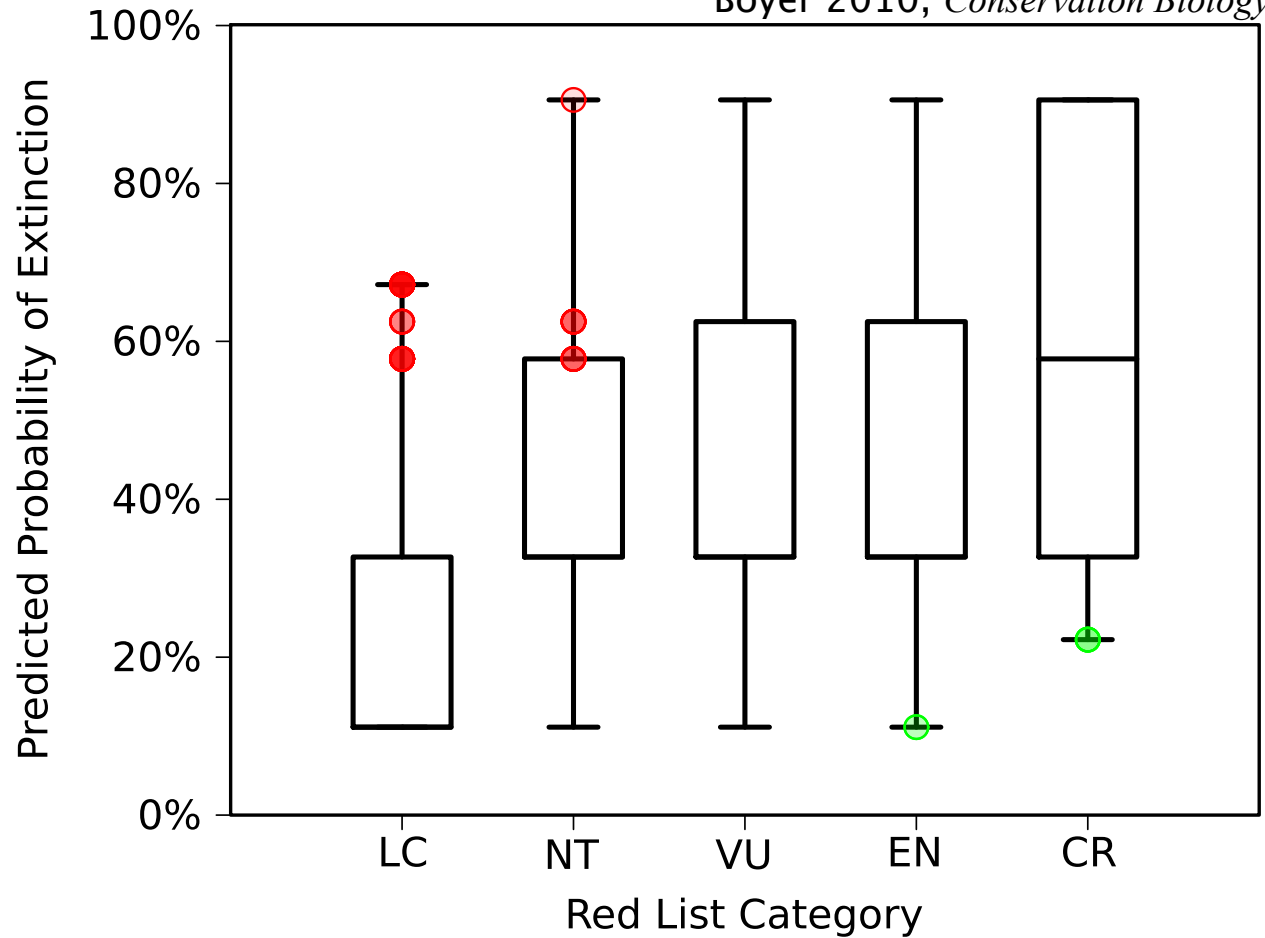
Random forest model

- $n = 1264$
- Accuracy: 87%
- False-negatives: 5.1%
- False-positives: 31%

Extinction risk predictions



Boyer 2010, *Conservation Biology*



Which species went extinct?

Large species

Those found on only a few islands

Diet of vegetation and seeds

Island characteristics and deforestation were less important



Giant Moa (*Dinornis robustus*), by Paul Martinson

Island bird extinctions

- How many species were lost?
- Which species went extinct?
- **How did extinctions change ecological communities?**
- How can they be prevented?

Ecosystem services provided by birds

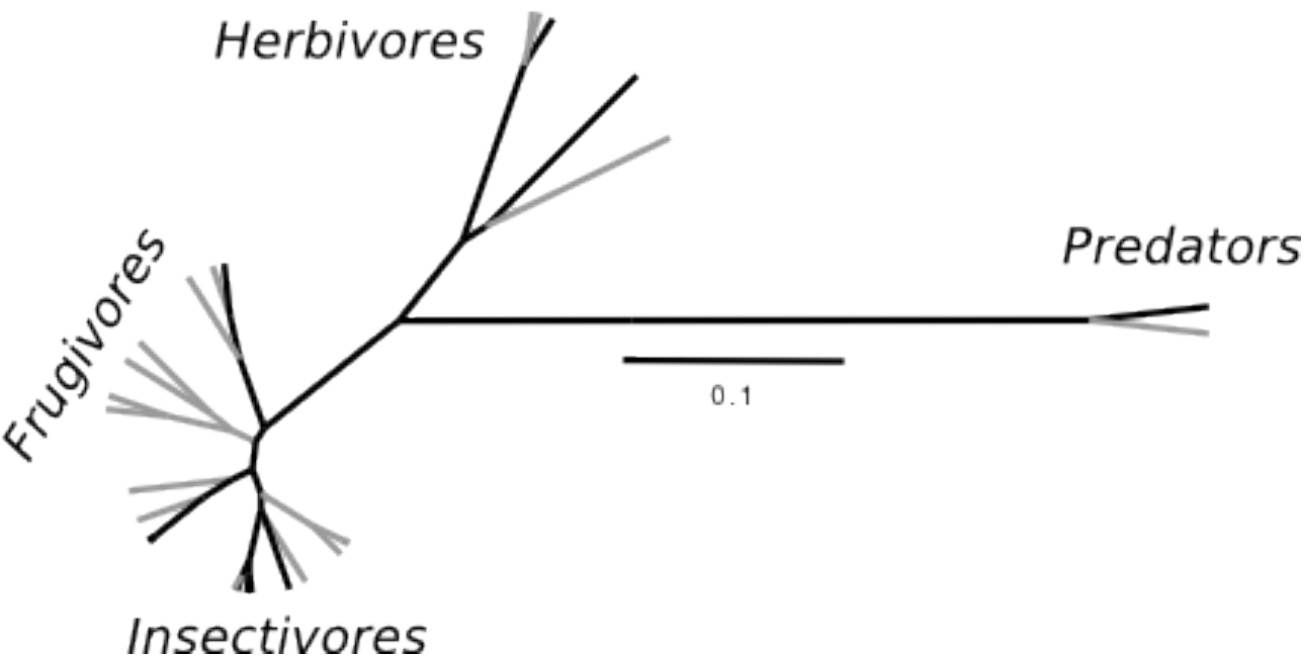


Functional
Diversity

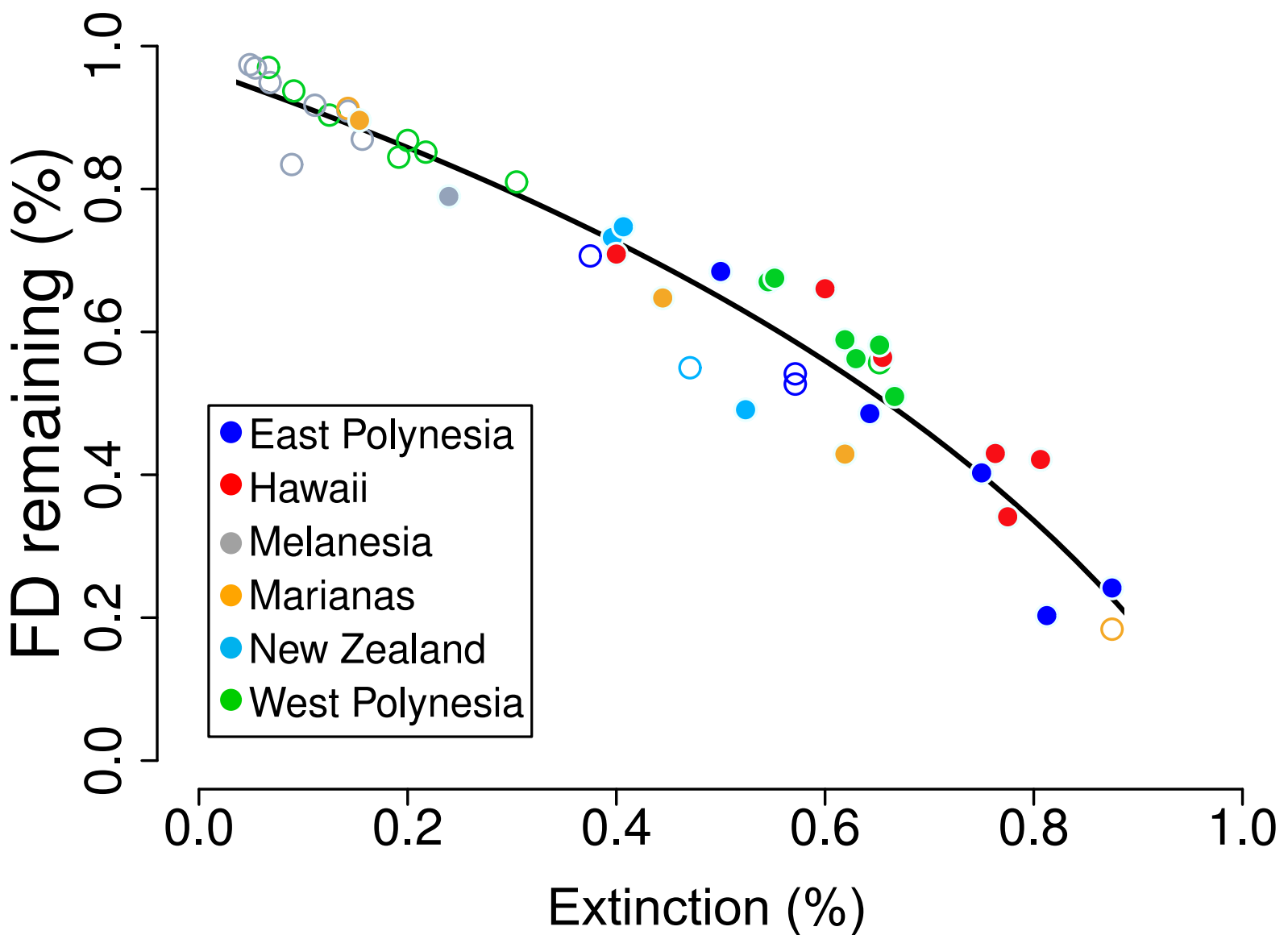


Functional diversity of the bird community

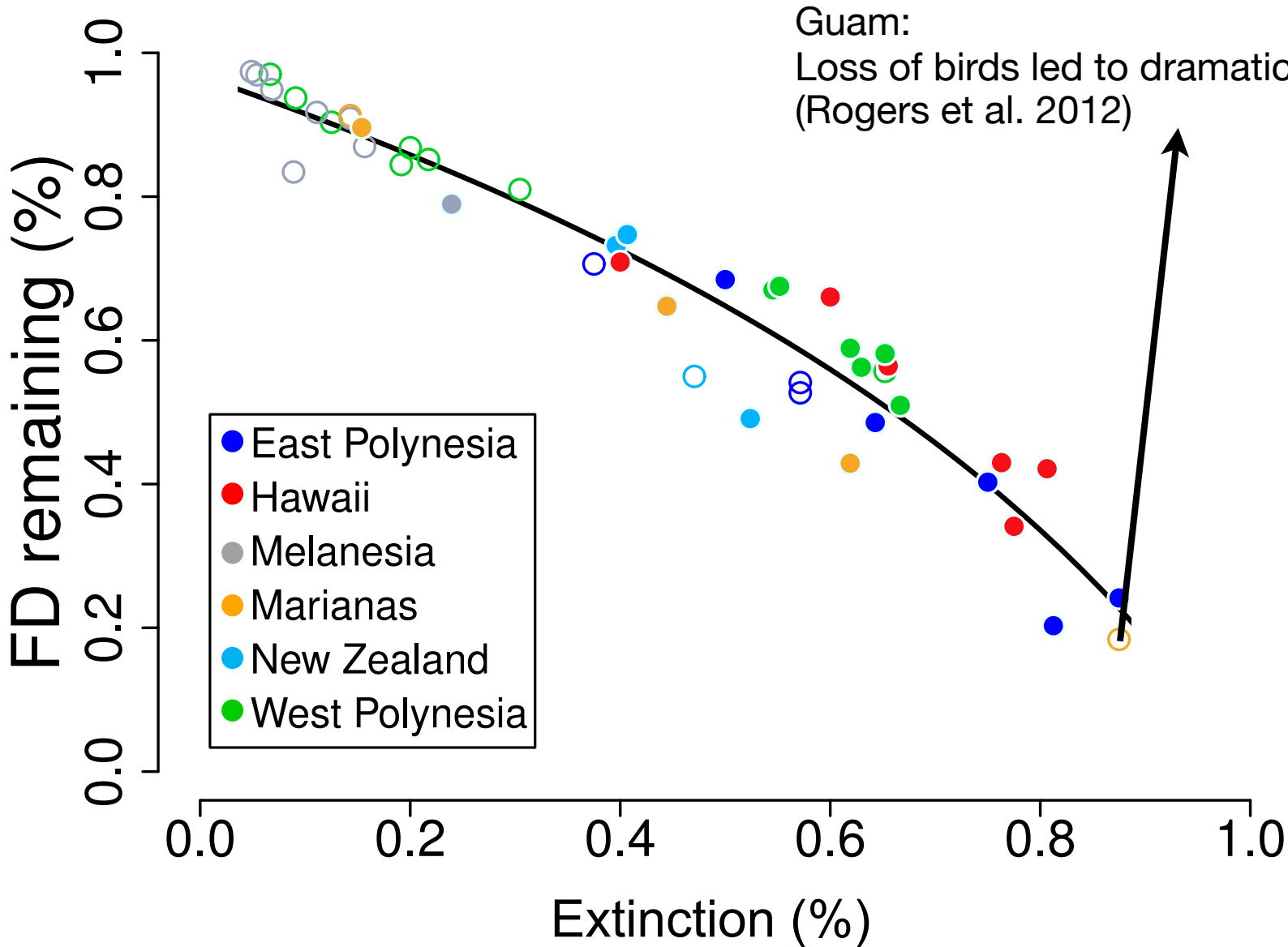
Trait	Category
Body mass	
Activity period	
Diet	Vertebrate prey
	Carrion
	Invertebrates
	Fleshy fruits
	Nectar
	Seeds
	Plant material
Foraging niche	Water
	Ground-level
	Understory
	Mid-canopy
	Upper canopy
	Aerial



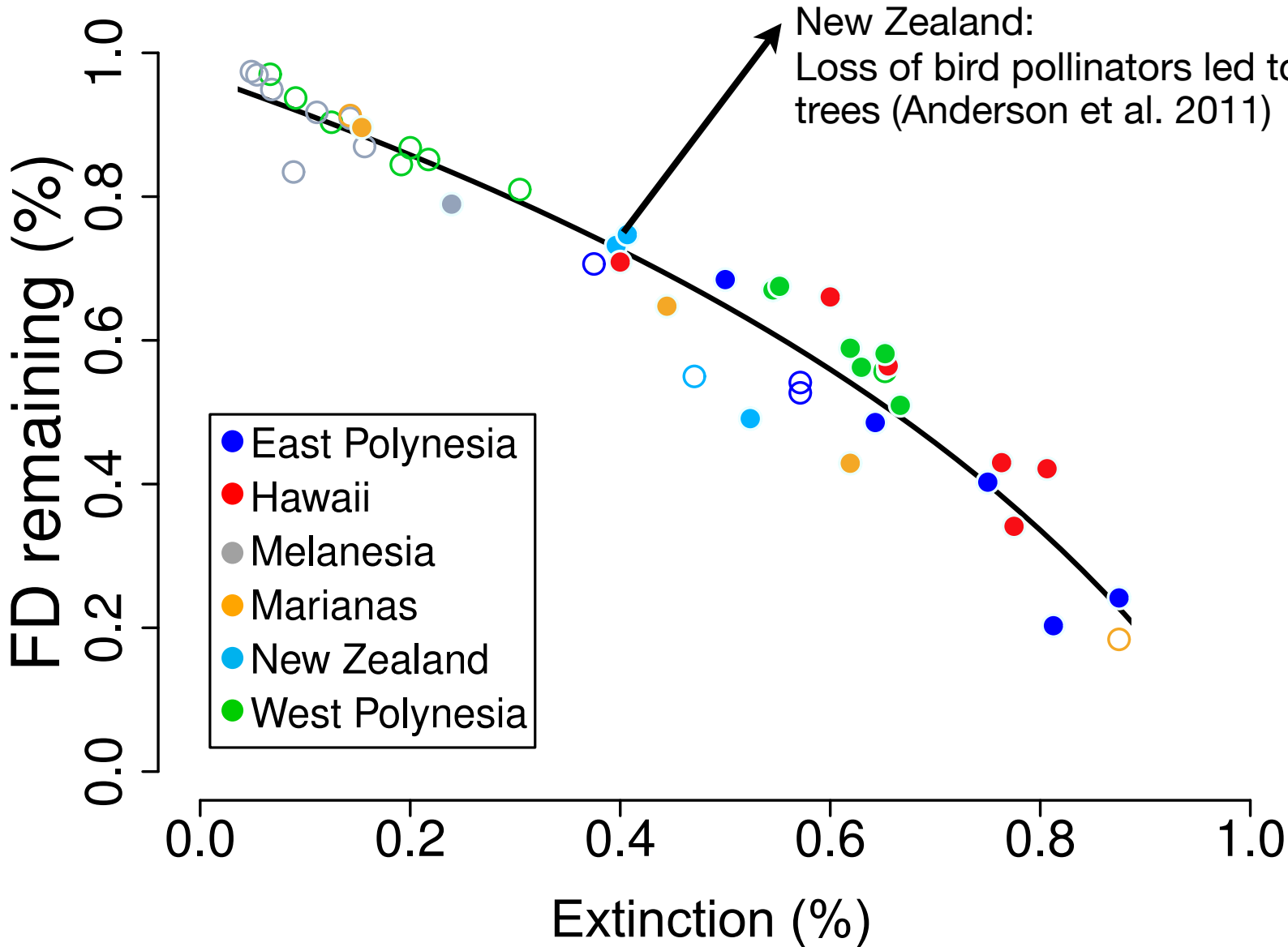
Declining Functional Diversity with Extinctions



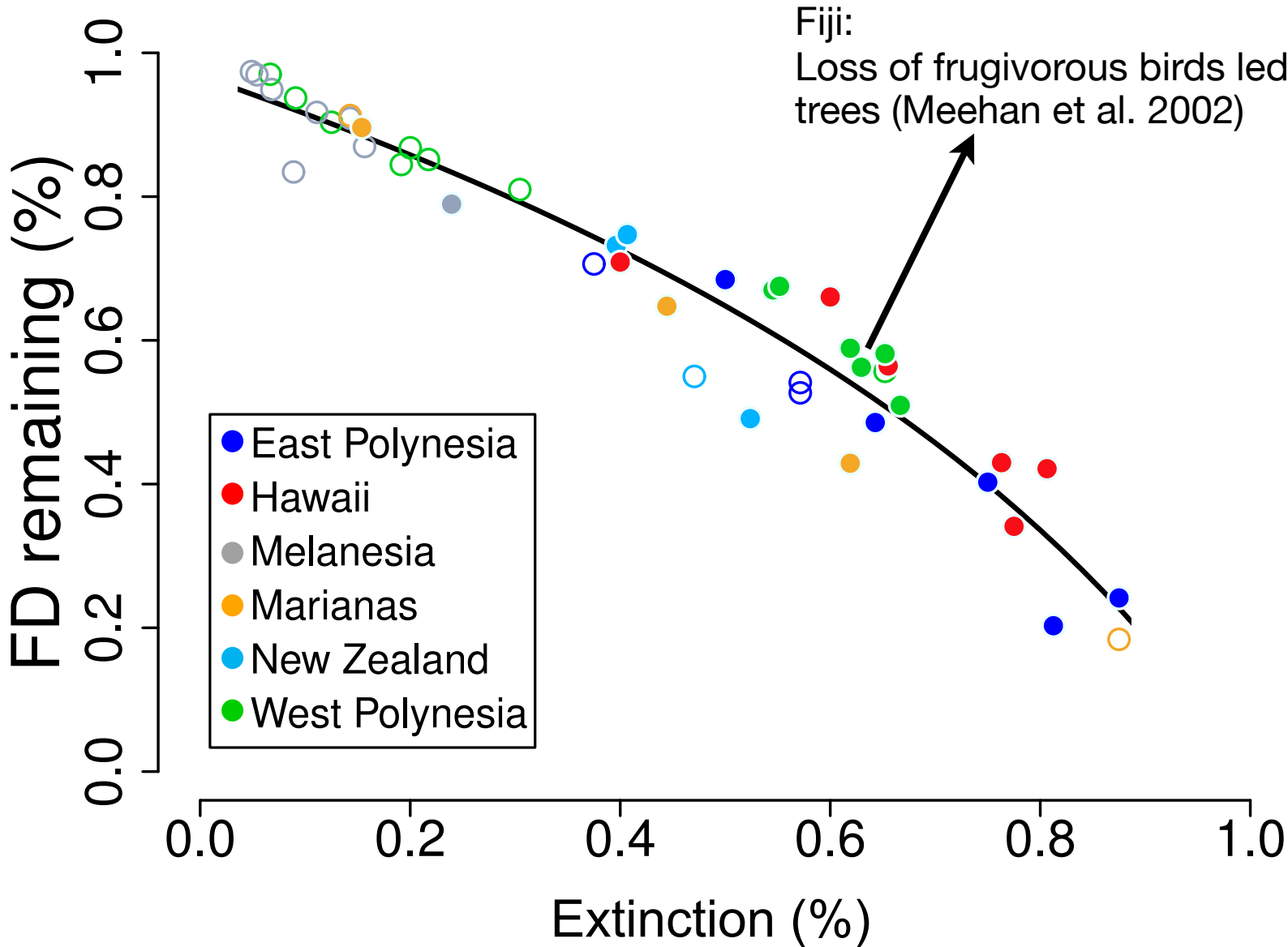
Declining Functional Diversity with Extinctions



Declining Functional Diversity with Extinctions



Declining Functional Diversity with Extinctions



Island bird extinctions

- How many species were lost?
- Which species went extinct?
- How did they change ecological communities?
- **How can extinctions be prevented?**

Modern biodiversity in crisis



Life Clock by Cai Shi Wei. good50x70.org

Threatened with extinction

- 12% of birds
 - 25% of mammals
 - > 30% of amphibians
-
- Nearly half of all threatened bird species are found on oceanic islands

Eradicate invasive predators



Eradicate invasive predators



Reintroduce birds to former range

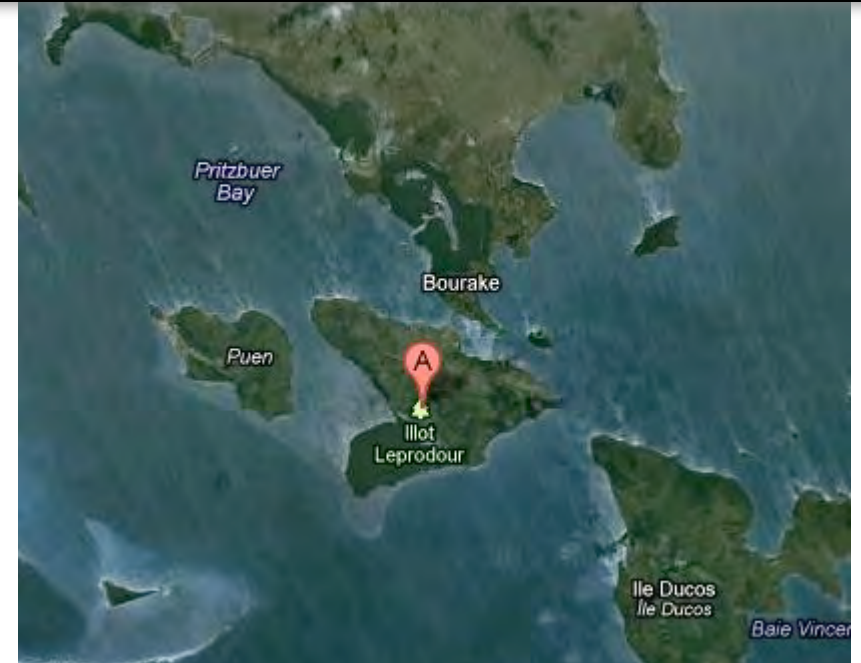
Rimatara Lorikeet
reintroduced to Atiu,
Cook Islands more than
200 years after



Restore habitats

Lepredour island, New Caledonia:

- eradication of deer, goats, cats
- dry forest restoration
- reintroduction of native birds



Oceanic islands as global microcosms

- Islands are self-contained, replicated units with a long record of coupled human-environmental history
- We study past extinctions to understand:
 - baseline conditions
 - causes of biodiversity loss
 - predictability of extinctions
 - consequences of extinctions for societies & ecosystems



