CISAC Science Talks, 2015

Anthropogenic Impact on Animal Life: Consequences for Ecosystem Processes and Services

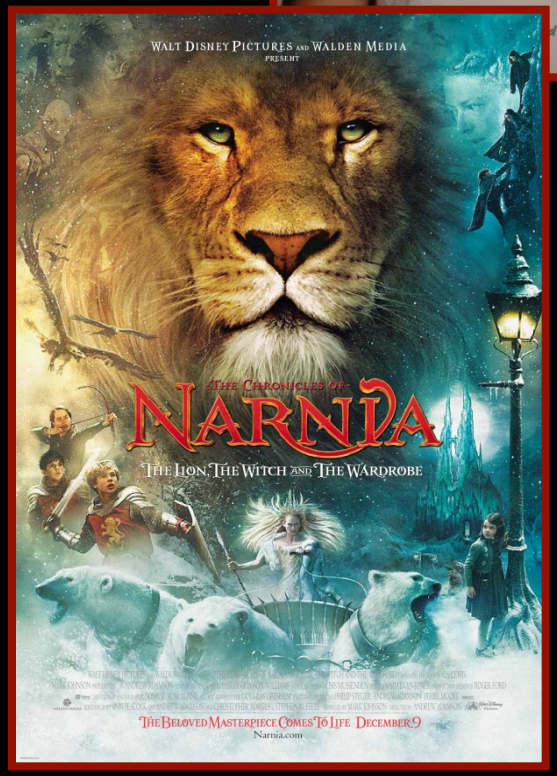
Rodolfo Dirzo
(Biology, CLAS)

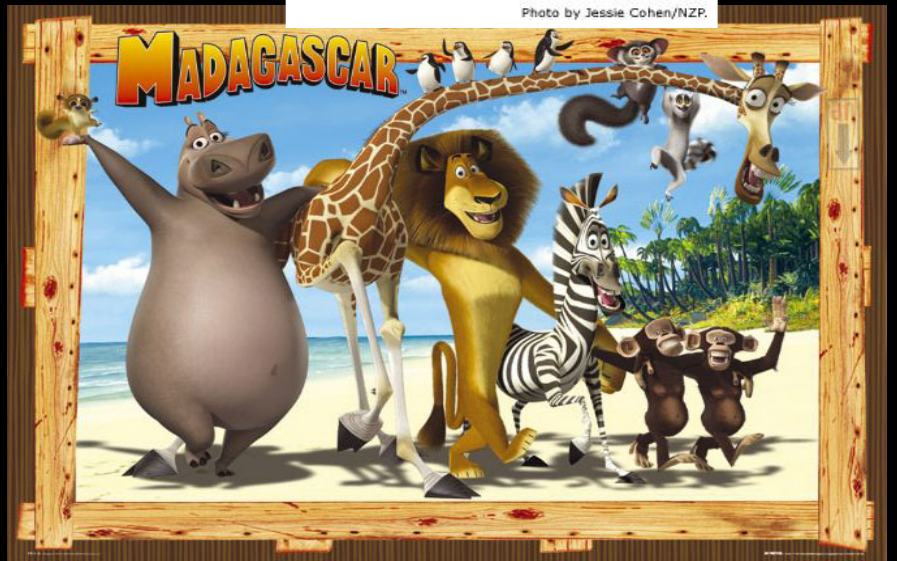
Discovery CHANNEL

An endangered Sumatran tiger.

Photo by Jessie Cohen/NZP.

WWF





Our affection for terrestrial animals

- Not paralleled by efforts to understand their role on:

  - Biotic interactions and community structure
  - Effects on ecosystem processes and services

- Such poor effort unjustified, in light of *Defaunation* – Another global change?!

DEFAUNATION

An under-appreciated global environmental change

(cf. Deforestation)

Frequently, a cryptic phenomenon

Several facets:

- Global extinction
- Population extinctions within species
- Local declines in abundance

DEFAUNATION

An under-appreciated GEC

(cf. Deforestation)

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Several facets:

- Global extinction
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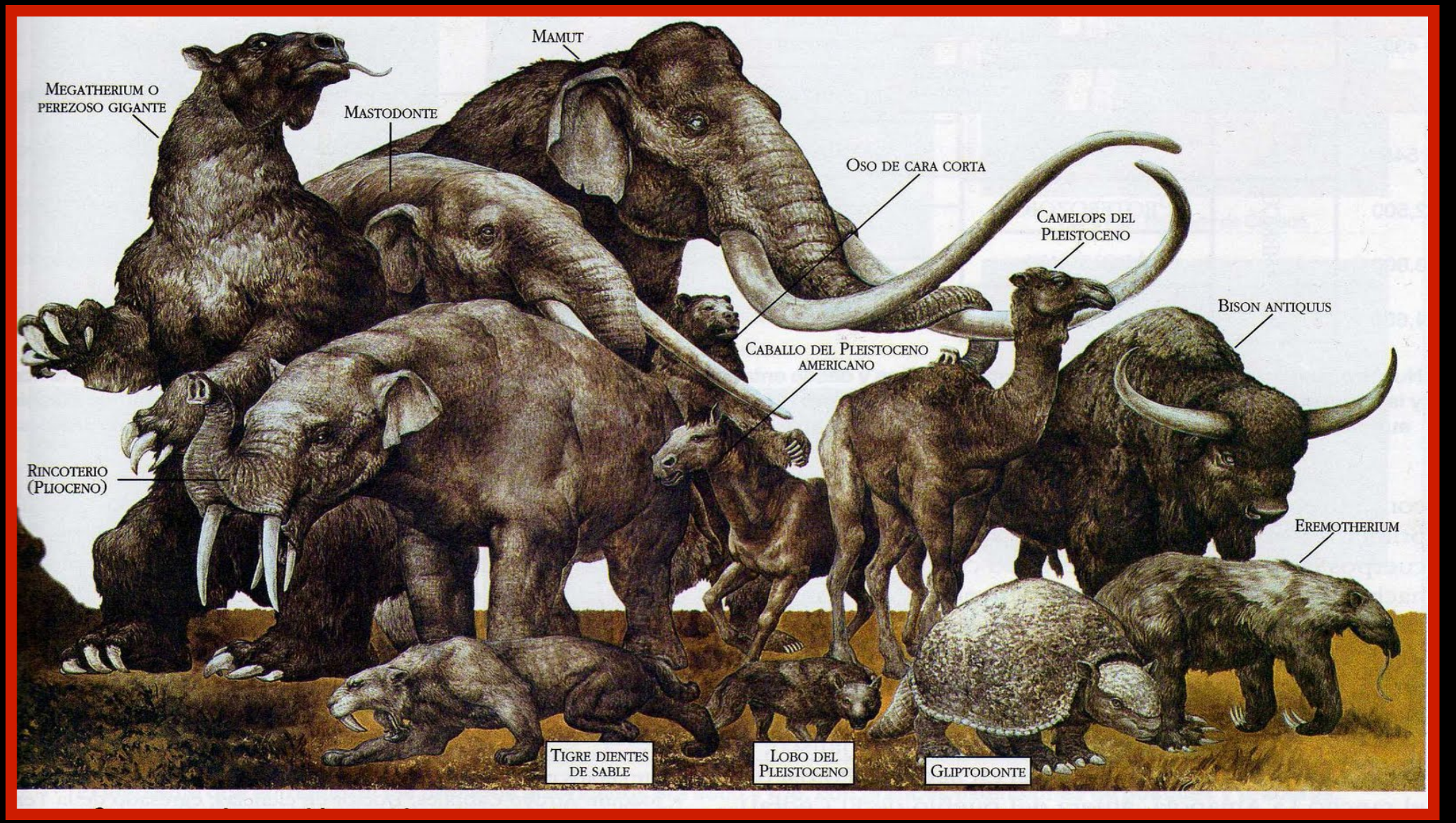
Until ~10,000 years ago….



Until a few years ago….

(322 spp. since 1500)

DEFAUNATION

An under-appreciated GEC

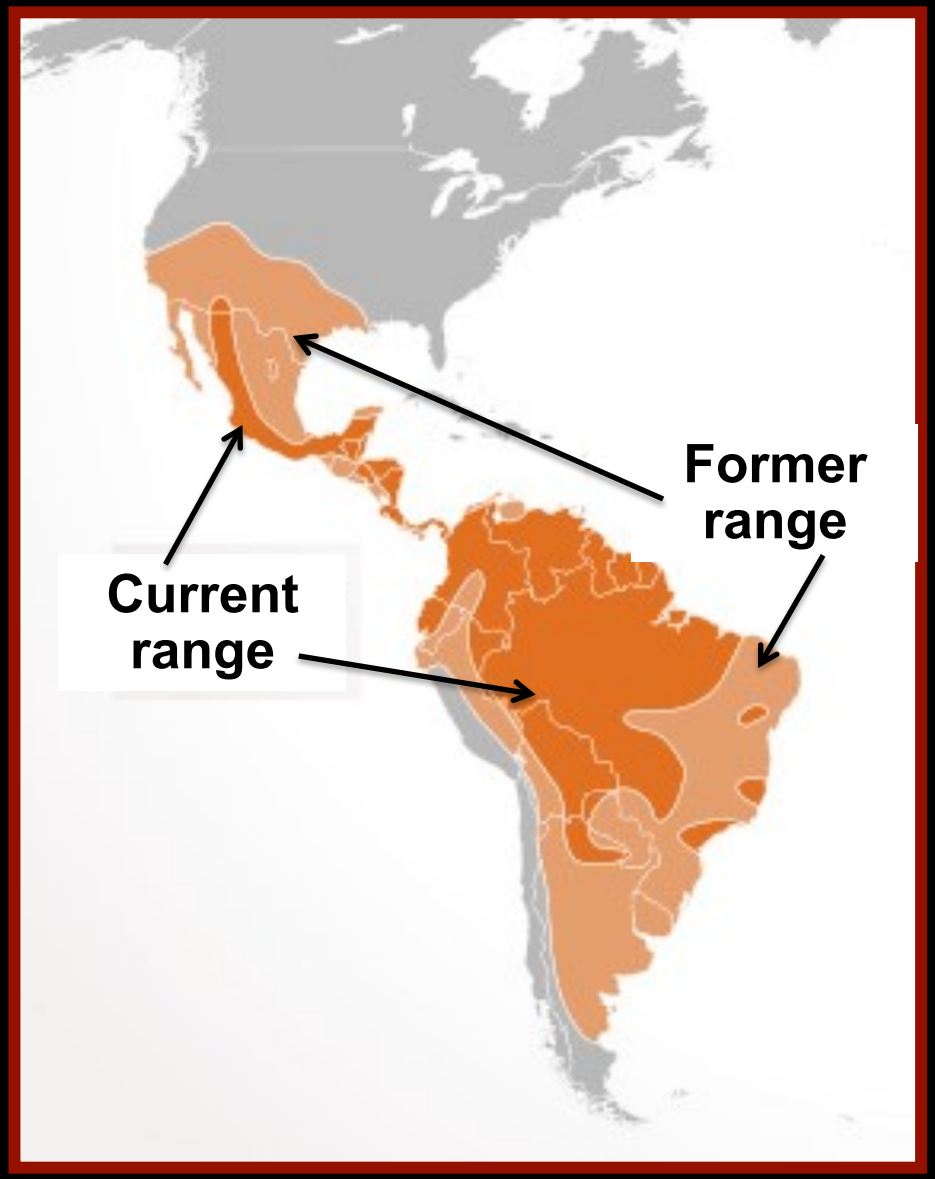
(cf. Deforestation)

Frequently, a cryptic phenomenon

Several facets:

- Global extinction
- Population extinctions within species
- Local declines in abundance

Jaguar contraction range and population extinctions



DEFAUNATION

An under-appreciated GEC
(cf. Deforestation)

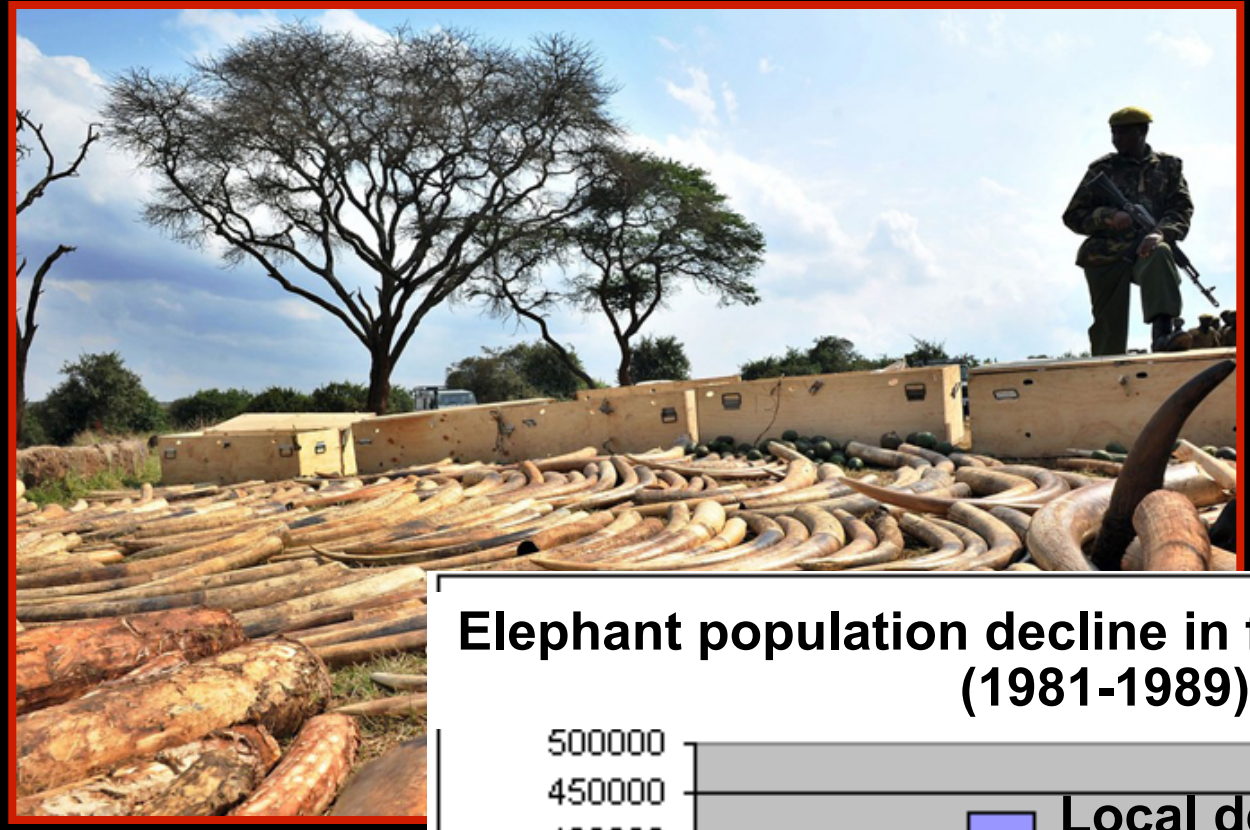
Several facets (~ extinction):

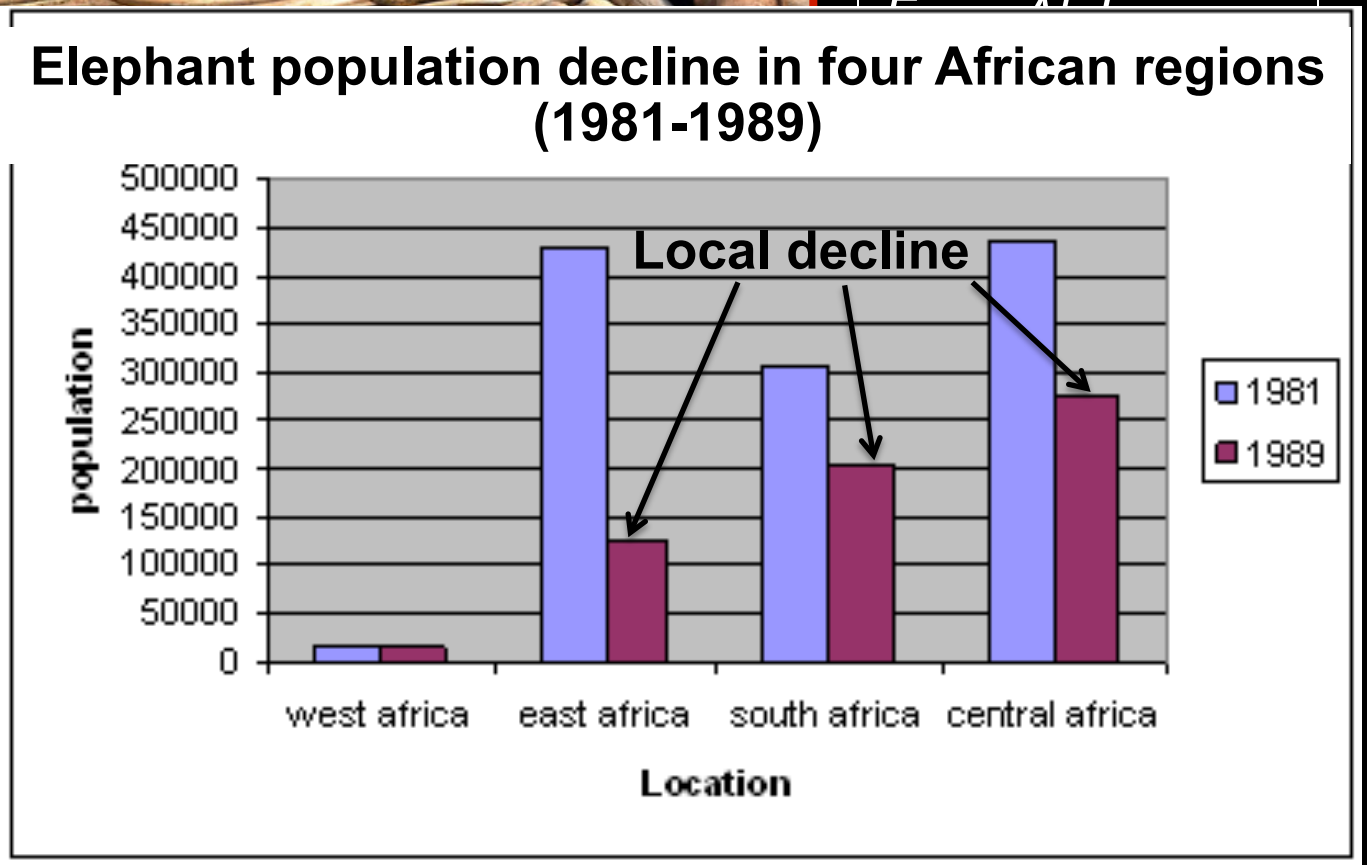
- Global extinction
- Population extinctions within species???
- Local declines in abundance

Frequently, a cryptic phenomenon

From Al Jazeera, Feb., 2013

Over-exploitation and habitat destruction lead to elephant population decline




Elephant population decline in four African regions (1981-1989)
500000
450000
400000
350000
300000
250000
200000
150000
100000
50000
0
population
Local decline
1981
1989
west africa
east africa
south africa
central africa
Location

DECLINES IN LOCAL ANIMAL ABUNDANCE

Three major defaunation issues:

1. Discernible patterns? (magnitude, where, traits)
2. Affects ecological processes?
3. Affects ecosystem services?

Frequently, a cryptic phenomenon

DECLINES IN LOCAL ANIMAL ABUNDANCE

Three major defaunation issues:

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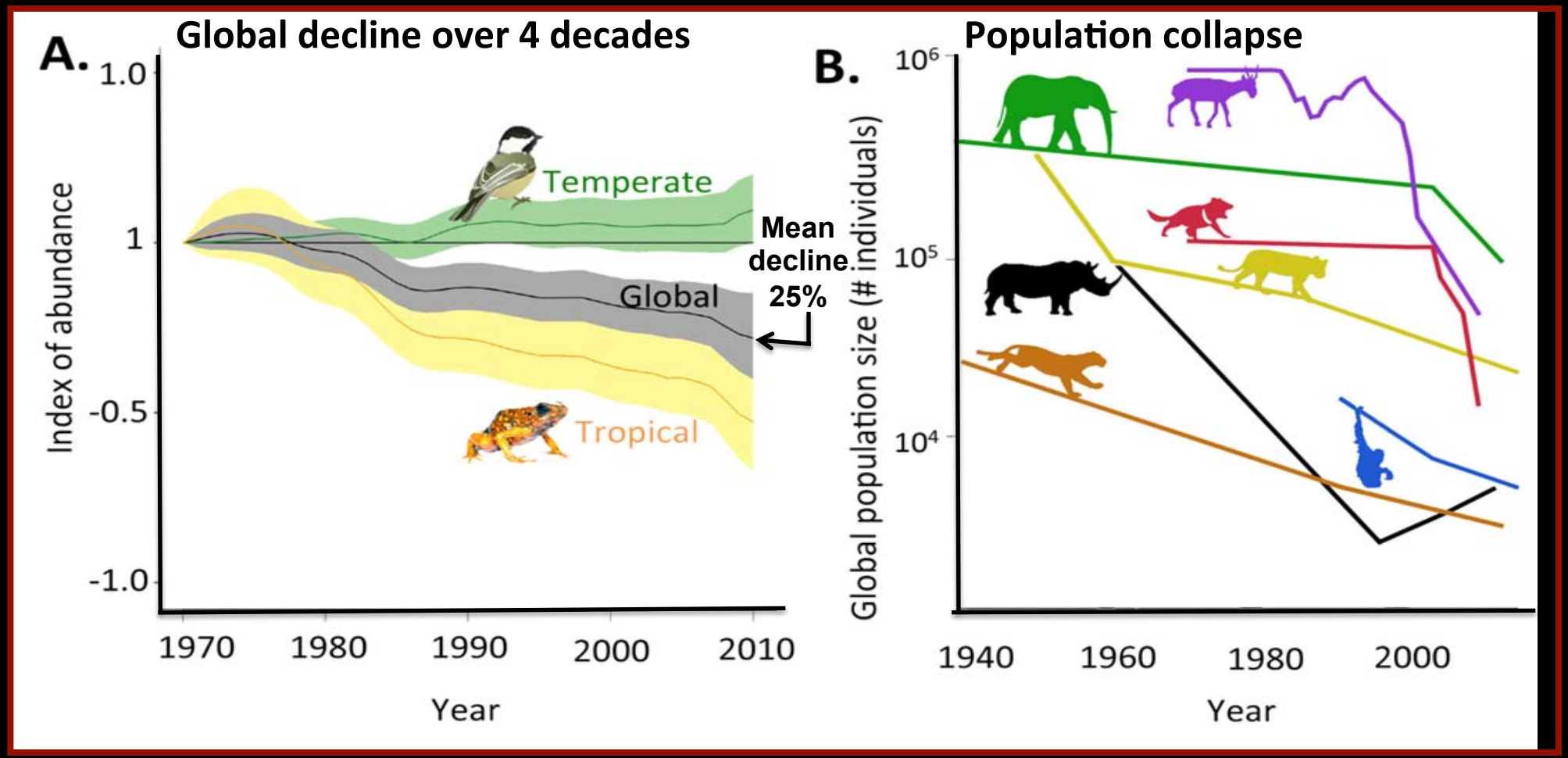
Frequently, a cryptic phenomenon

Patterns: Magnitude

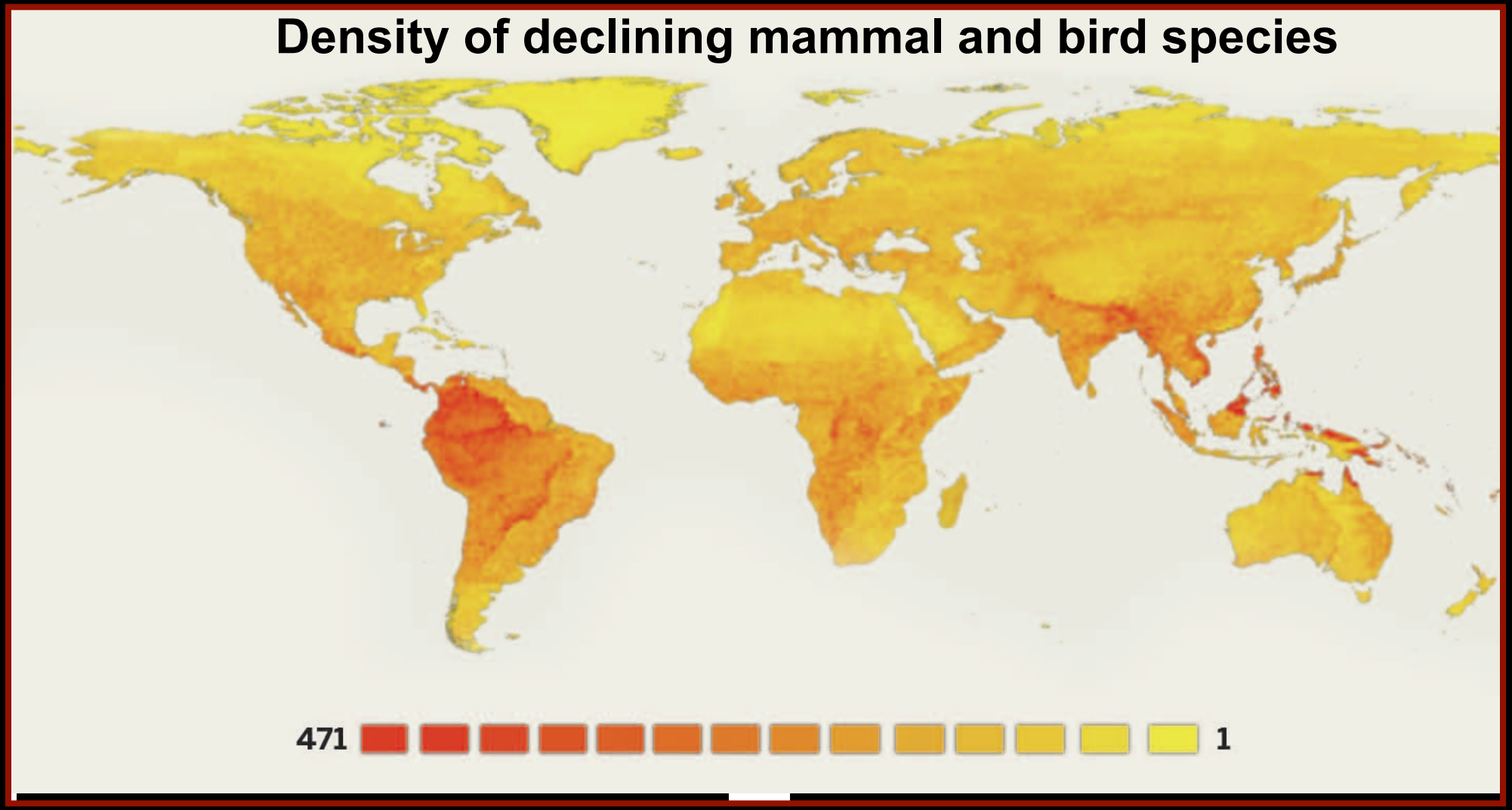
Vertebrate decline over previous decades



(Dirzo et al. 2014)

Patterns: Where is it happening?

Vertebrate decline heterogeneous across world

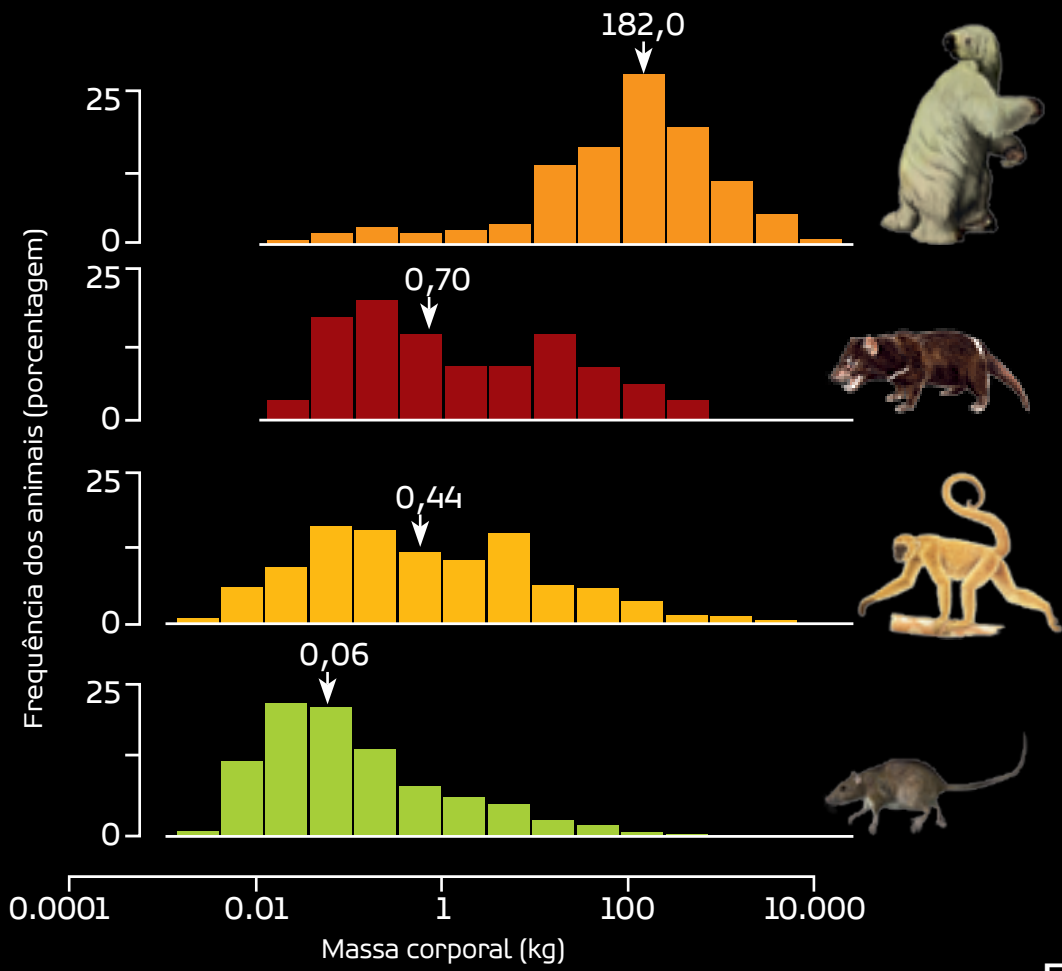


(Dirzo et al., 2014)

Patterns: Animal traits

Vertebrate decline varies with body size

Size-differential defaunation Pleistocene-now



1 EXTINÇÕES DO PLEISTOCENO
A maior parte das extinções do final da última Era do Gelo atingiu a Megafauna. O peso médio dos animais mortos foi de 182 kg

2 EXTINÇÕES DO ANTROPOCENO
O homem foi responsável inconteste pela extinção de espécies de grande e médio porte, como o dodô e o tigre-da-tasmânia

3 AMEAÇADOS DO ATROPOCENO
Se todas as espécies ameaçadas de extinção sumirem, o planeta vai perder animais grandes como o elefante e o monocarvoeiro

4 ESPÉCIES NÃO AMEAÇADAS
Nesse caso, só sobrariam no planeta espécies pequenas, como os ratos e esquilos. O peso médio dos animais seria de apenas 60 g

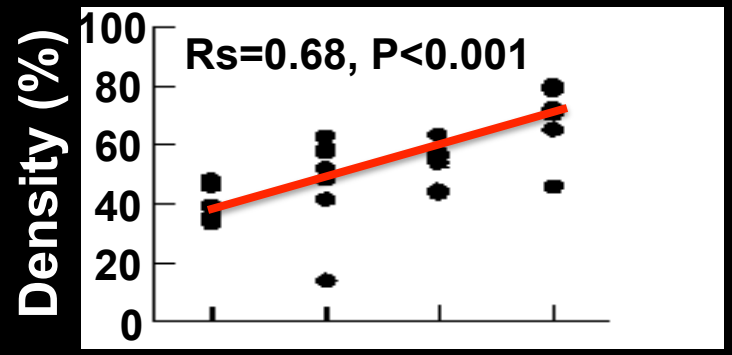
From Dirzo et al. 2014; Ciencia Hoje)

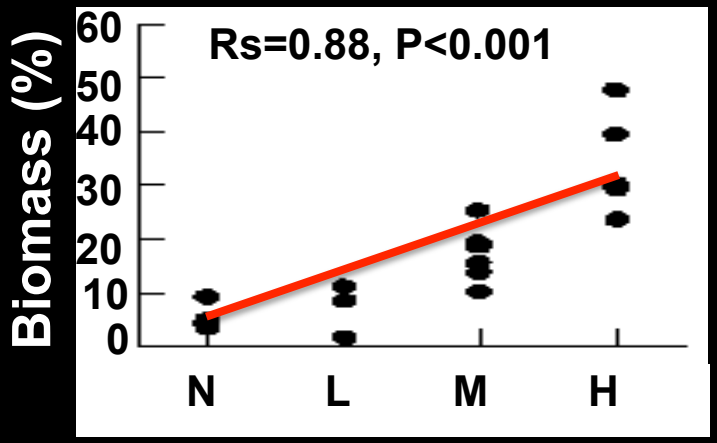
Massive, omnipresent phenomenon

Vertebrate decline varies with body size

(Brazilian Amazon, Peres 2000)

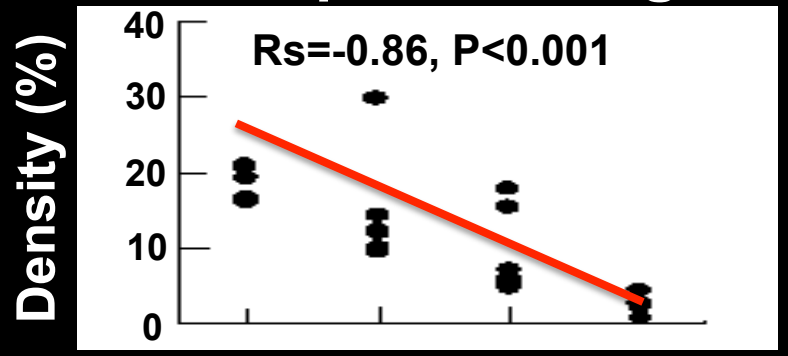
Species<1 kg

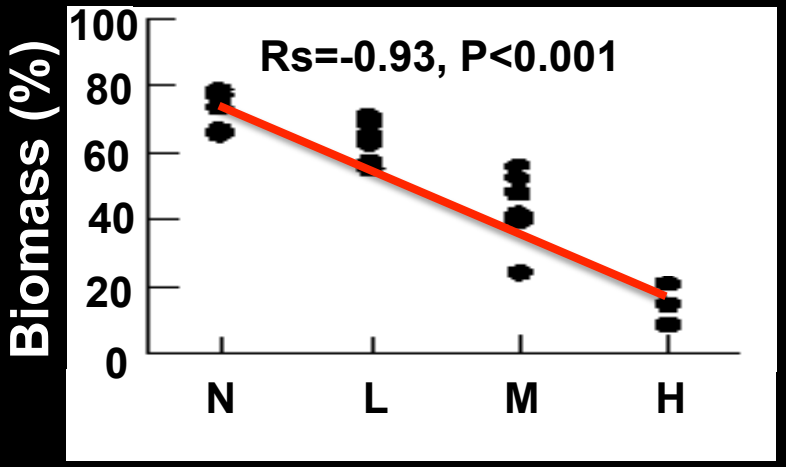




Hunting Intensity

Species>5 kg





Hunting intensity

Levels of hunting: N = None, L= Light, M = Moderate, H = High

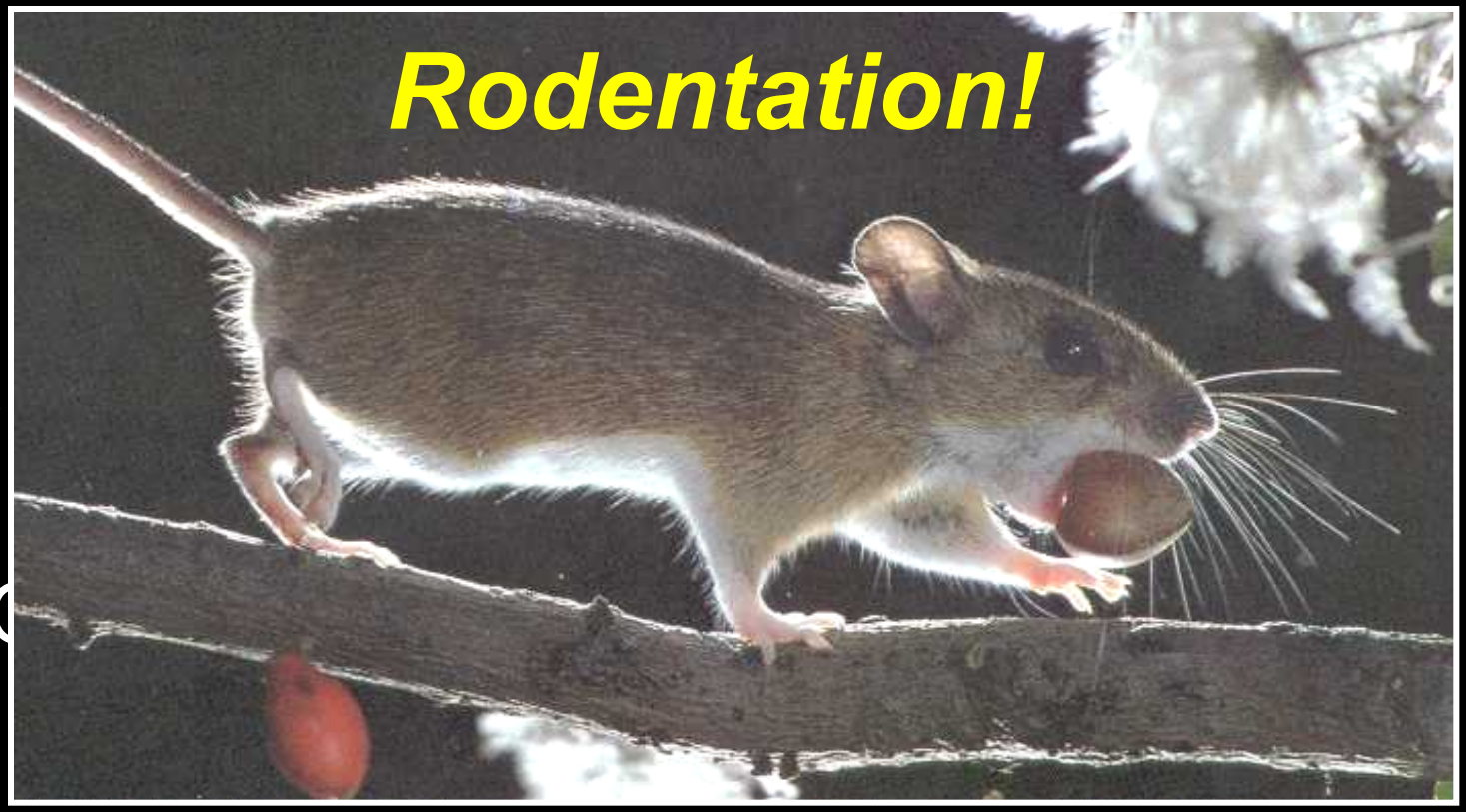
VERTEBRATE DEFAUNATION: SALIENT PATTERNS

1. GREAT MAGNITUDE

2. TROPICS: SERIOUSLY IMPACTED

3. DIFFERENTIAL: MEDIUM/LARGE, MOST IMPACTED; SMALL NOT SO AFFECTED; FAVORED—RODENTS!

VERTEBRATE DEFAUNATION: SALIENT PATTERNS



1. GR

2. TR

3. DIFFERENTIAL: MEDIUM/LARGE, MOST IMPACTED; SMALL NOT SO AFFECTED; FAVORED—RODENTS!

DEFAUNATION

Declines in local abundance

Three major defaunation issues:

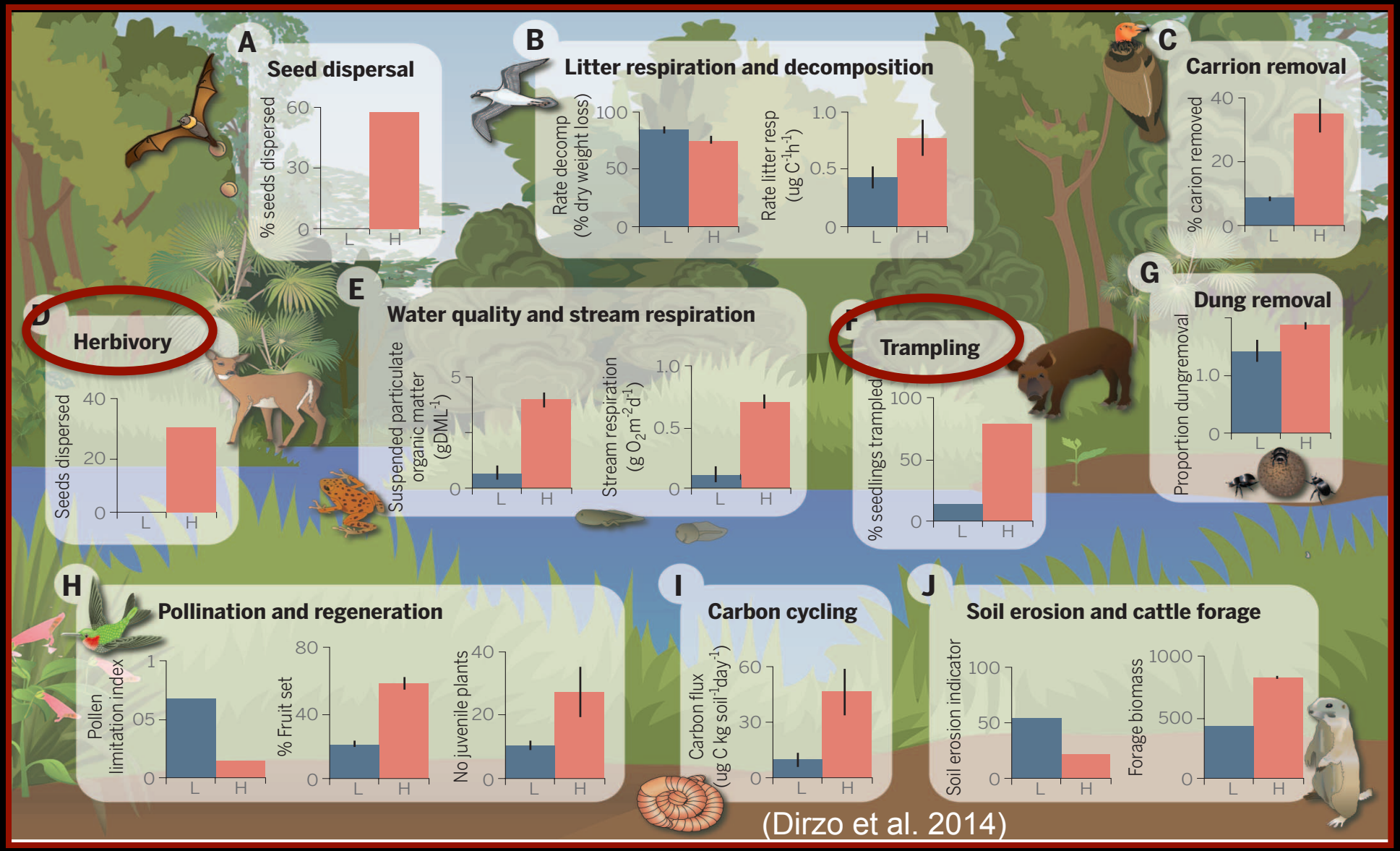
1. Discernible patterns? (magnitude, where, traits)
2. Affects ecological processes?
3. Affects ecosystem services?

Frequently, a cryptic phenomenon

DEFAUNATION AFFECTS ECOLOGICAL PROCESSES

Omnipresent, diverse cascading effects

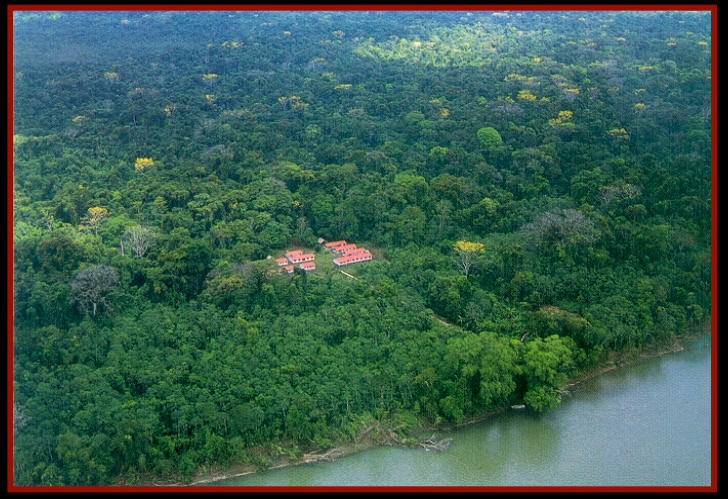
Low ( ) vs. High ( ) animal abundance



(Dirzo et al. 2014)

UNDERSTORY HERBIVORY

Two-site comparison: Defaunated (■) and Intact (■)



MAMMALIAN HERBIVORY

% plants/leaves with damage by vertebrates, 1991
(Monitored plants in permanent plots)

	Montes Azules		Los Tuxtlas	
				
	Plants	Leaves	Plants	Leaves
Seedlings	29.0	30.5	0	0
Saplings 0.5-1.5 m	30.0	24.0	0	0
Overall	29.3	27.2	0	0

(Dirzo and Miranda, 1992)

MAMMALIAN HERBIVORY

% plants with damage by vertebrates, 2004
(Instantaneous survey of 1000 plants/site)

	Montes Azules 	Los Tuxtlas 
Site 1	13.5	0
Site 2	26.7	0.0
Overall	19.1	0.0

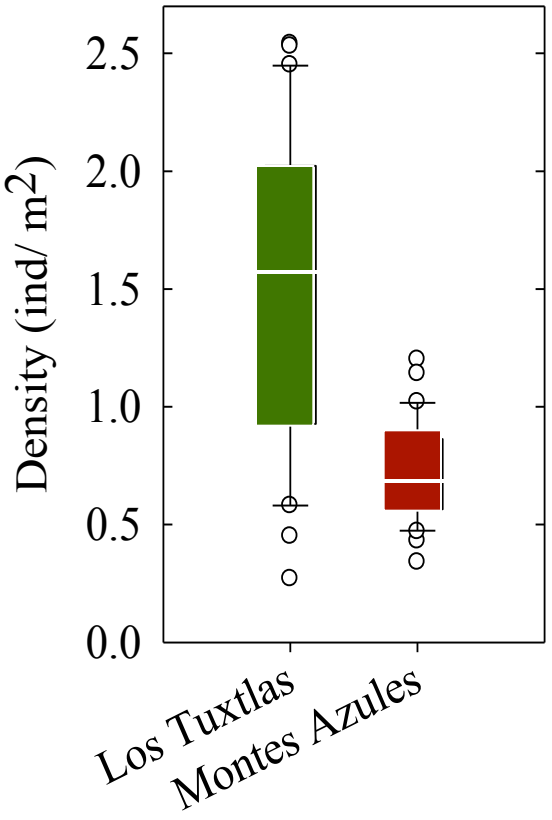
Local extinction of herbivory!!!

Prediction: Changes in structure/diversity of understory

UNDERSTORY DIVERSITY AND STRUCTURE

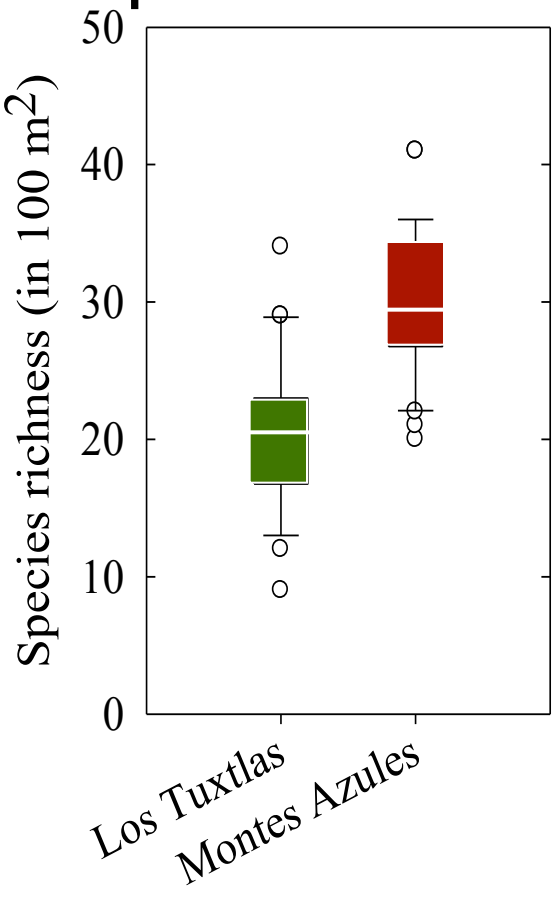
Two-site comparison: Defaunated (■) and Intact (■)

Species density



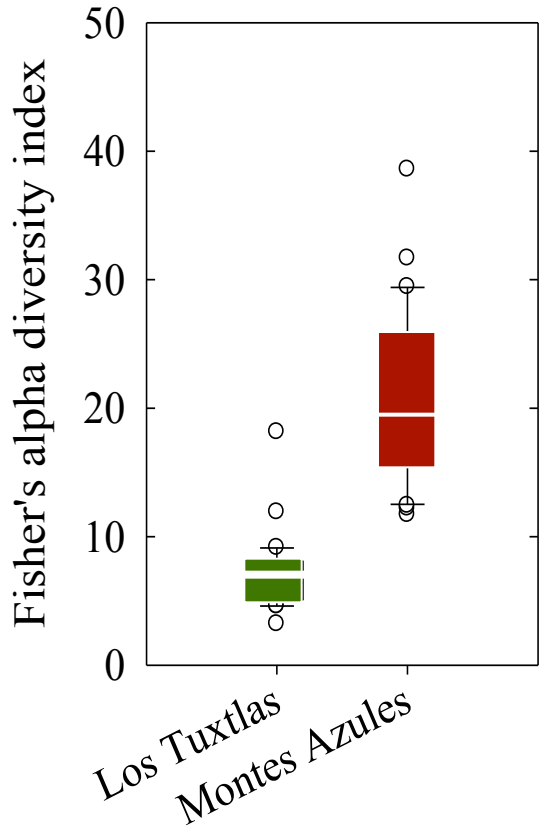
***F* = 5.81; *P* = 0.07**

Species richness



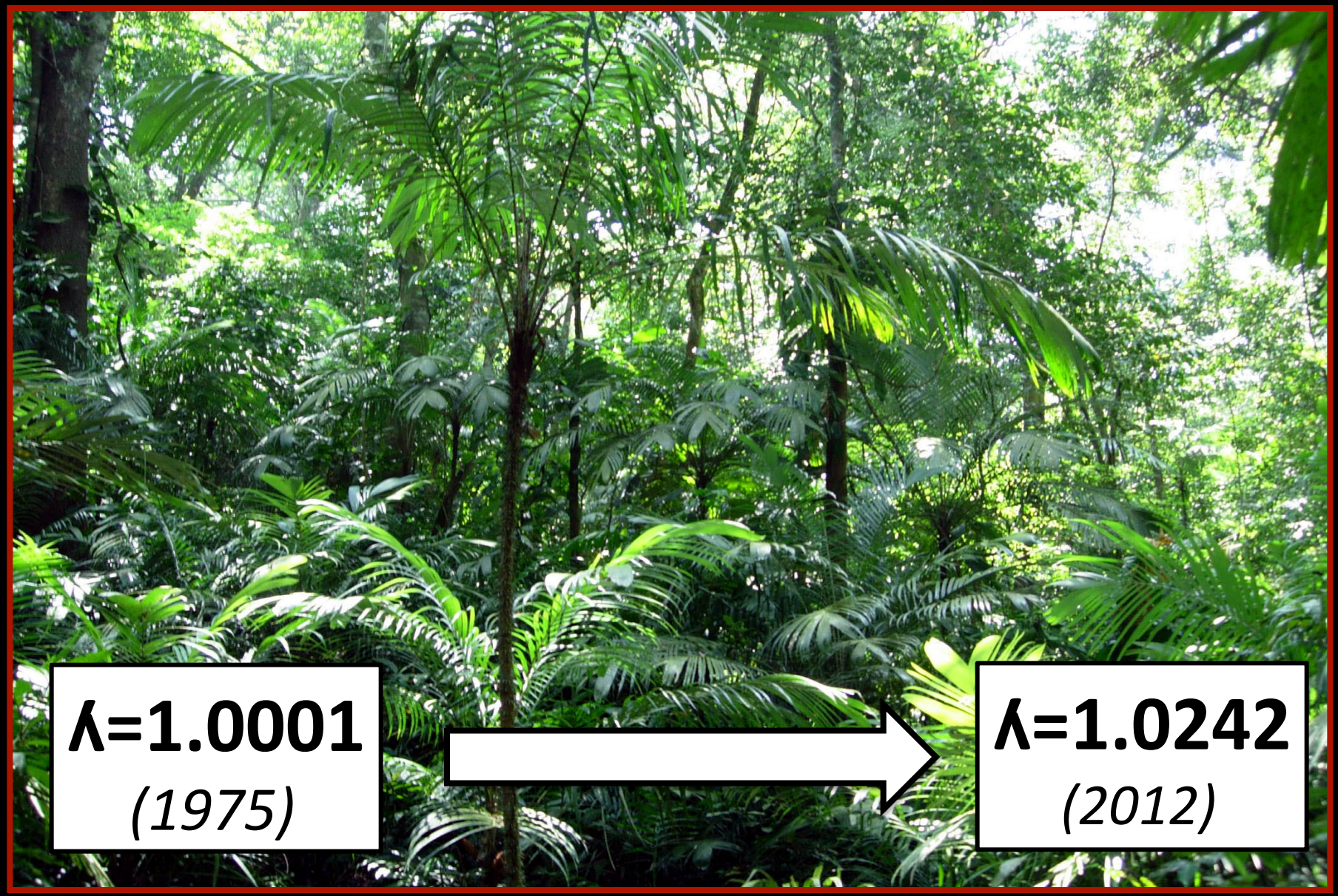
***F* = 9.66; *P* = 0.03**

Diversity: Fisher's α



***F* = 38.96; *P* = 0.003**

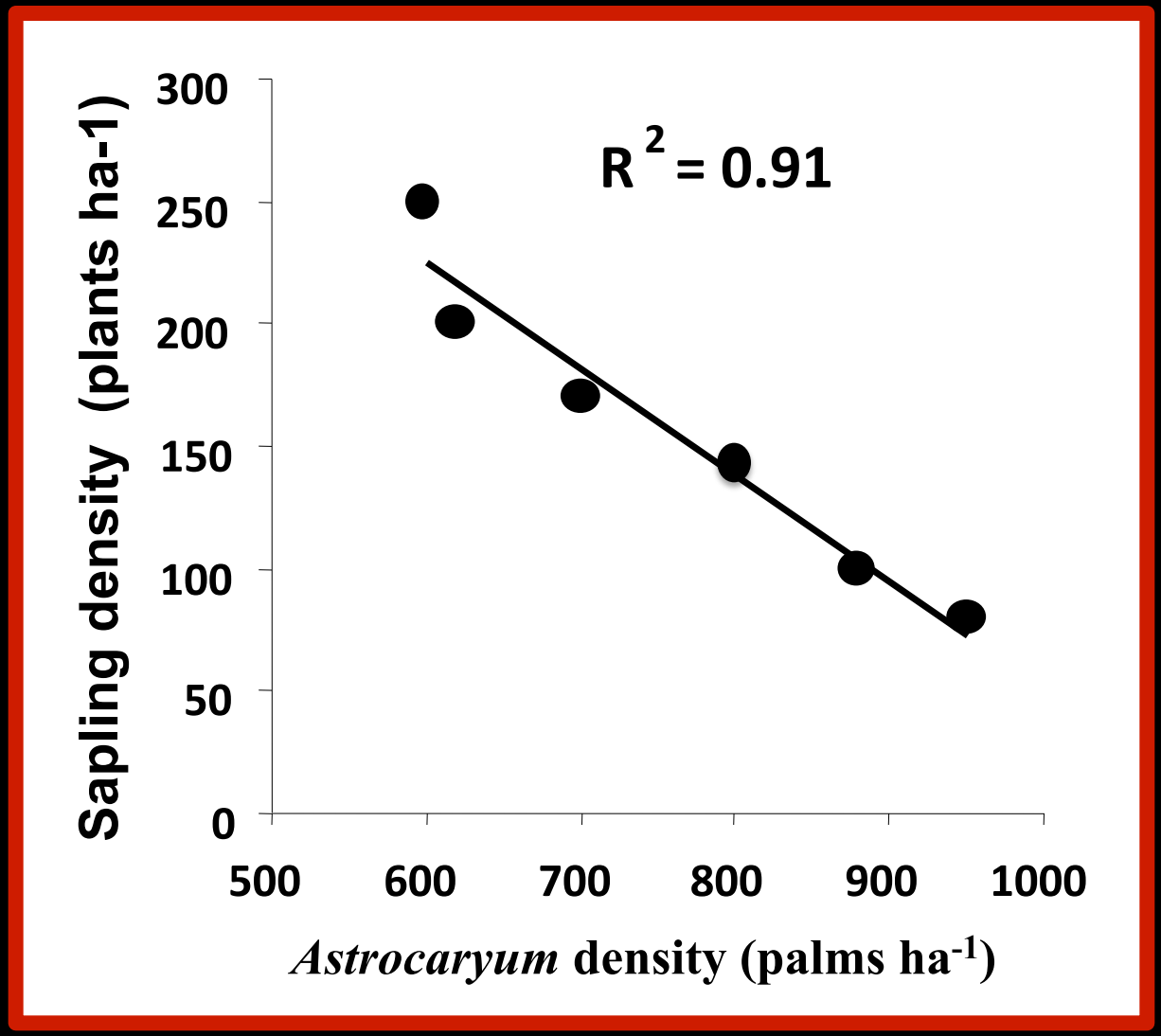
(Dirzo et al., in review)



Astrocaryum mexicanum dominates defaunated understory

(Martínez-Ramos, Sarukhán, Dirzo, in rev.)

Astrocaryum mexicanum
Impacts plant community of defaunated understory



(Martínez-Ramos, Sarukhán, Dirzo, in rev.)

CONCLUSIONS DEFAUNATION-RODENTATION:

- Local decline/extinction of mammalian fauna affects ecological processes

- Co-extinction of mammalian herbivory

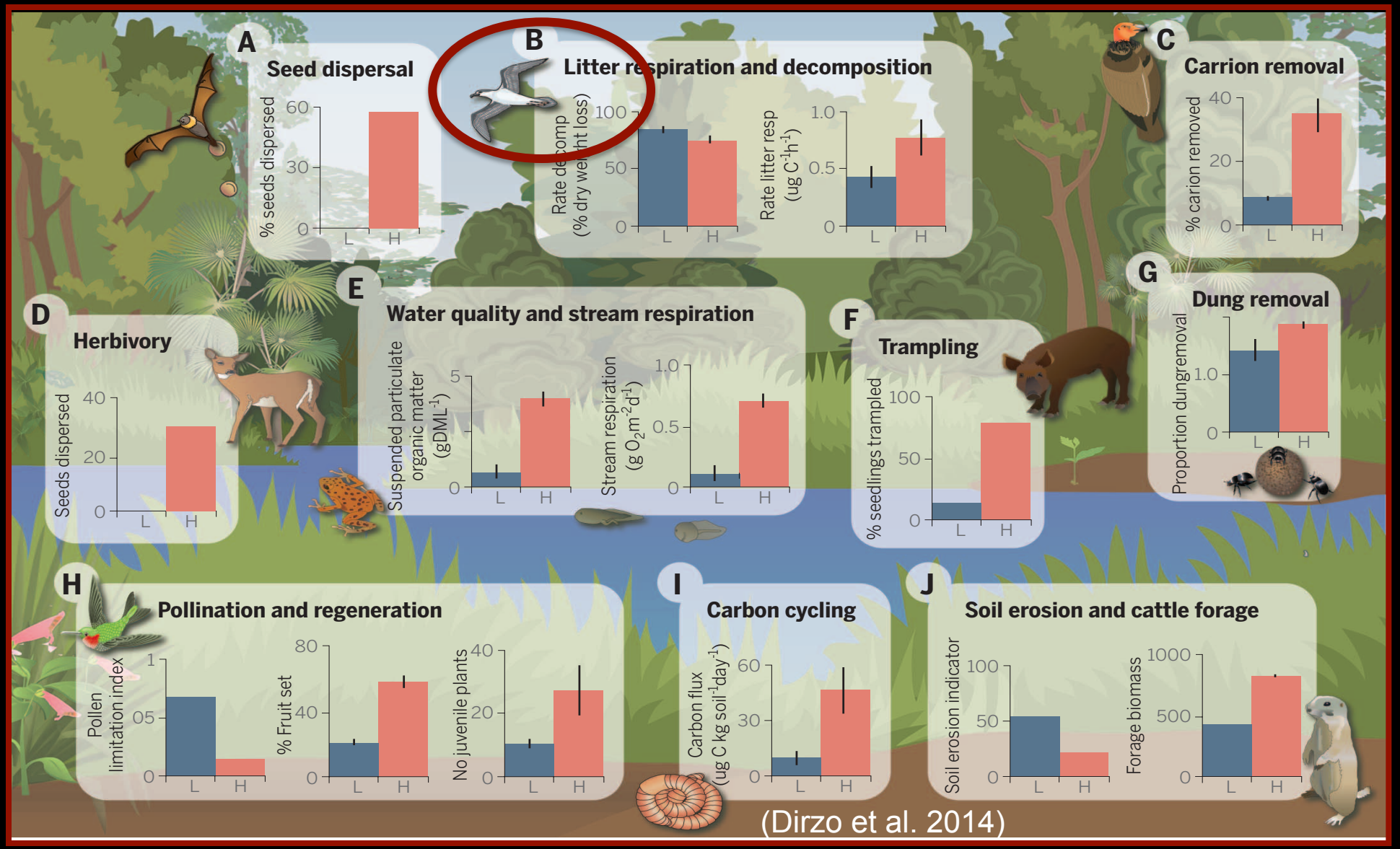
- Cascading changes in understory plant community: impoverishment of diversity

- Loss of plant resources for local people

DEFAUNATION AFFECTS ECOLOGICAL PROCESSES

Omnipresent, diverse cascading effects

Low (■) vs. High (■) animal abundance

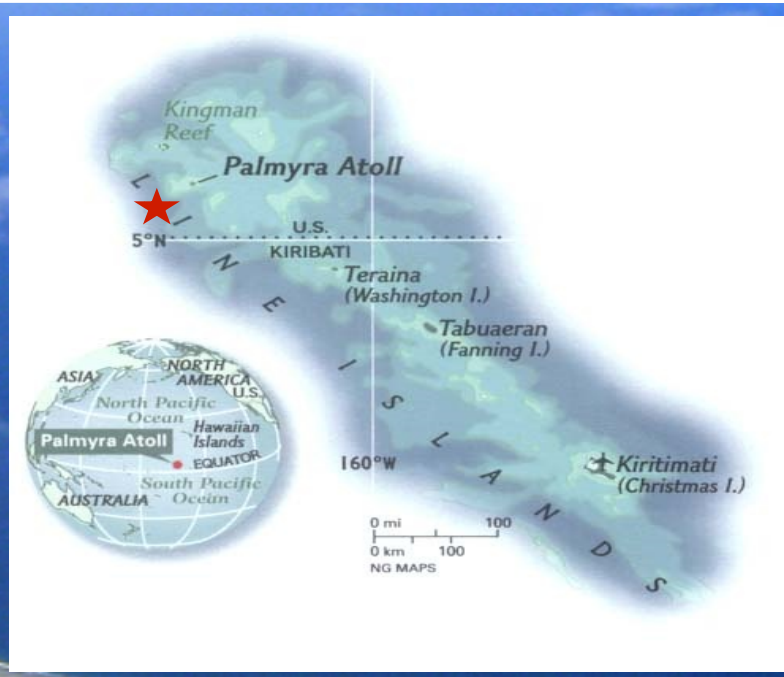


(Dirzo et al. 2014)

Palmyra Atoll, Central Pacific

Native forest

Marine bird colonies



Sea bird defaunation: Invasive species proliferation

(Palmyra Atoll, Central Pacific)

Cocos nucifera

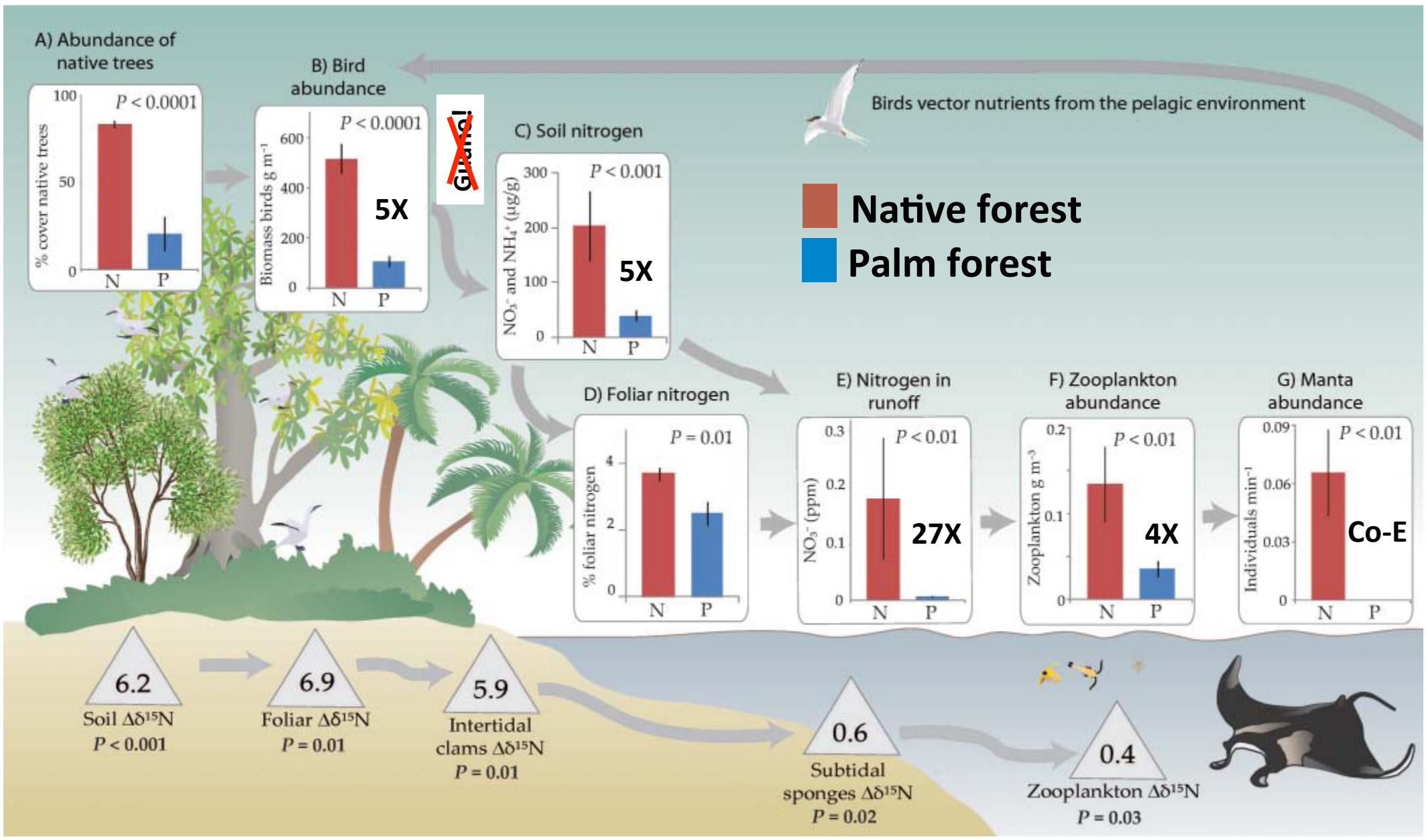
Native seabirds
decline/co-extinction

Native trees
decline/extinction

Ratus ratus

(Young et al., 2011)

Bird defaunation effects cascade through the ecosystem



(McCauley et al., 2012; Young et al., 2011; Young & Dirzo, 2012)

INVASION-RODENTATION IN ISLANDS

- *Cocos* invasion → Extinction of native forest plants

- Co-extinction of marine birds

- Cascading effects leading to co-extinction/loss of several biotic and abiotic interactions

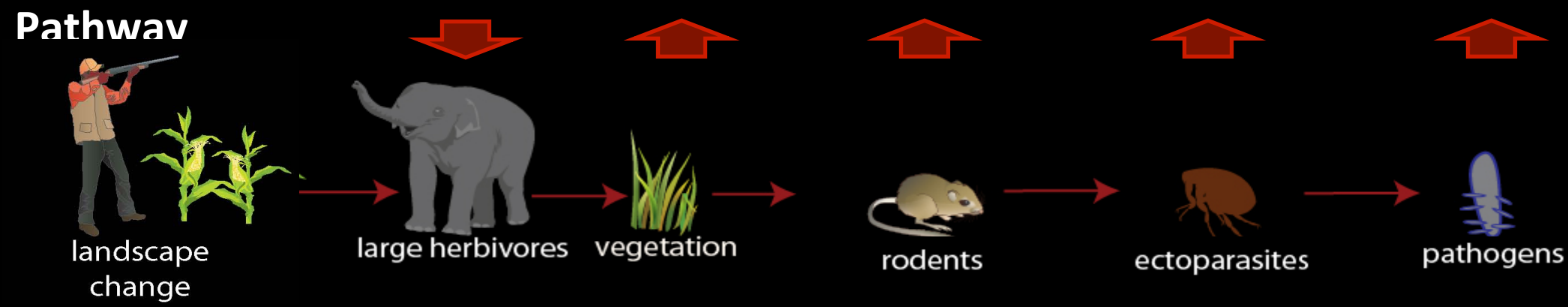
- Effects on processes in land and sea

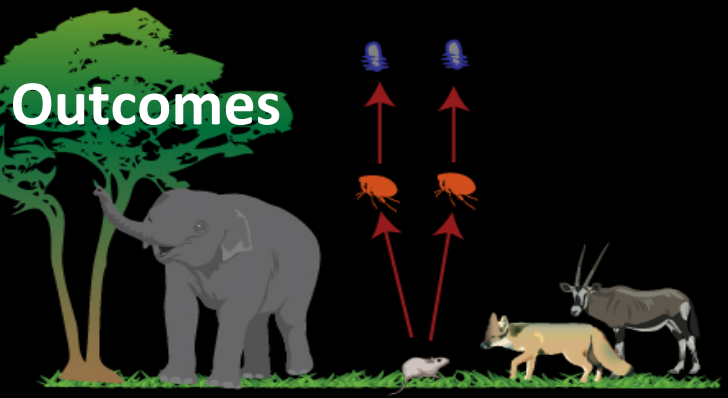
DEFAUNATION
Declines in local abundance

Three major defaunation issues:

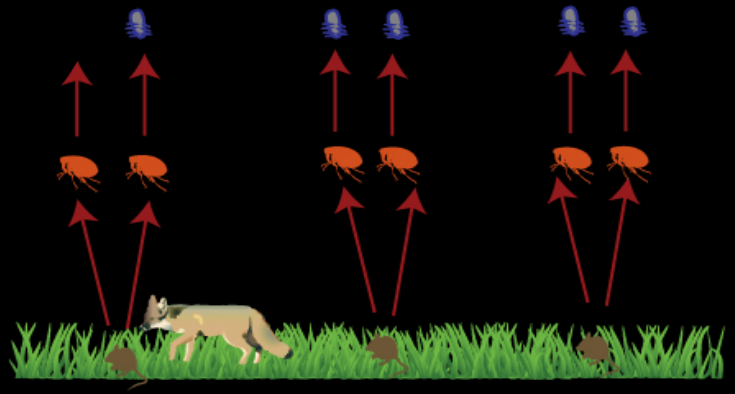
1. Massive, omnipresent
2. Affects ecological processes
3. Affects ecosystem services? African savannah (Rodent ecological release → cascading effects on health)

Potentially a major defaunation cascade

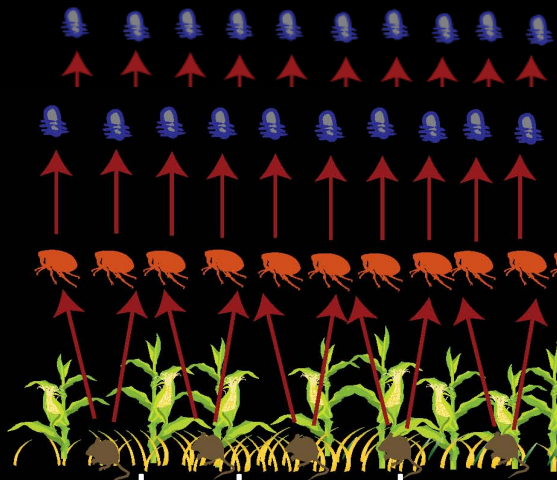




Intact
High diversity,
low risk



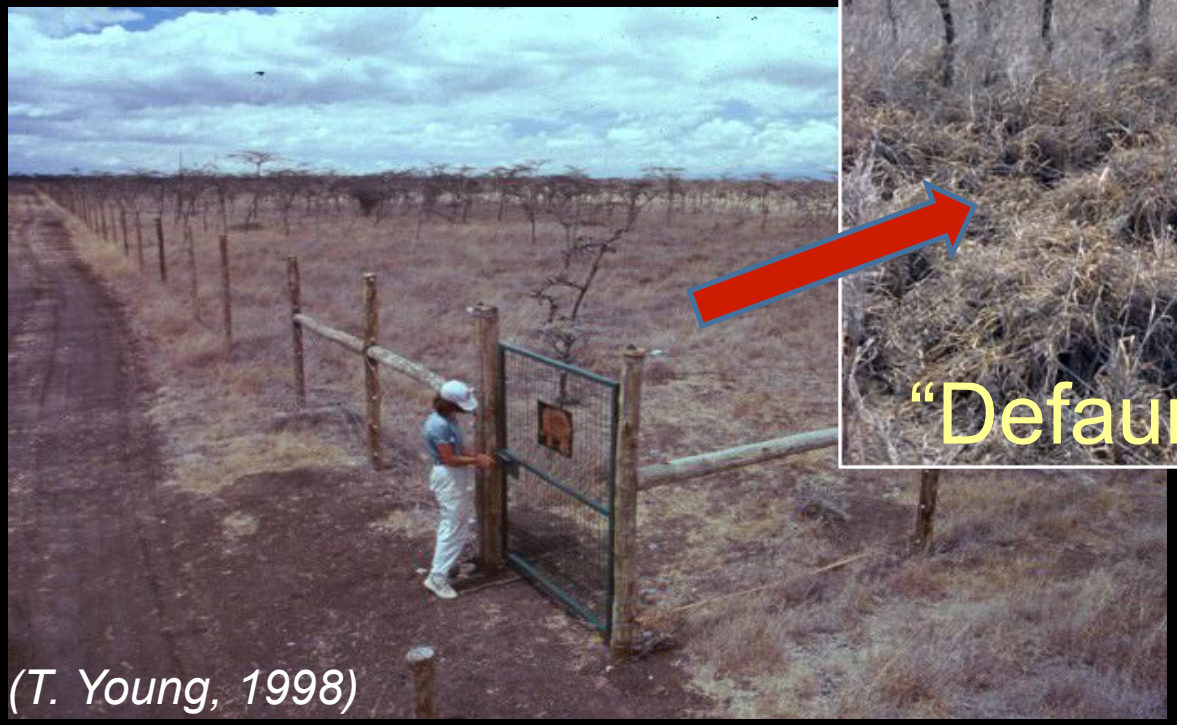
Defaunated
Moderate diversity,
moderate risk



Defaun+ land use change
Low diversity, high risk

Approach I: replicated experimental plots

(Mpala Research Station, Kenya)



(T. Young, 1998)

"Defaunated"

Control

Adult *Acacia* OK,
but lack seed dispersal
→ Seed concentration patches

Intensive rodent trapping program (N=2500)

For each rodent….

Fleas, ticks…
Blood…
Hair…
Tissue…
Feces…
Urine…
Morphometrics…
Ear tagging…

Screening for pathogens (CDC)

Kenya

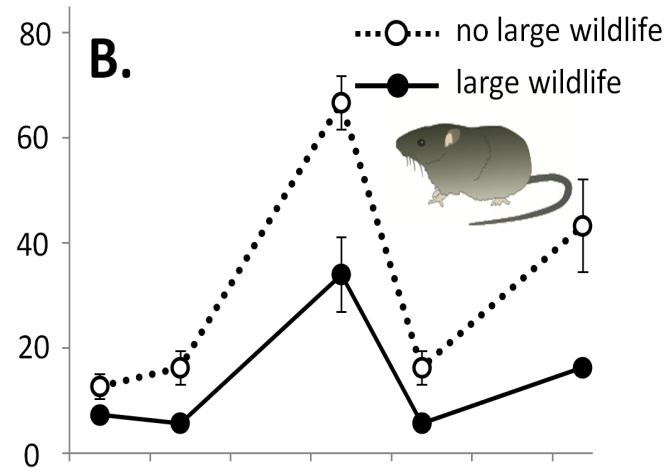
- *Bartonella* spp.
- *Borellia recurrentis*
- *Rickettsia africae*
- *Trypanasoma* sp.
- *Leishmania* sp.
- *Orthopox* virus

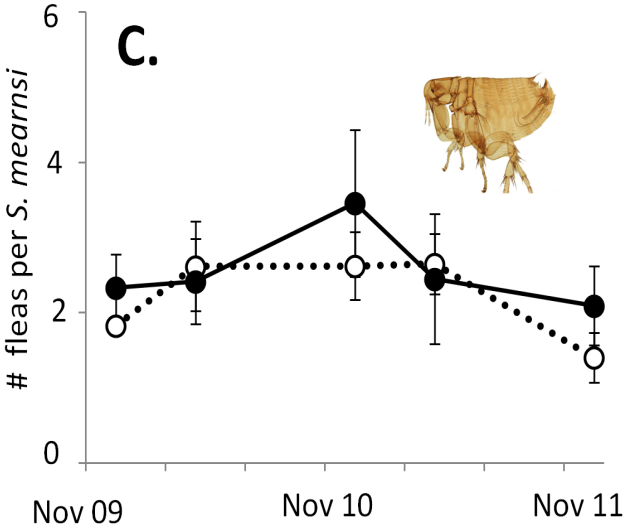
Tanzania

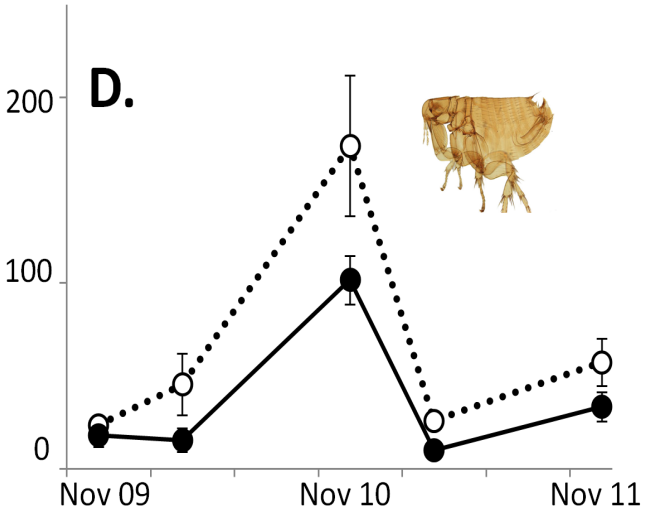
- *Bartonella* spp.
- *Borellia recurrentis*
- *Yersinia pestis*
  (seroprevalence)

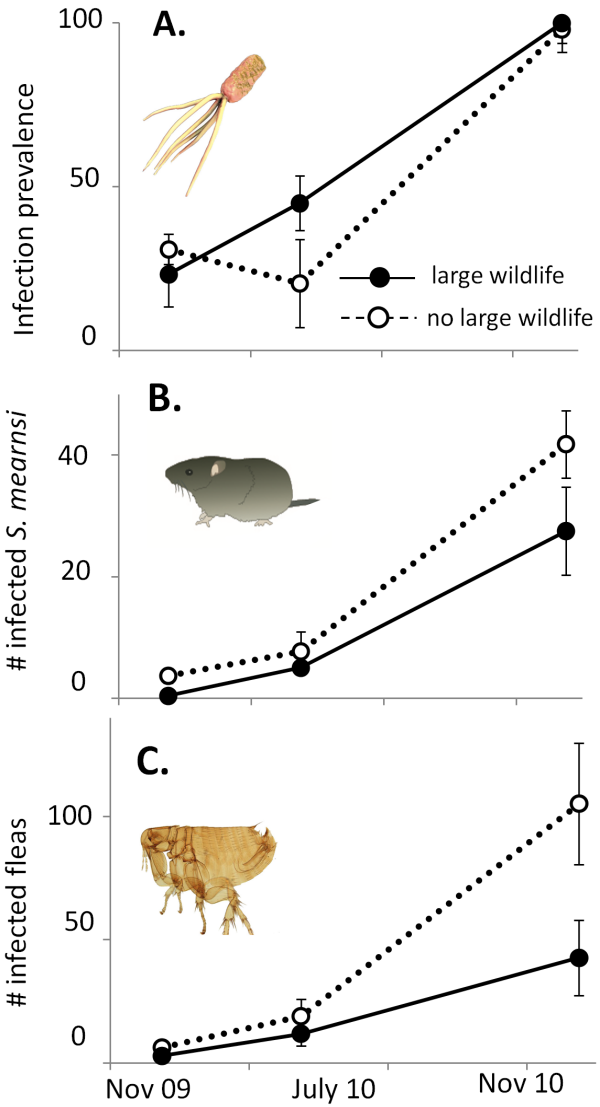
Results: Rodentation and disease risk—Bartonellosis

Experimental sites—*Saccostomus mearnsei*



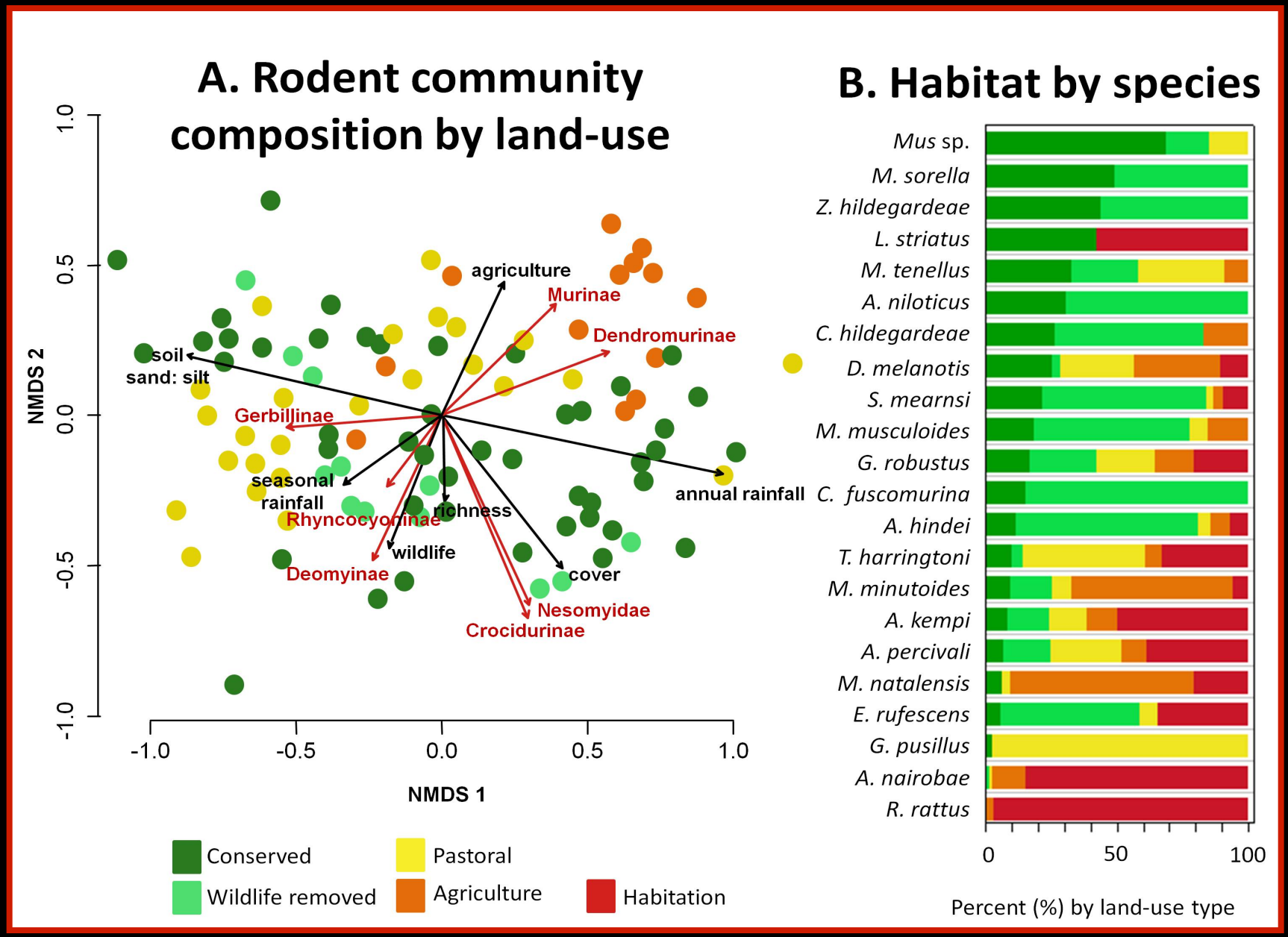






(Young *et al.2014*, PNAS)

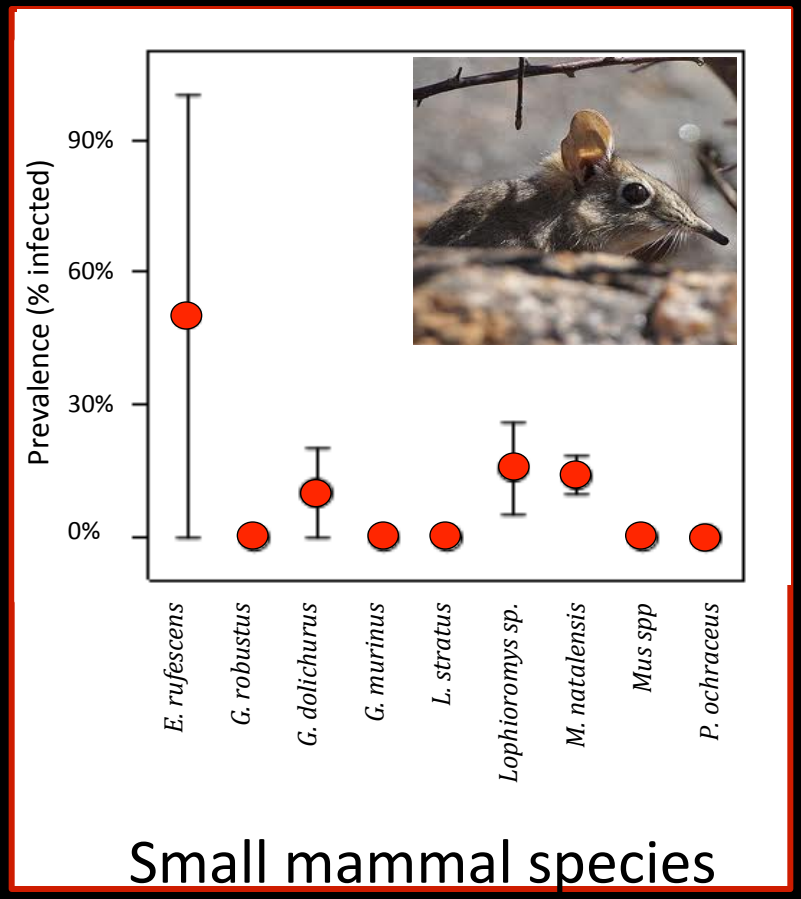
Rodent species responses can be habitat-specific



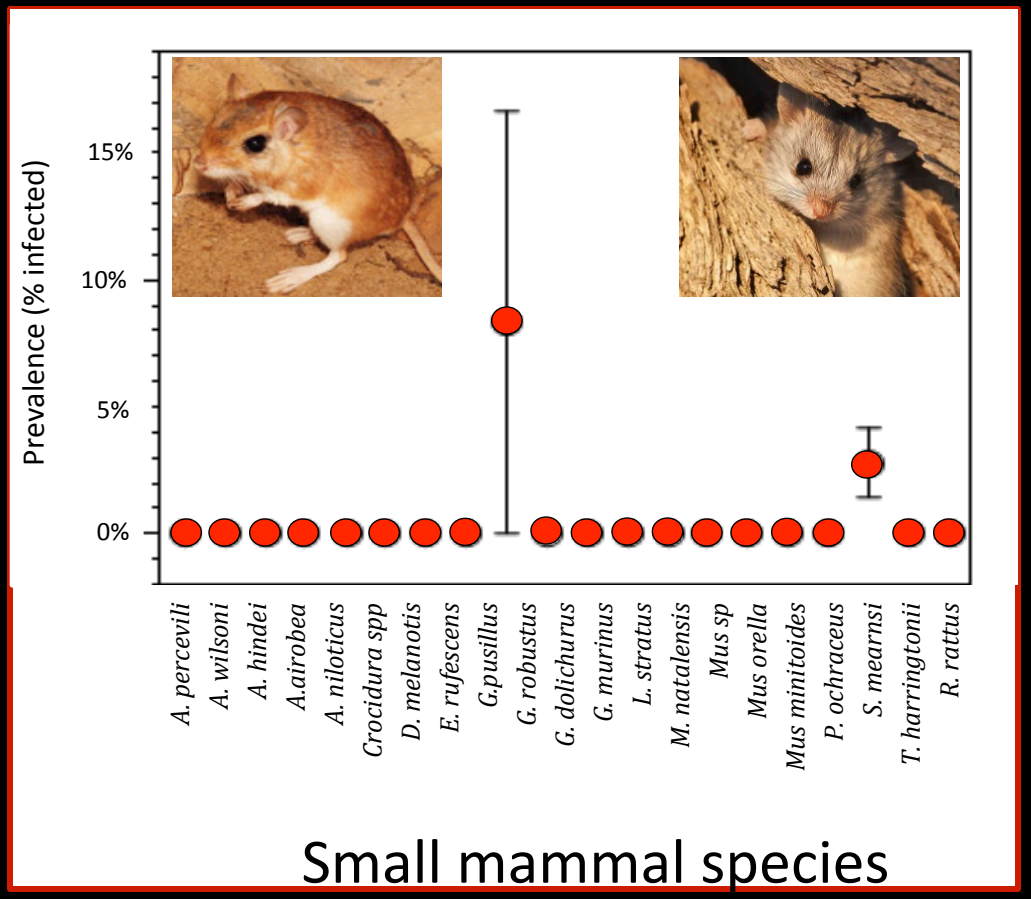
(Young et al. 2014)

Host pathogen specificity

Yersinia pestis (seroprevalence)
BUBONIC PLAGUE



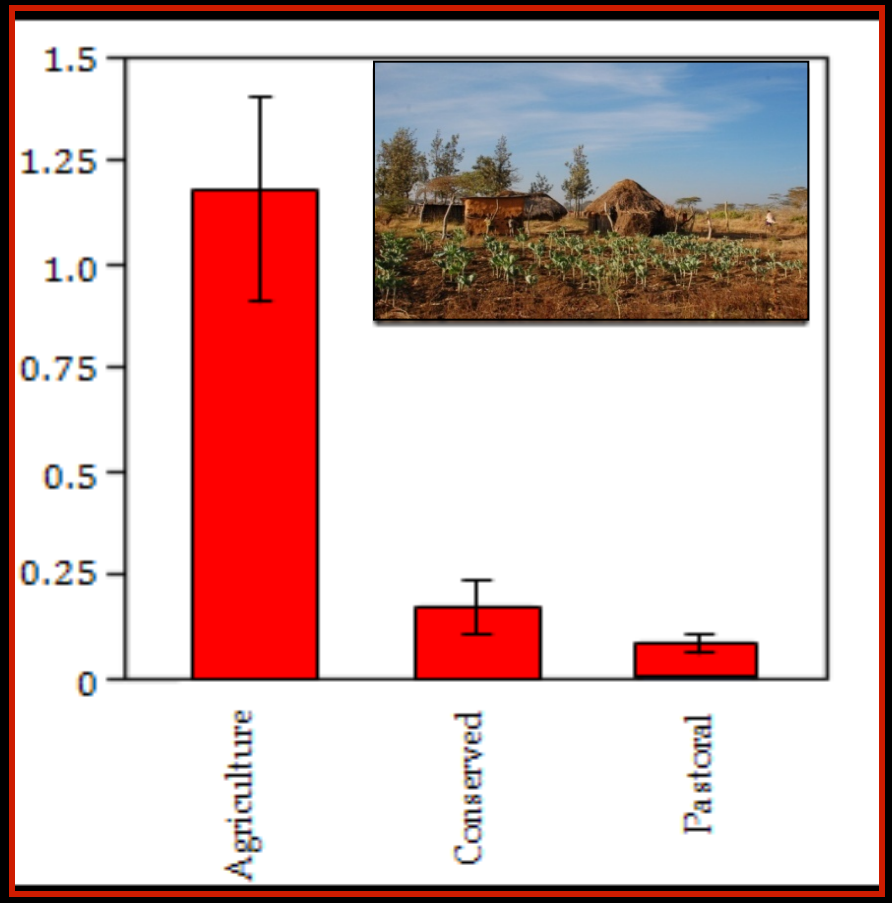
Borellia recurrensis (active infection)
RELAPSING FEVER



Net effect: *Pathogen specific* effects depend on SPECIFIC land-use

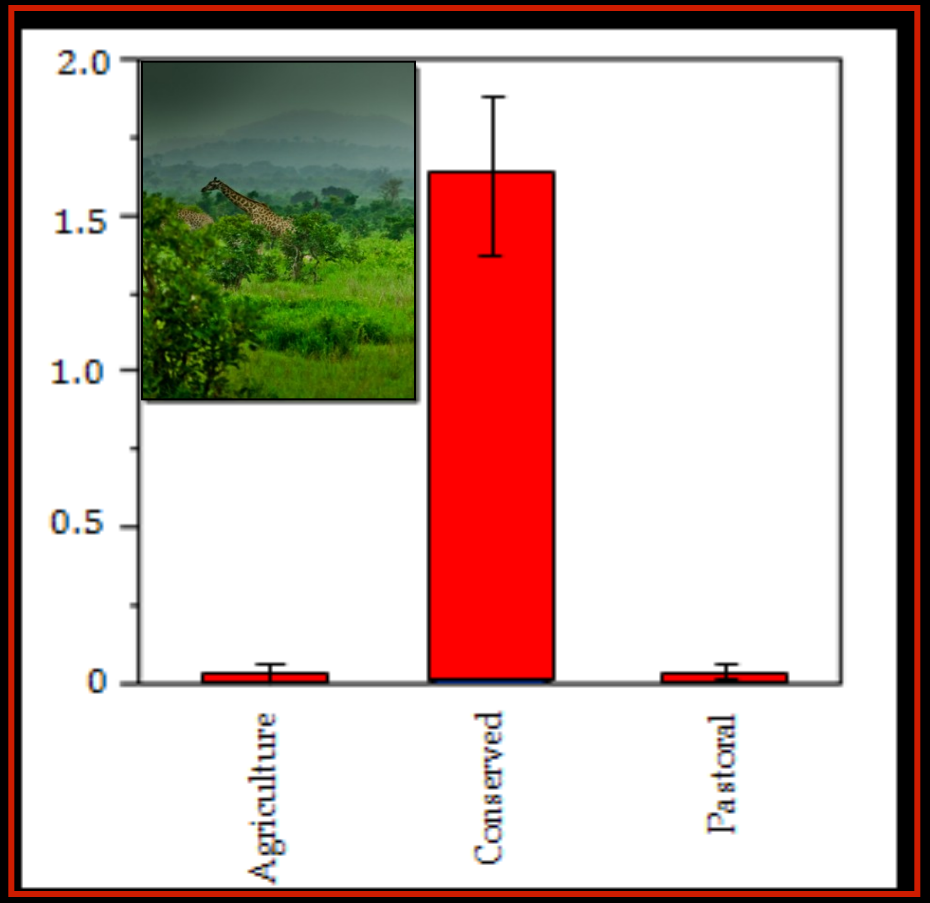
Bubonic plague (seroprevalence)

Yersinia pestis



Relapsing fever (active infection)

Borellia recurrensis



ONGOING WORK:

II. Assessing public health; local communities

(M. Barrow, Whitney Bagge, Lynn Gaffikin)

- Household interviews
- Work with local clinics
- Mine existing disease data

III. Predicting distribution of disease risks

(Eric Lambin)

- Models to separate out role of different factors in driving changes in rodent plagues
- Spatial projections of disease trajectories

DEFAUNATION-RODENTATION IN SAVANAH

- Extinction of meso- & mega-fauna, synergizes with land use change → rodentation
- Rodentation: clear, consistent under experimental manipulation
- Defaunation-rodentation: Increase of disease risks relevant to humans
- Understand; hopefully predict, spatial dynamics of disease in human- and nature-dominated landscapes

GENERAL CONCLUSIONS

- Defaunation: ongoing, massive, extinctions and declines (Vert + Invert); directly/indirectly → co-extinctions
- Declines and co-extinctions → anthropogenic alteration/ elimination of ecological processes
- Defaunation disrupts linkages between ecosystem processes and services, including control of risks to human health
- Defaunation: threat to the most significant features of the planet: their biodiversity and people