

Cenozoic mammals and the biology of extinction

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All species that have ever lived are, to a first approximation, dead.

(Raup 1986 The Nemesis Affair)

Question

Why do certain taxa go extinct while others do not?

In context of this study

Rephrased

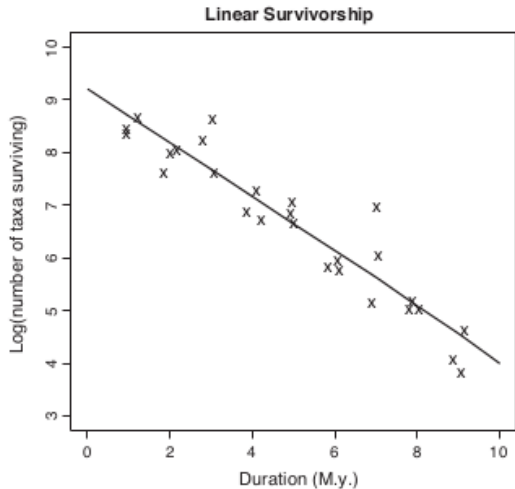
How does a taxon's **adaptive zone** affect **extinction risk**?

Modes of extinction

Field of Bullets – Wanton – Fair Game

(Raup 1991 Extinction: Bad Genes or Bad Luck?)

Van Valen's observation



(Liow et al. 2011 *TREE*)

Law of Constant Extinction

Definition

Extinction rate, in a given adaptive zone, is taxon–age independent.

(Van Valen 1973 *Evol. Theory*)

Questions

- ▶ Do interactions involved in environmental preference predict differential survival?
 - ▶ Is survival best modeled by a single interactor or multiple interactors?
 - ▶ How do factors, such as climate, contribute?
- ▶ Is extinction taxon-age independent or dependent?
- ▶ Do genera and species have fundamentally different survival distributions?

Survival analysis

Definition

Analysis of **time till event data**.

i.e. Time from origination to extinction (**duration**, T).

Formalization of Van Valen

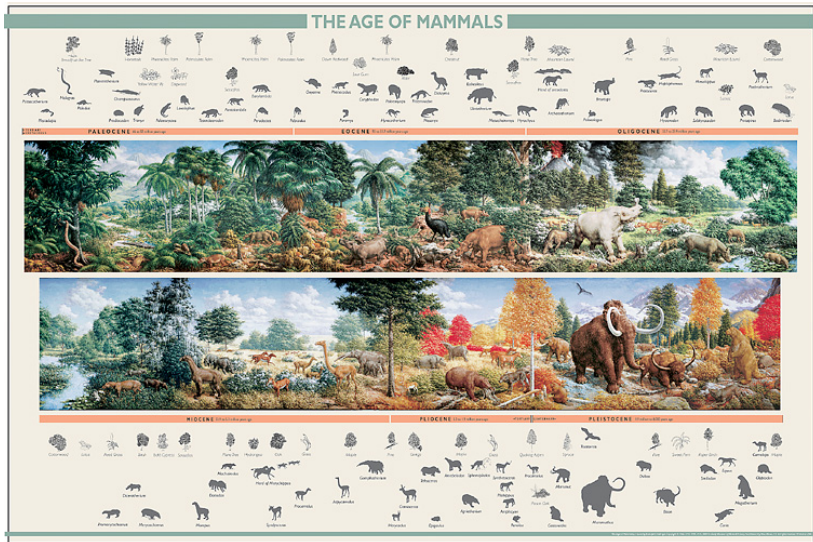
Law of Constant Extinction

$$T \sim \text{Exp}(\lambda)$$

T : survival time

λ : expected number of
extinctions per unit time

Mammals



(Yale Peabody Museum)

Regions

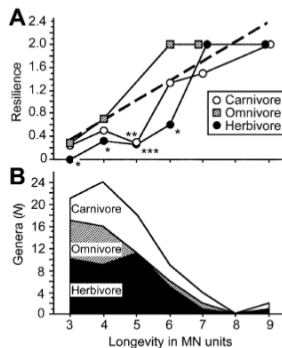
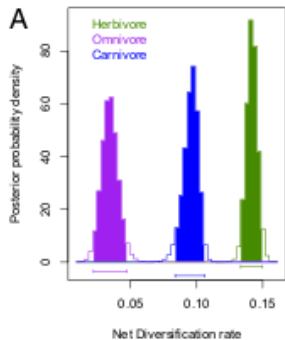


North America:
2366 species, 1003 genera



Europe:
1767 species, 658 genera

Diet



carnivore, herbivore, omnivore, insectivore

herbivore > carnivore

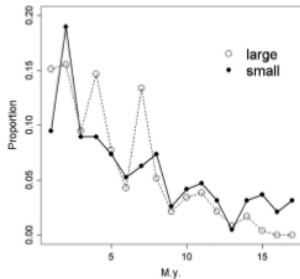
omnivore \simeq carnivore

insectivore ?

ground dwelling, scansorial,
arboreal

- ▶ ground dwelling $>$ arboreal
- ▶ scansorial \simeq ground dwelling

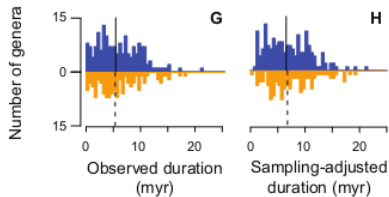
Body size



↑ mass, ↑ range size, ↑ survival

OR

↑ mass, ↓ reproductive rate, ↓ survival

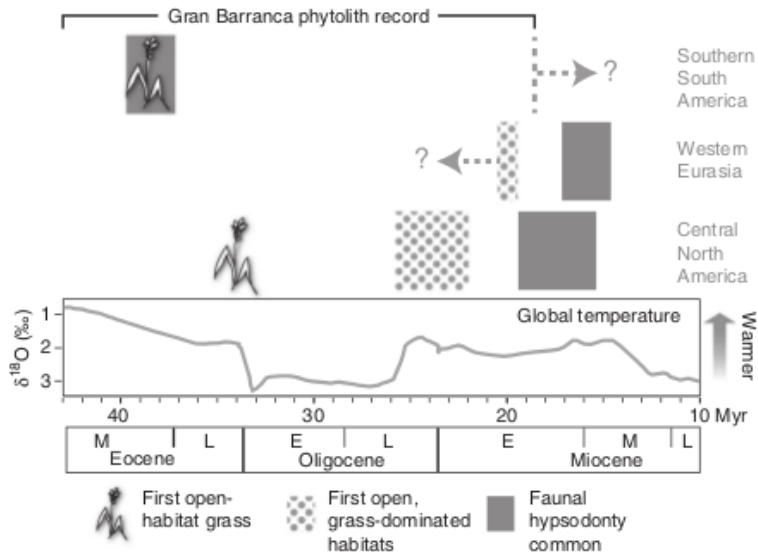


The Elephant in the Range

mean, CV occupancy

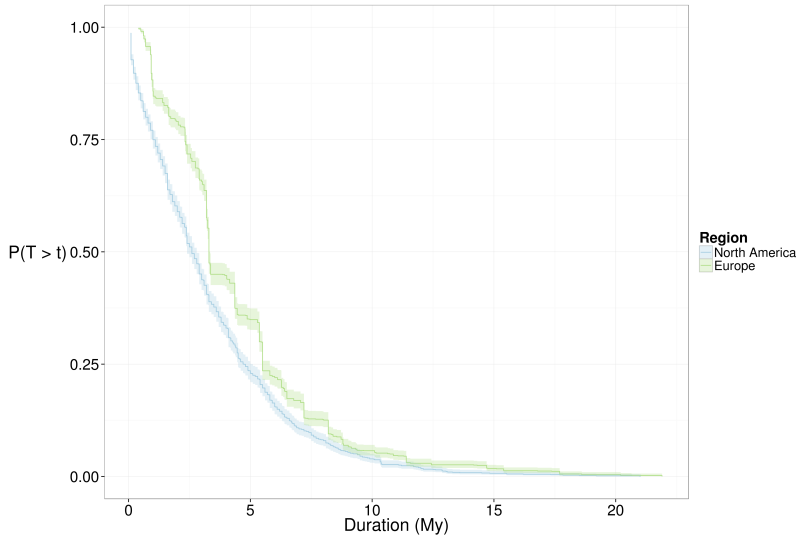
↑ occupancy, ↑ duration

Climate



(Strömberg *et al.* 2013 *Nature Com.*)

Regional nonparametric survival curves



Model selection

“Best” model

Parameter interpretations

Conclusions, future work

Acknowledgements

▶ Committee

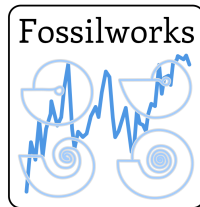
- ▶ Kenneth D. Angielczyk
(co-advisor)
- ▶ Michael J. Foote
(co-advisor)
- ▶ P. David Polly
- ▶ Richard H. Ree

▶ Discussion

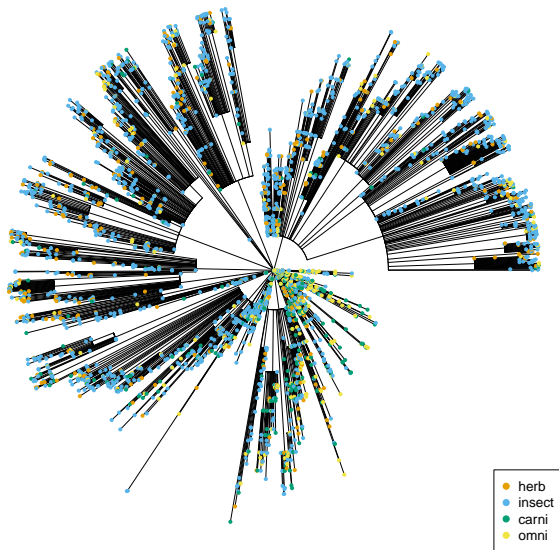
- ▶ David Bapst, Megan Boatright, Ben Frable, Colin Kyle, Darcy Ross, Liz Sander
- ▶ John Alroy, Graeme Lloyd, Kathleen Ritterbush, Carl Simpson, Graham Slater



The **Field**
Museum



(Informal) phylogeny

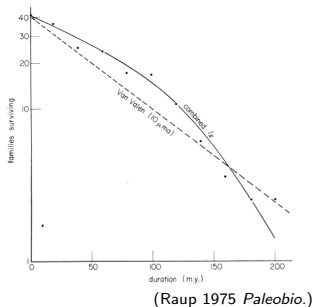


Analytical approach

frailty coefficient

conditional autoregressive prior

Differential preservation and survival



two groups in four scenarios

- ▶ = birth, death;
= preservation
- ▶ = birth, death;
! = preservation
- ▶ ! = birth, death;
= preservation
- ▶ ! = birth, death;
! = preservation

