Changes in the use of “Ecospace” in the Marine Realm over time

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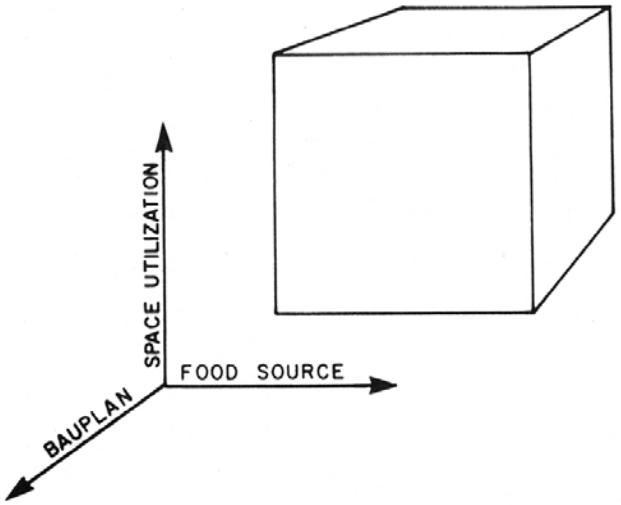
Ecospace Utilization and Guilds in Marine Communities through the Phanerozoic



BAUPLAN

- REPRODUCTION
- DEVELOPMENT
- GROWTH
- PHYSIOLOGY

FOOD SOURCE

- SUSPENDED MATTER
- DETRITUS
- PLANTS
- ANIMALS

SPACE UTILIZATION

- PELAGIC: PLANKTON, NEKTON
- EPIFAUNA: MOBILE, ATTACHED, RECLINING
- INFAUNA: ACTIVE, PASSIVE, SHALLOW, DEEP

Diagrammatic representation of ecospace using the three general criteria used in this chapter for defining guilds as axes. A guild would be represented by the species of a community that all fall in the same place on each axis and therefore occupy one small segment of the ecospace "cube," such as a corner.

The Guild Concept

Bambach (1983)

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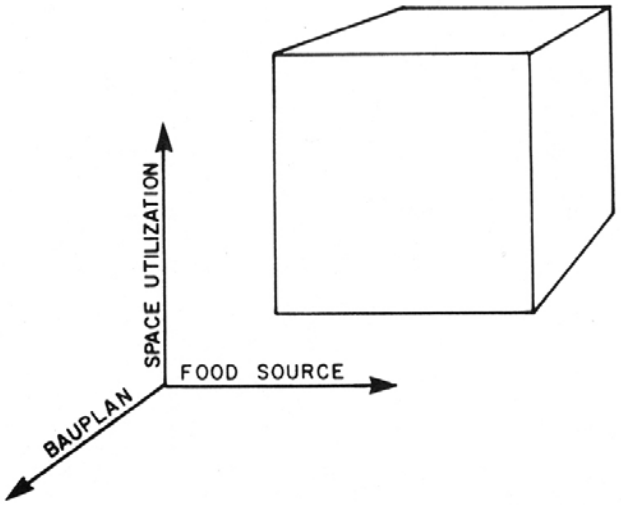

Arbitrary and vague >

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< Not always determinable

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< Too broad, Mixes dimensions

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Bambach (1983)

An improved methodology for general paleoecological assessment of assemblages and faunas:

Use ecologic axes for which assignment of fossils is feasible:

Tiering (spatial position relative to the sea-floor)

[Implications for mechanical adaptations]

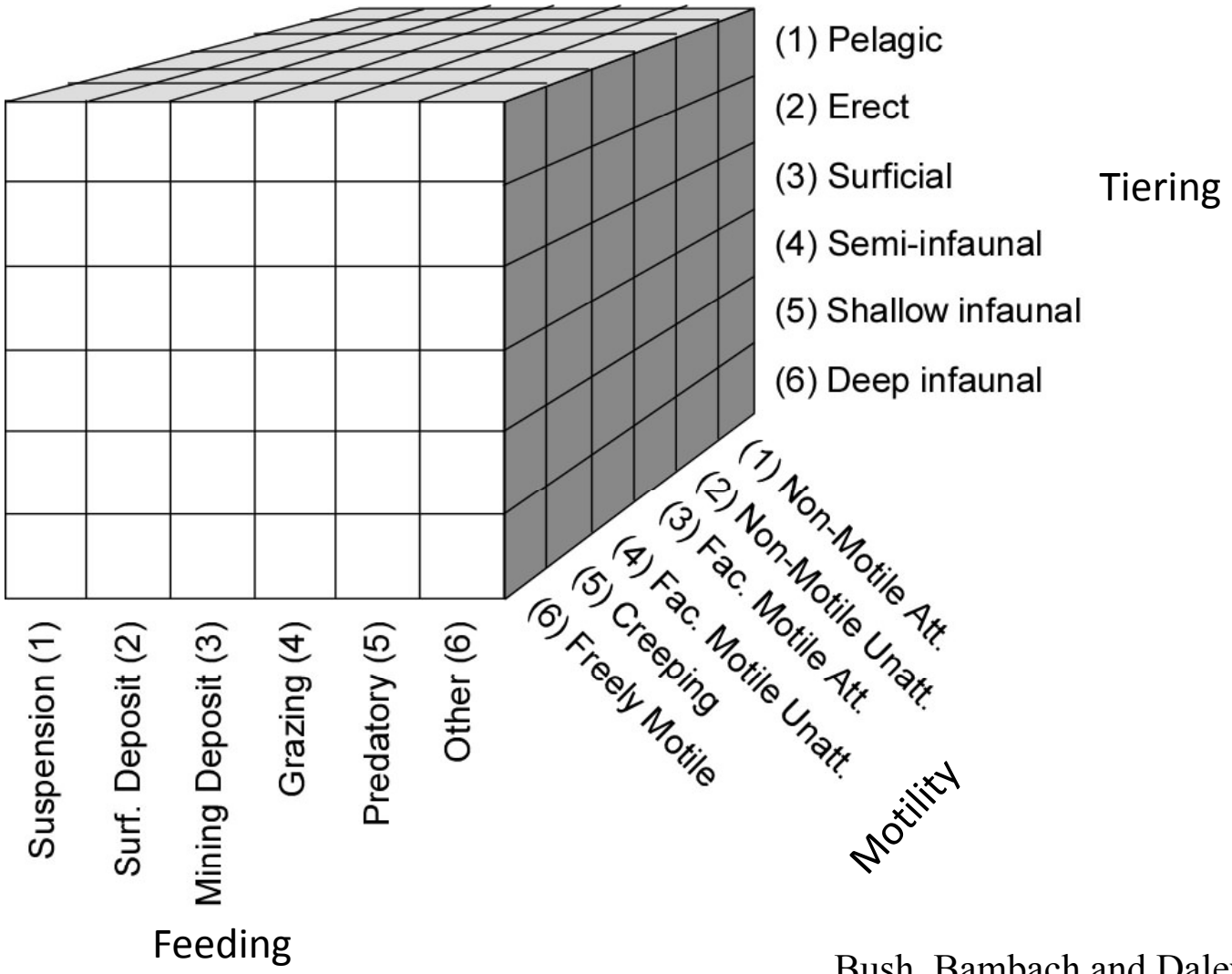
Motility level (ability to change position, respond to external events)

Feeding strategy (method of acquiring energy to maintain life functions and reproduce)

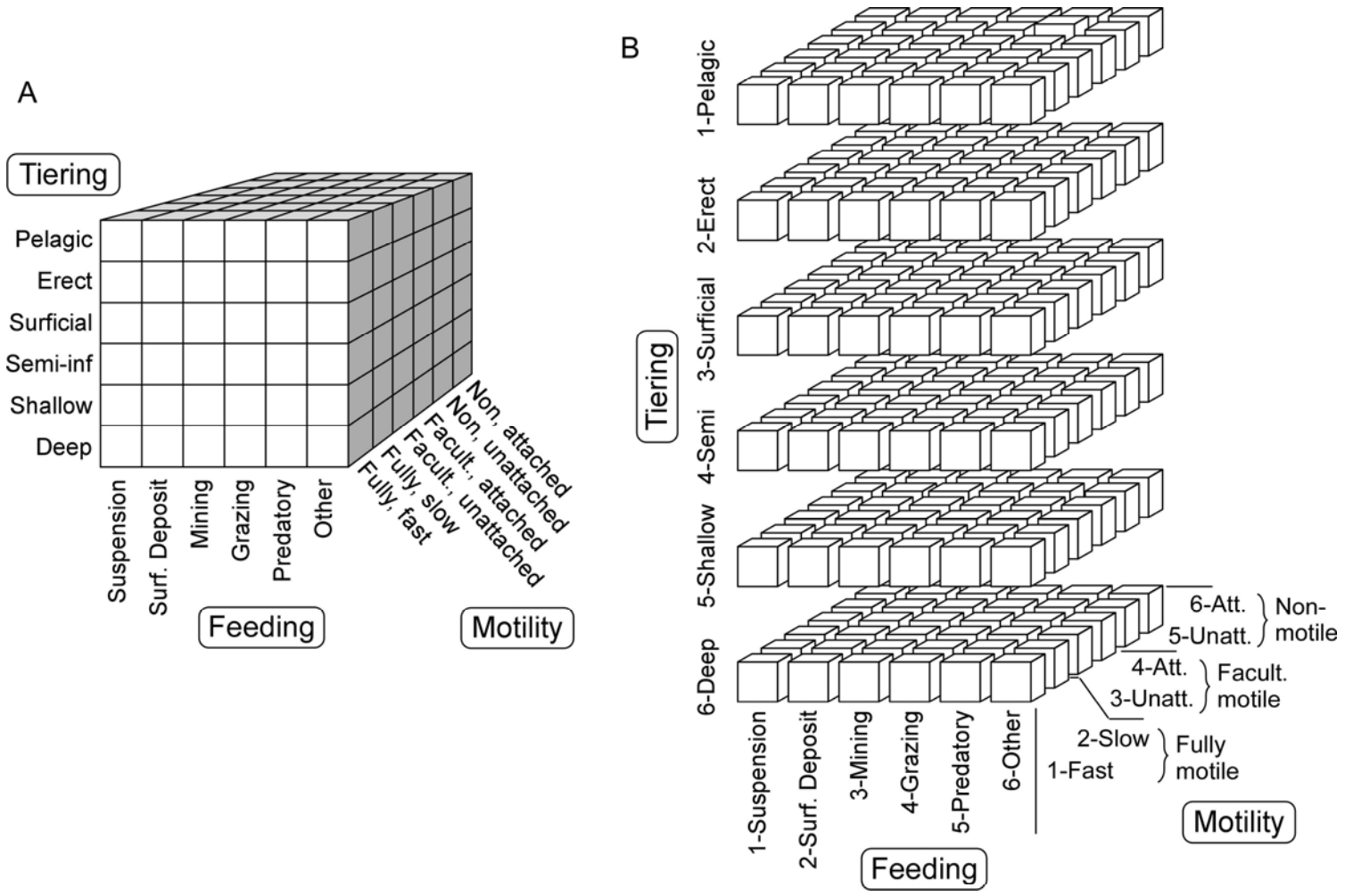
Each axis subdivided to designate the full range of possibilities

From counts of taxa with each combination of properties a quantitative evaluation of the importance of each ecological combination is possible.

3-D Ecospace Use Cube

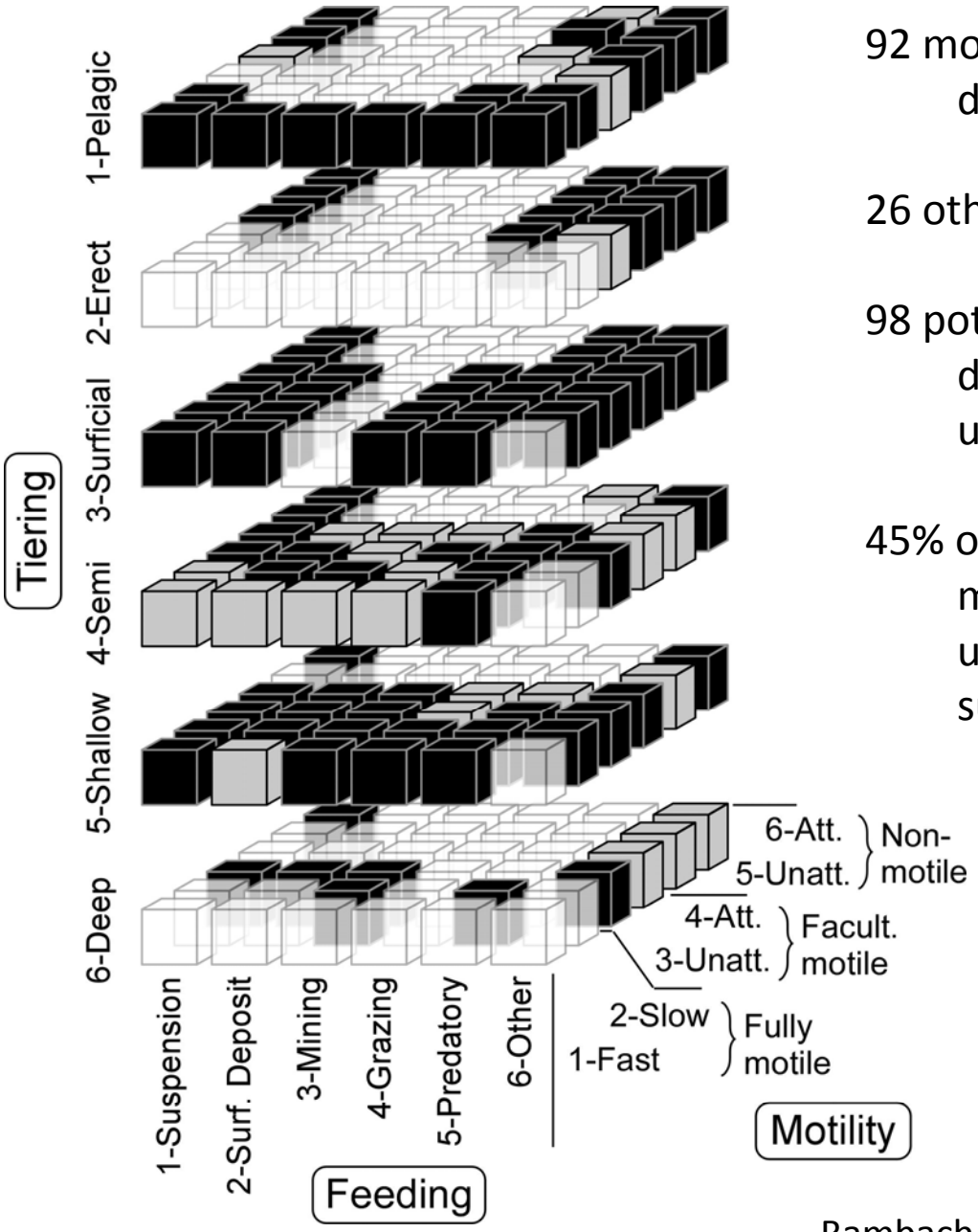


Bush, Bambach and Daley 2007



216 combinations encompass all possible modes of life

"Complete" Survey of the Living Fauna



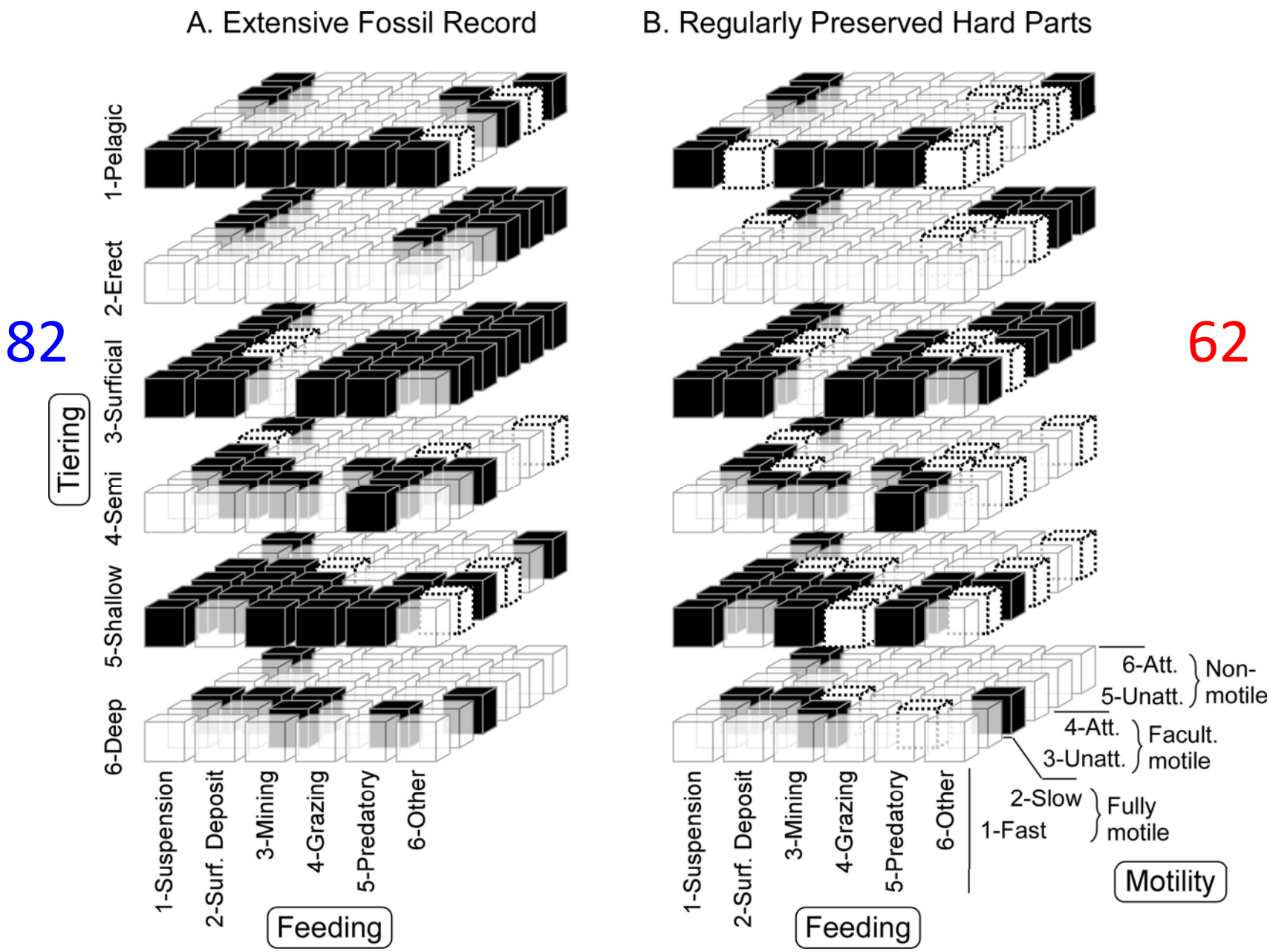
92 modes of life documented

26 others reasonable

98 potential modes of life do not seem to be utilized

45% of conceivable modes of life are unlikely to be successful.

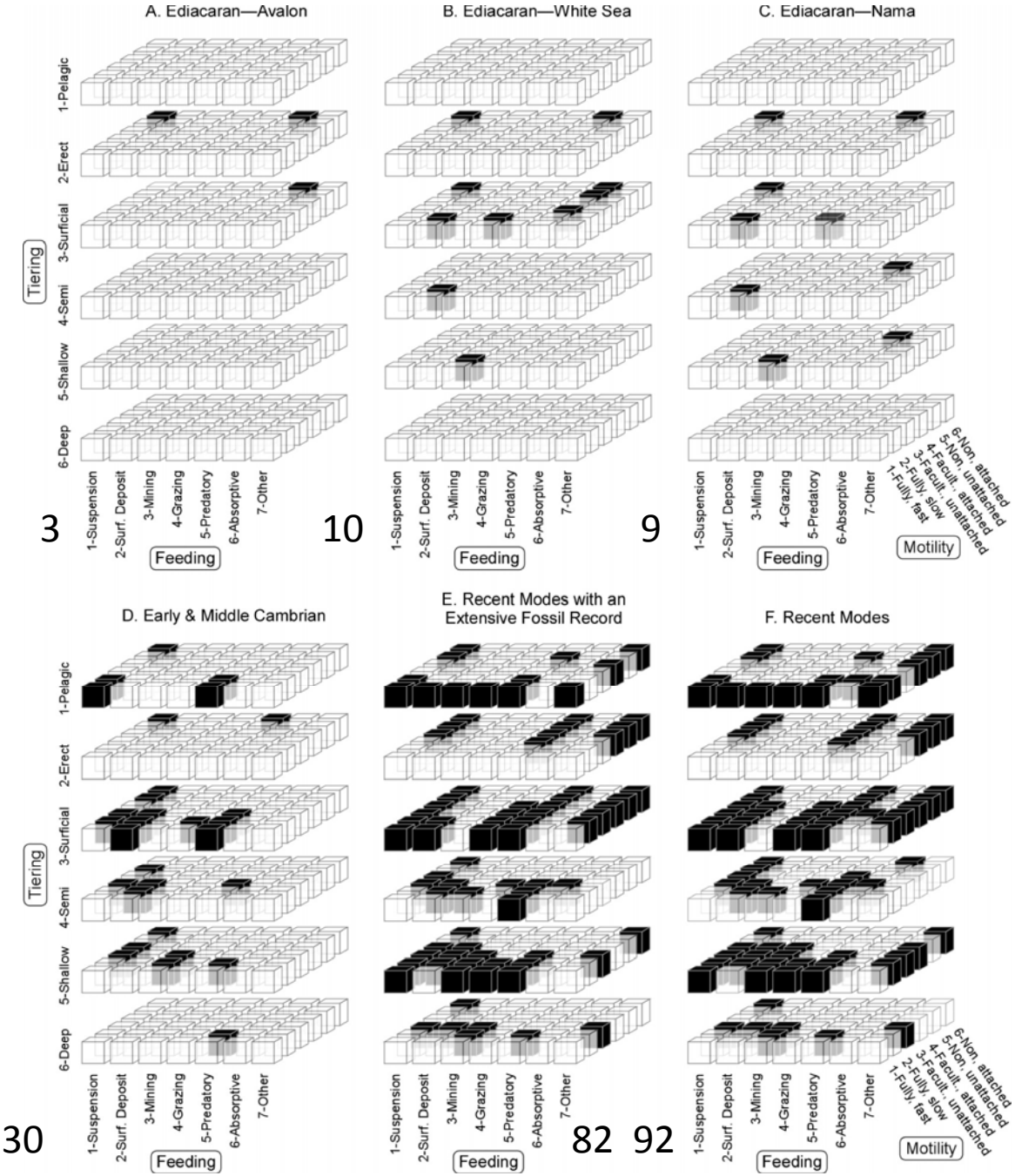
Bambach, Bush and Erwin 2007



Bambach, Bush and Erwin 2007

Ecospace — from the Ediacaran to the Cambrian to Now

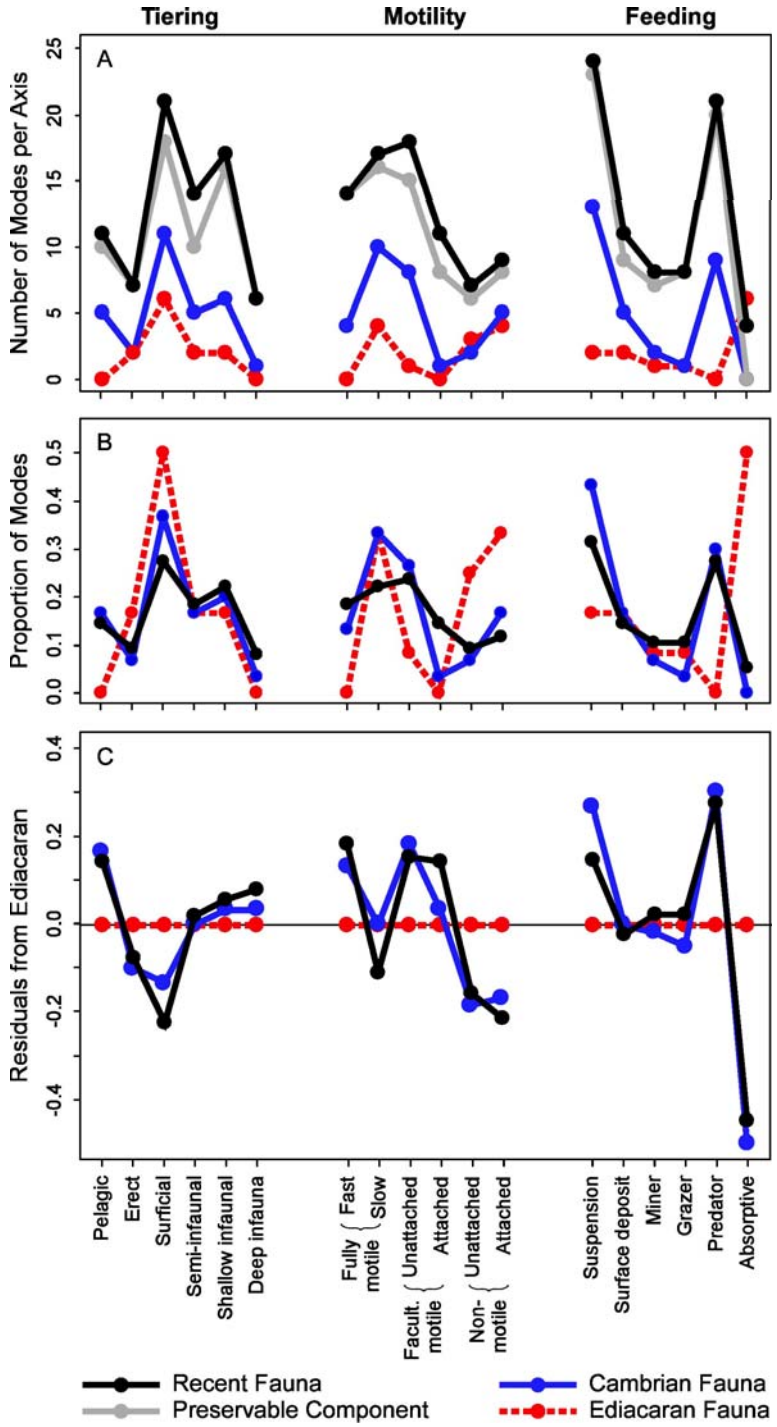
Faunas including non-skeletal organisms



3 10 9 12 in all

30 82 92

Bush, Bambach and Erwin in press



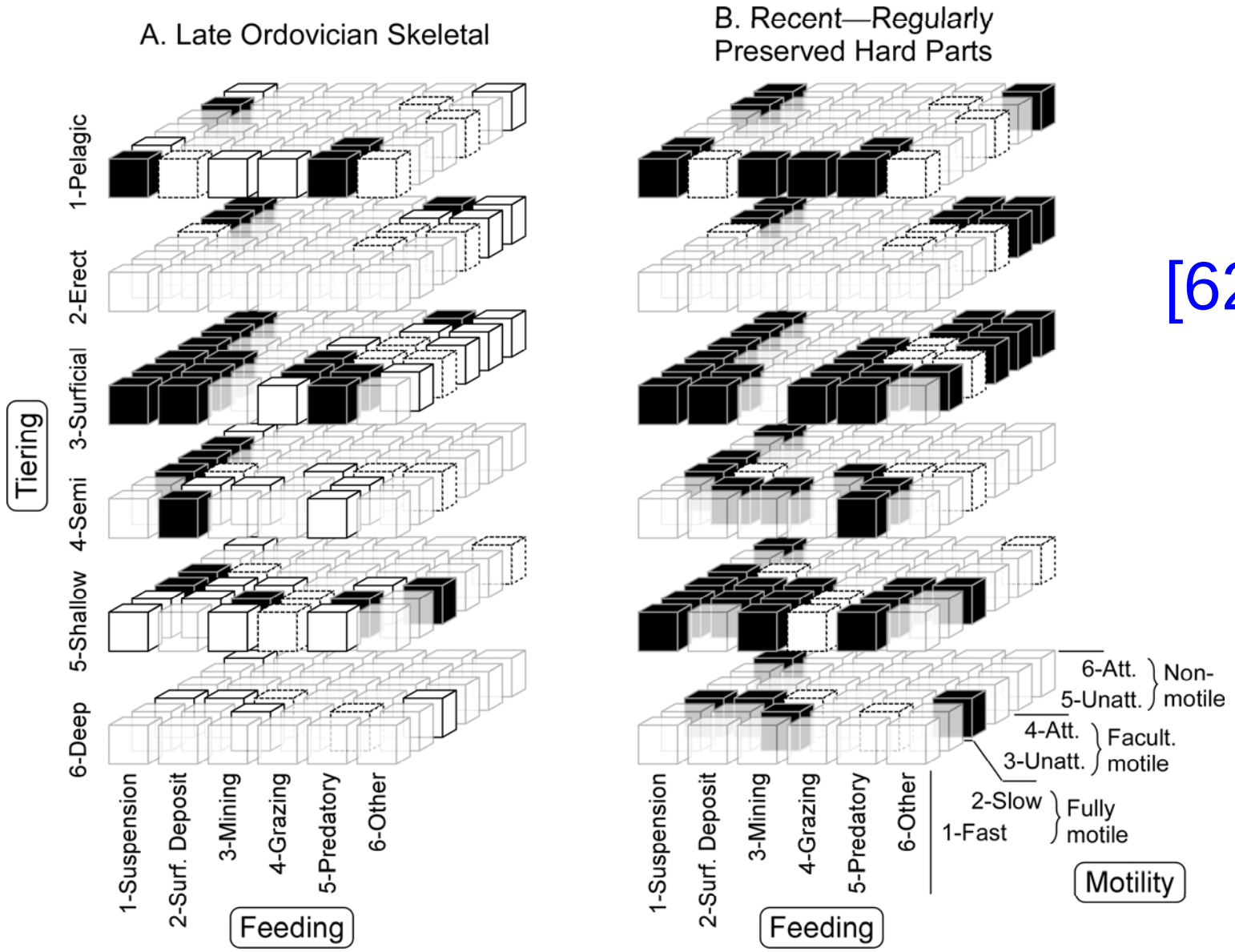
Number of modes in each category has systematically increased

"Normal" Phanerozoic marine animal life has a truly different relation to ecospace utilization compared to the Ediacaran fauna

Bush, Bambach and Erwin in press

The “normal” fossil record — just skeletal preservation
Comparing the Paleozoic to the Late Cenozoic

[30]



[62]

Bambach, Bush and Erwin 2007

Comparison of "communities" (fossil assemblages from just one habitat)

(Bush and Bambach 2004, and later papers)

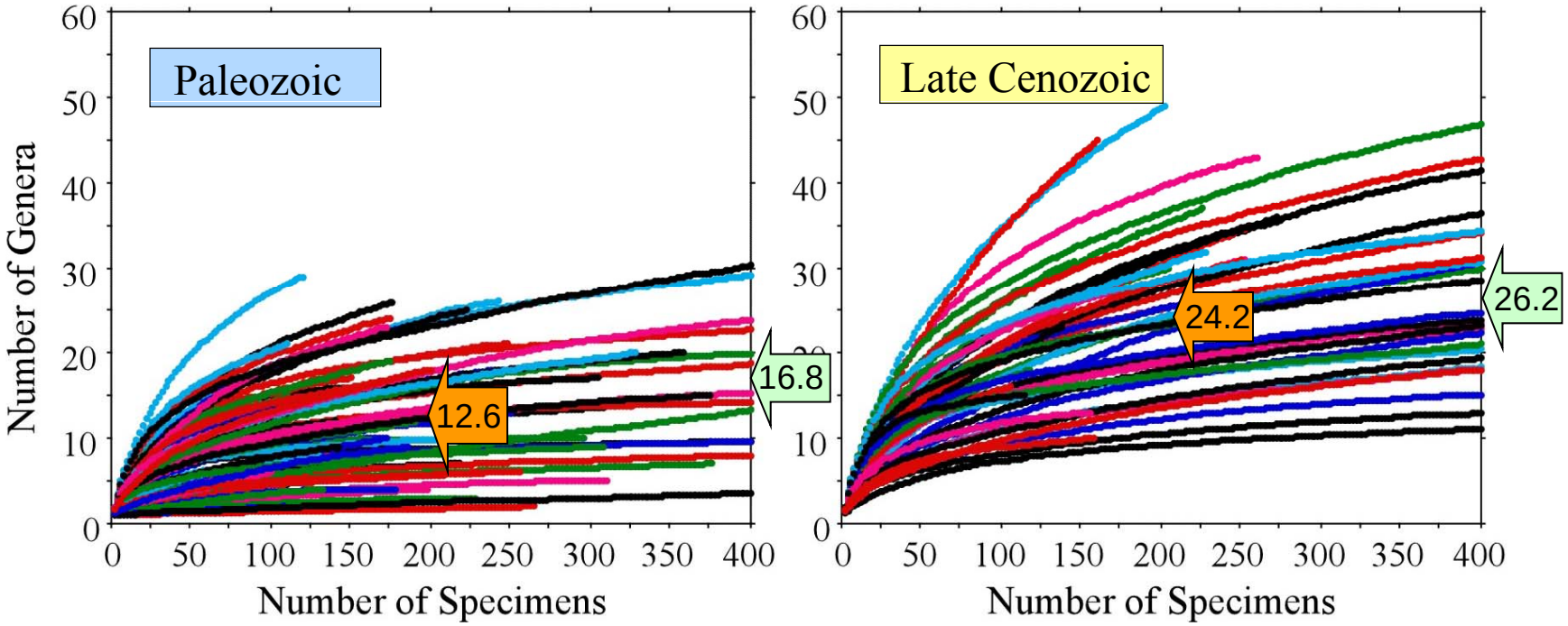
	Temperate		Tropical
• **Late Cenozoic**			
– Plio-Pleistocene	24	47 Total	235
– Miocene	23		
• **Middle Paleozoic**			
– Devonian	4	79 Total	
– Silurian	49		
– Late Ordovician	26		

All samples contain over 100 specimens

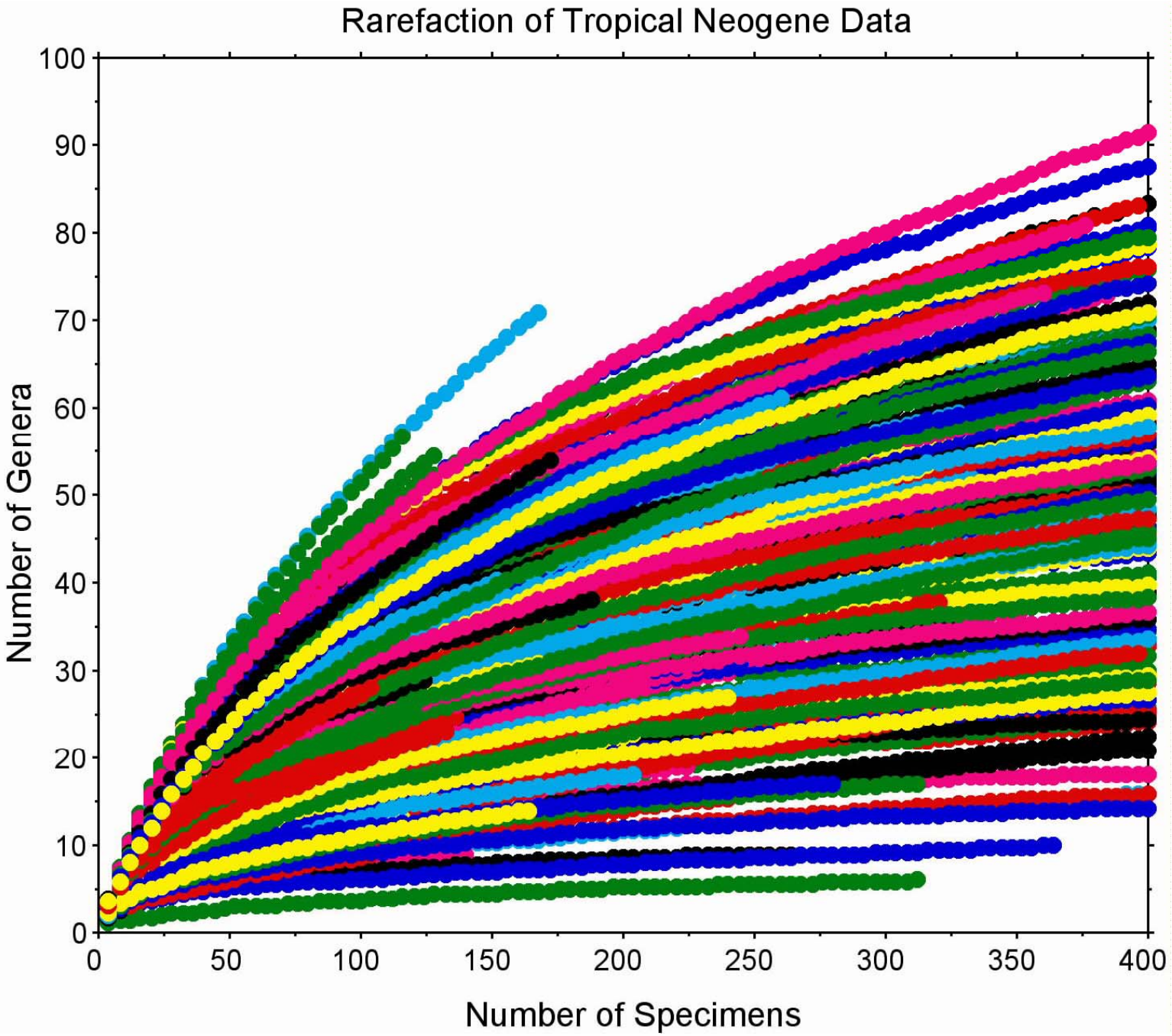
37 Paleozoic and 38 Cenozoic temperate contain over 200 specimens

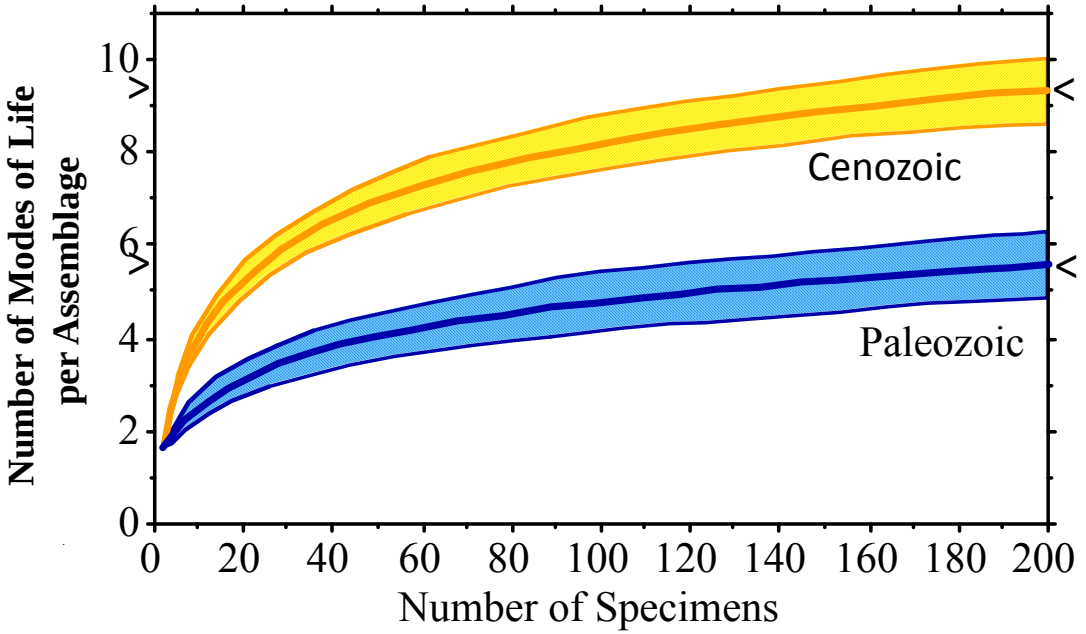
182 of the Cenozoic tropical samples are over 200 specimens and 71 are over 800

Rarefaction: Paleozoic vs. Cenozoic alpha diversity

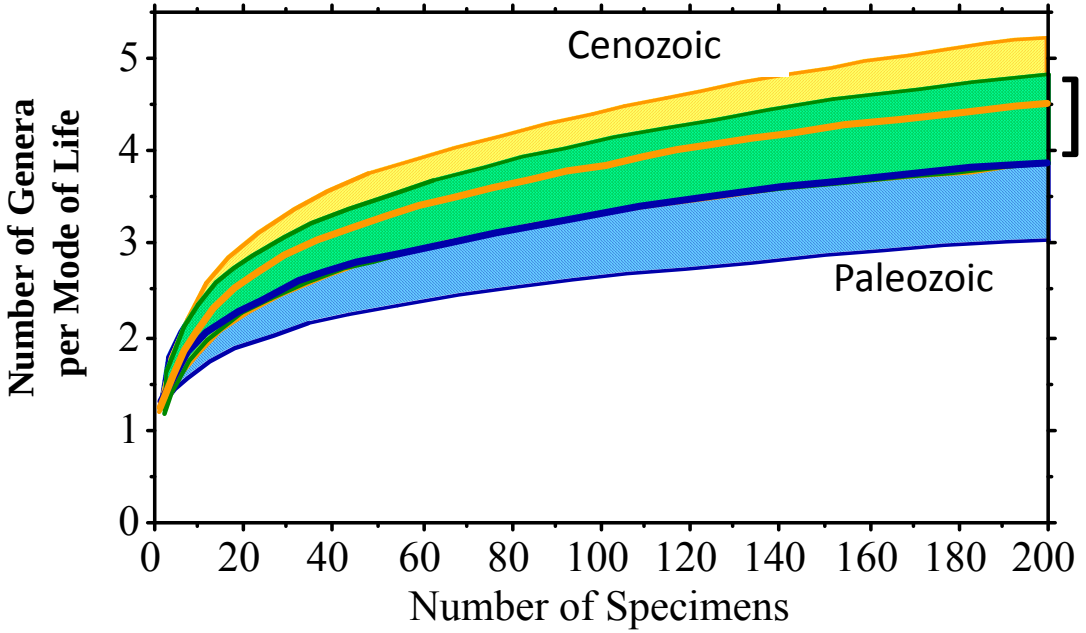


Bush and Bambach (2004), *J. Geol.*


Rarefaction of Tropical Neogene Data
Number of Genera
Number of Specimens
0
10
20
30
40
50
60
70
80
90
100
0
50
100
150
200
250
300
350
400
< Trop
< Temp
< Pz



Number of modes of life per paleocommunity increased greatly between the Paleozoic and late Cenozoic

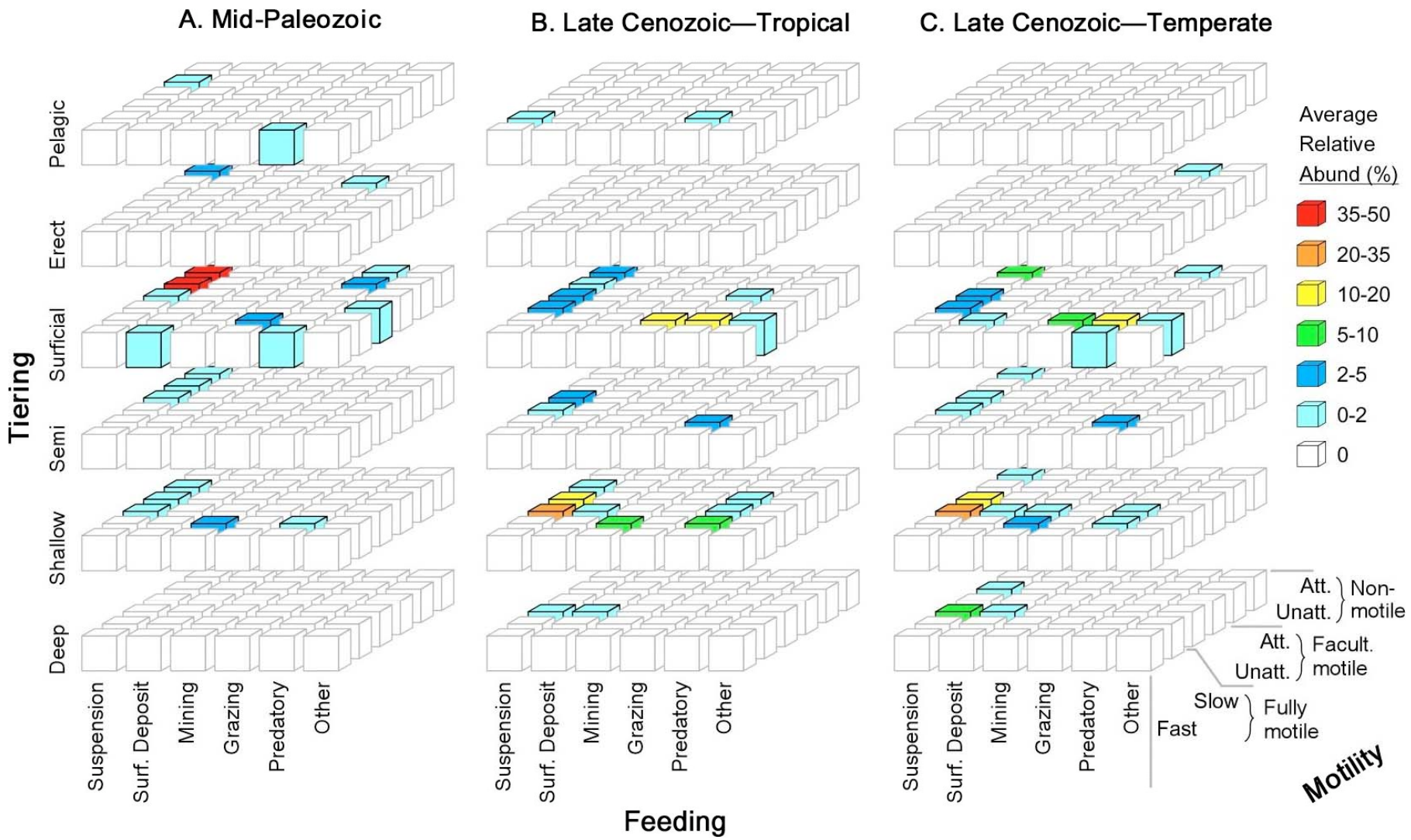


Number of genera per mode of life did not increase significantly

[Note overlap of confidence intervals]

Bush et al. in preparation

Environmental conditions in particular habitat settings
(in this case the loose-sediment level bottom habitat)
encourage habitation by just a restricted range of modes of life

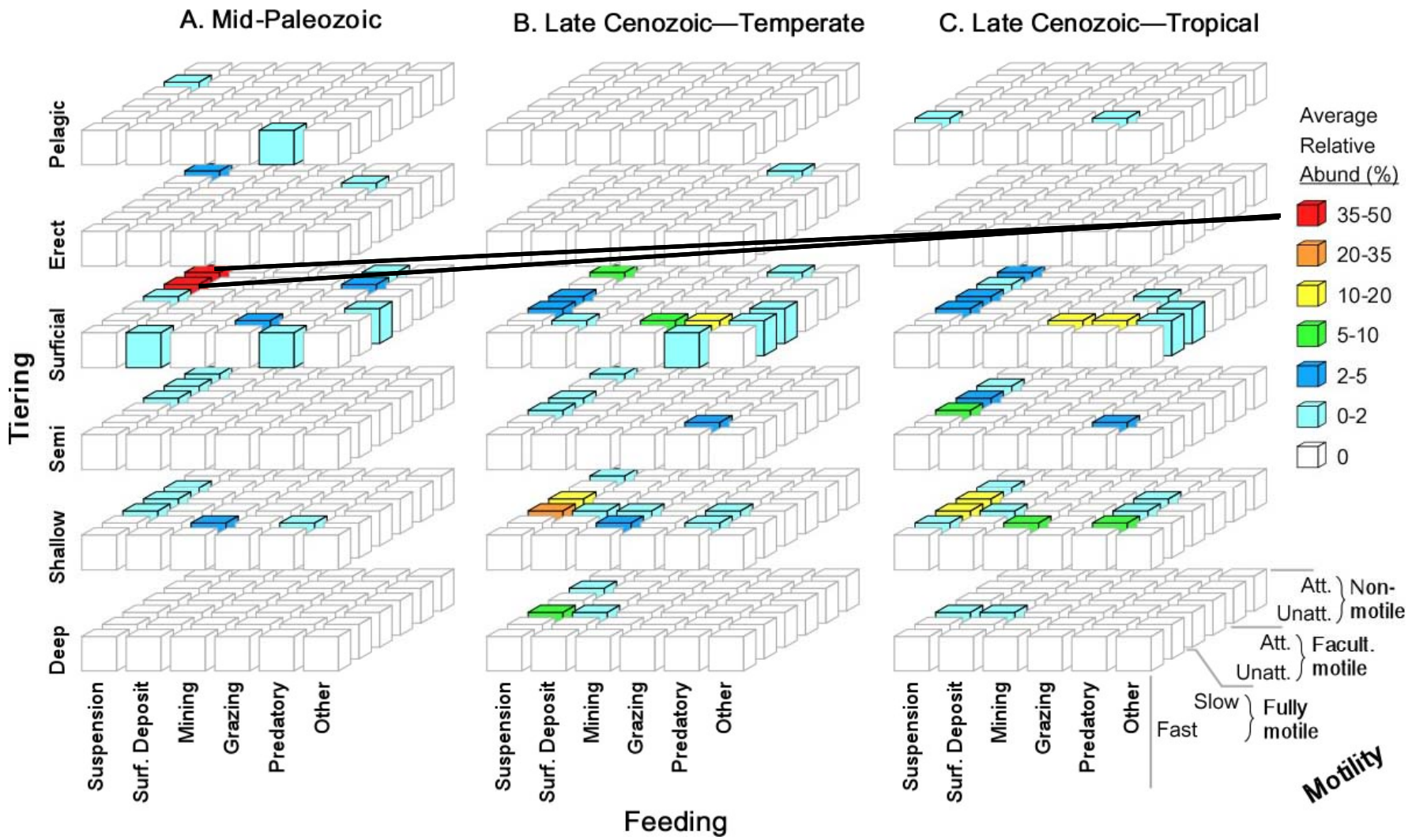


21 23 25

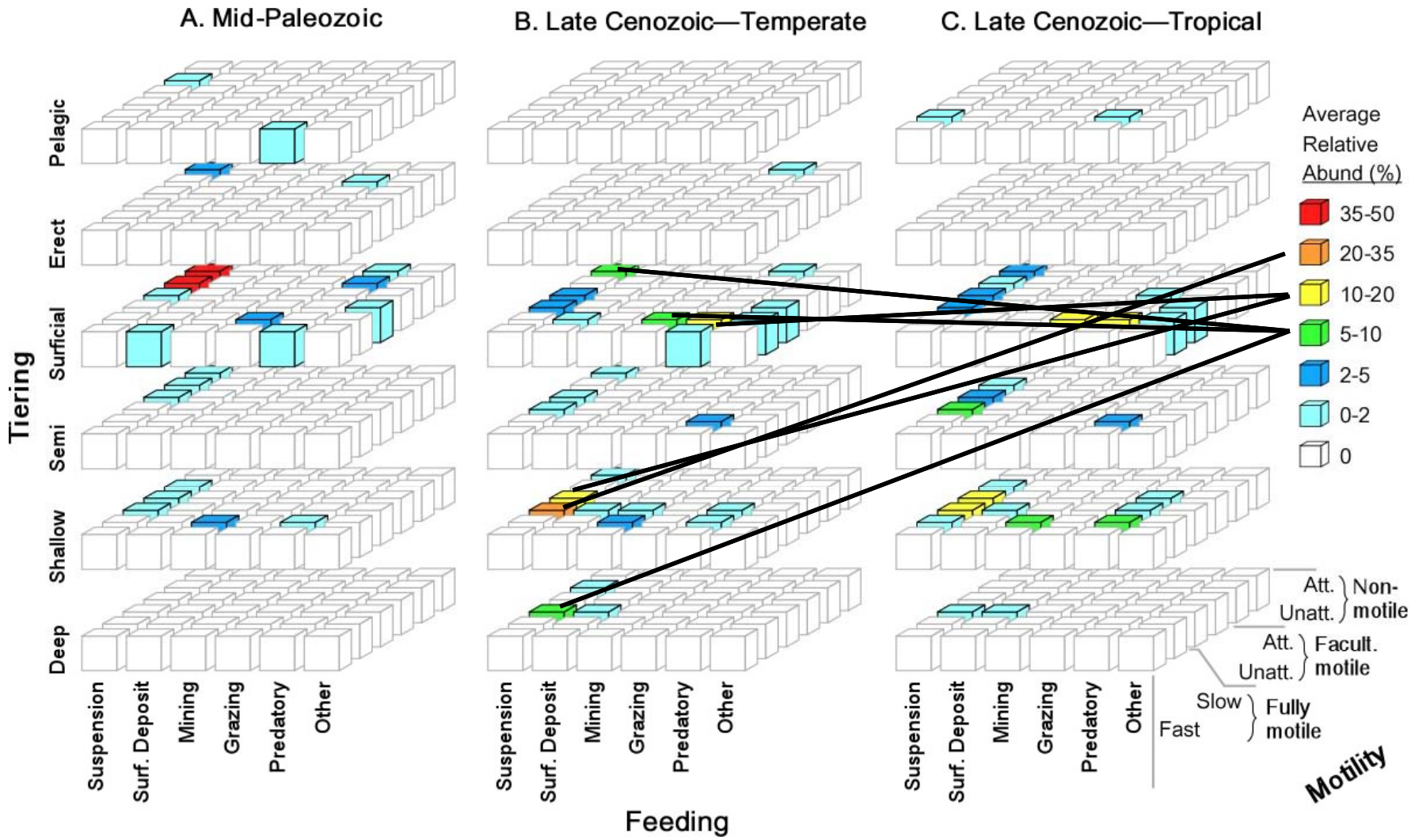
If there are 21 to 25 modes of life represented
in both mid-Paleozoic and late Cenozoic
level-bottom marine ecosystems,
how, on average, can there be almost twice as many
modes of life (9.5)
represented in late Cenozoic assemblages
as there are in mid-Paleozoic assemblages (5.5)?

In Mid-Paleozoic assemblages

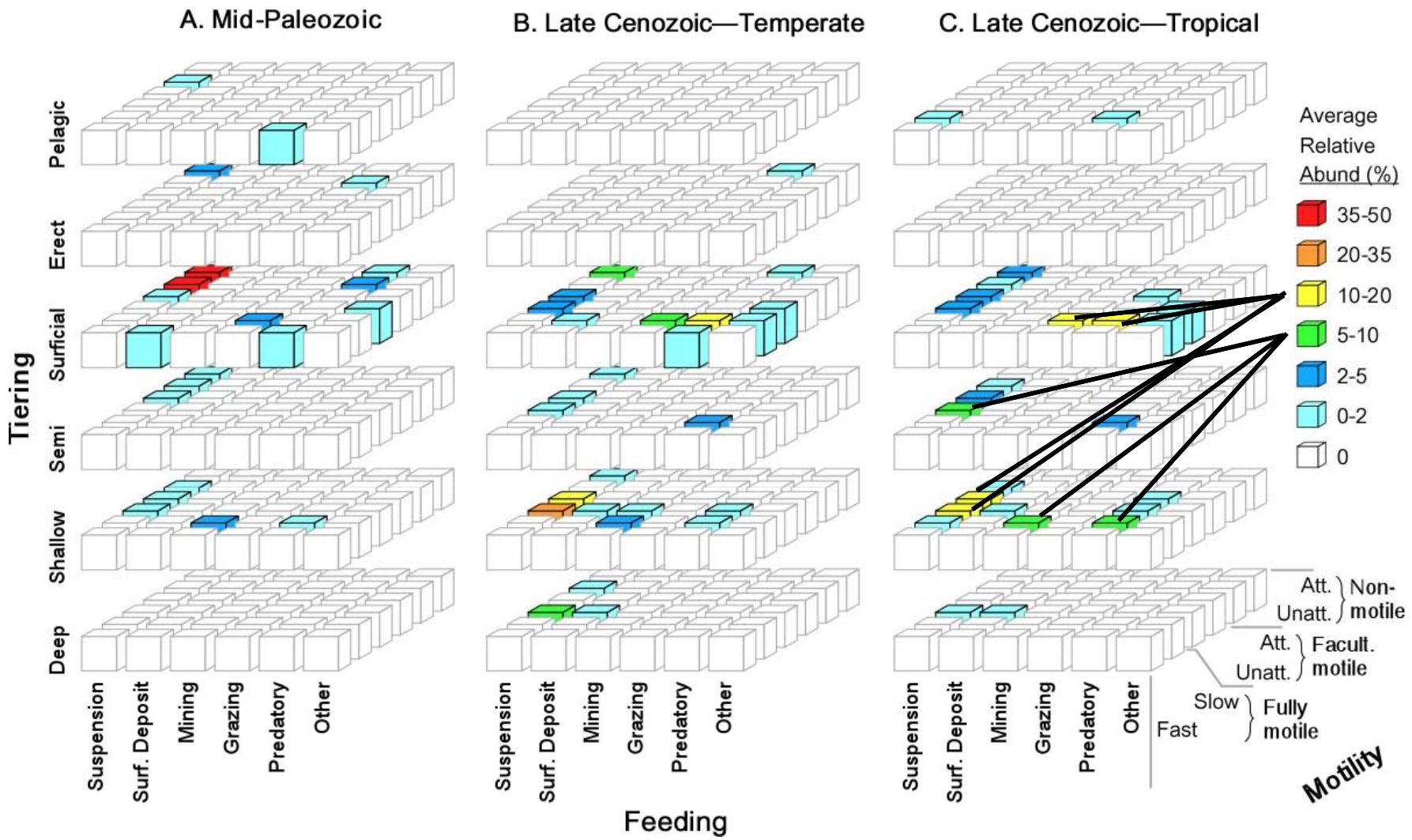
~80% of individuals utilized just two modes of life

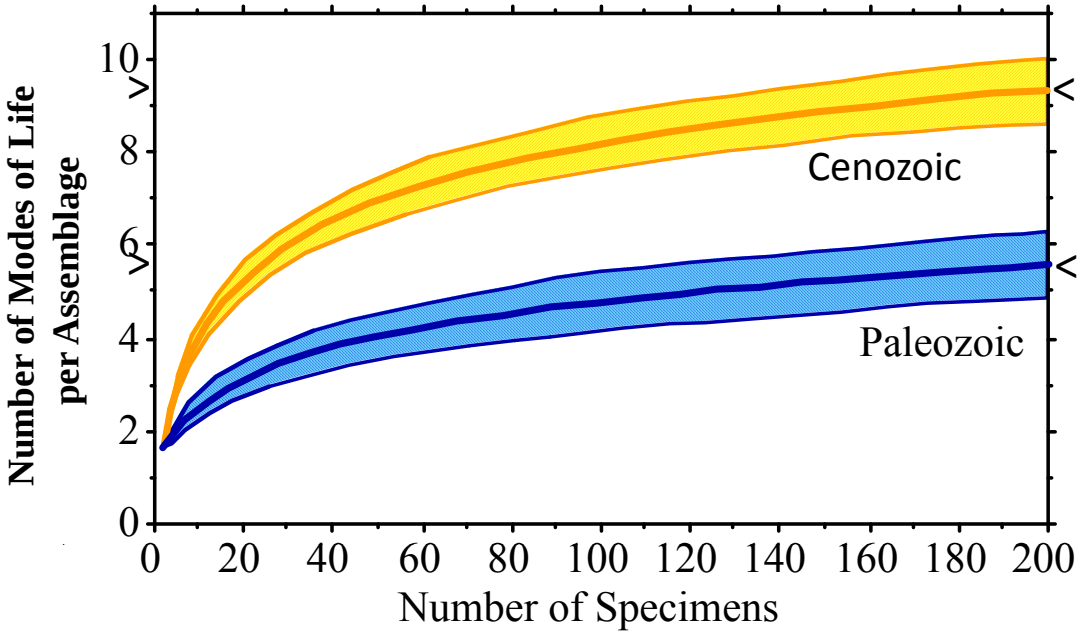


~75% of individuals in Cenozoic Temperate assemblages were distributed among six modes of life, not just two

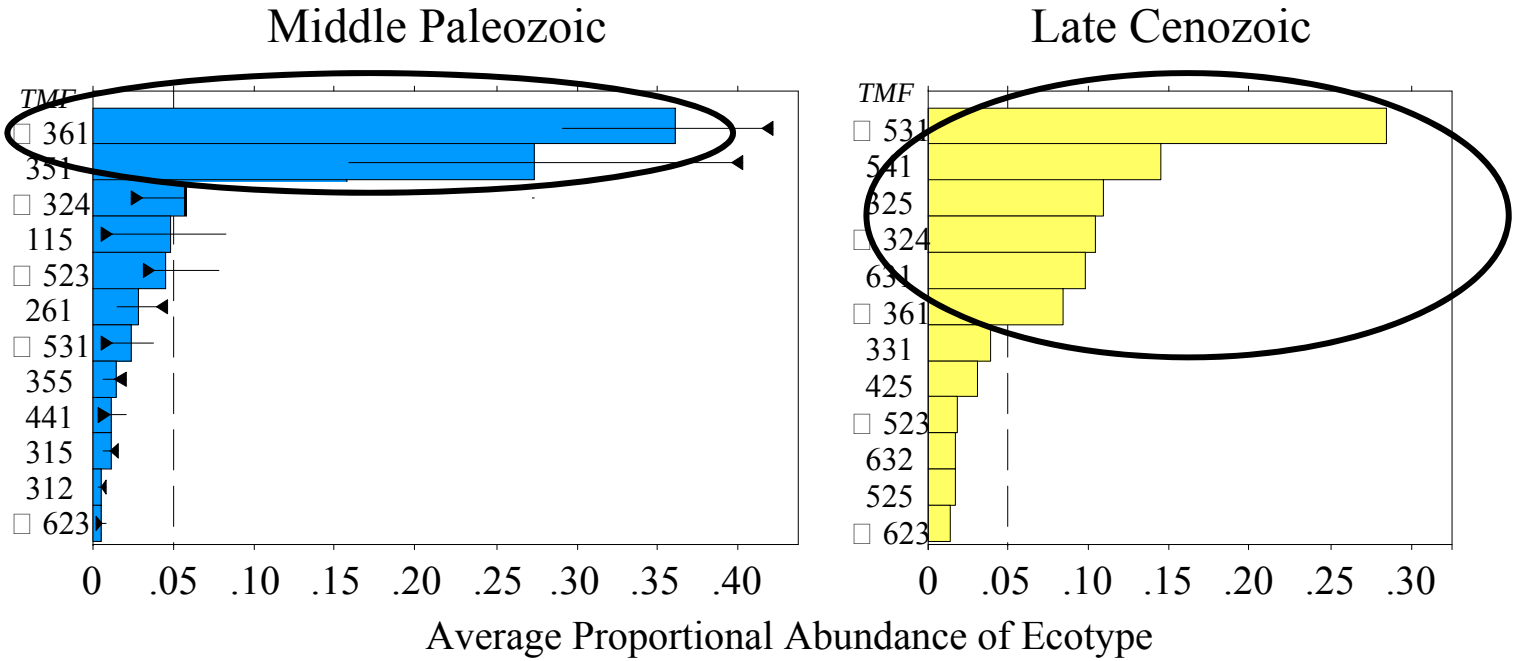


In late Cenozoic Tropical assemblages ~80% of individuals were distributed among seven "dominant" modes of life

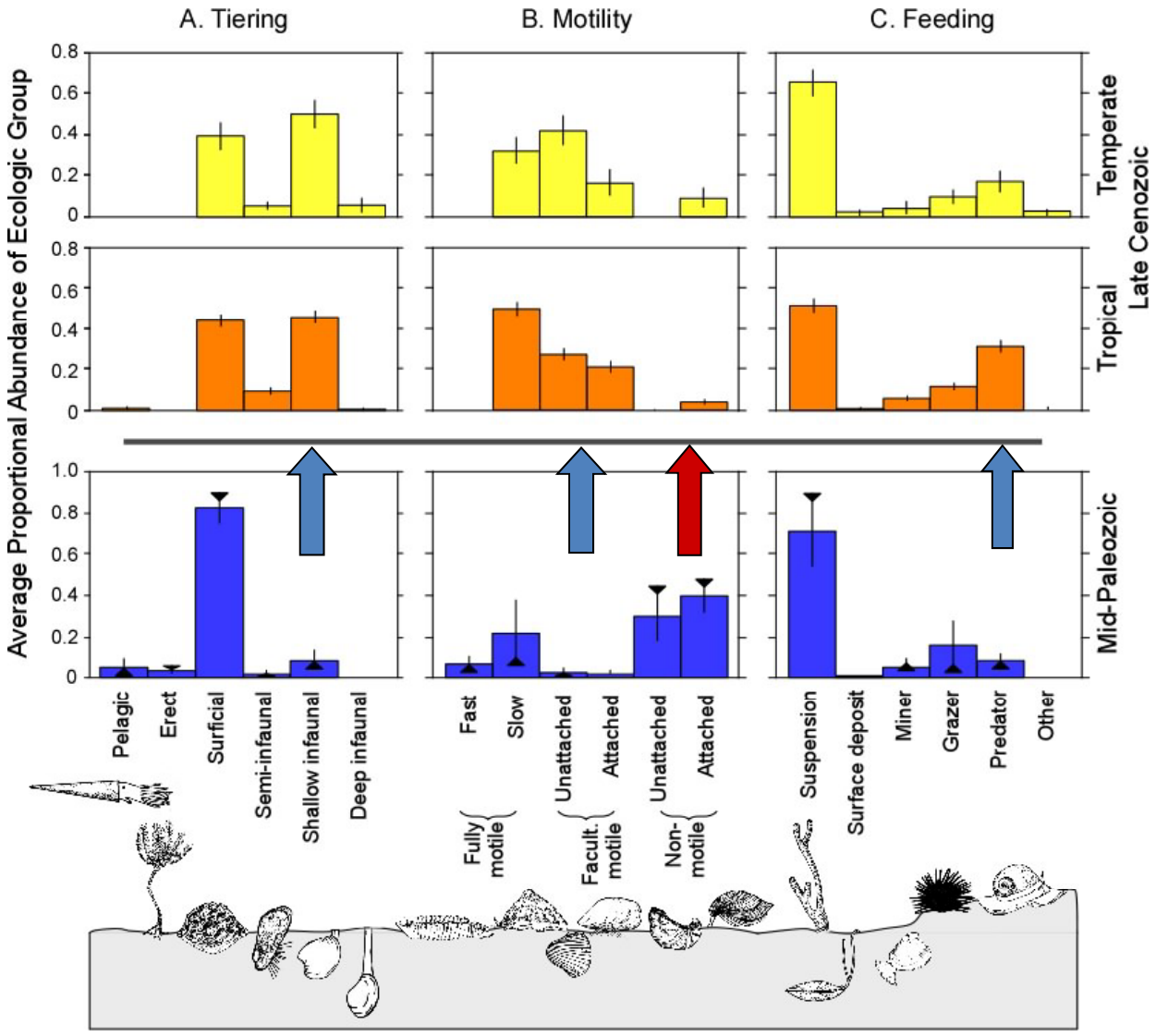




The difference in number of modes of life in mid-Paleozoic and late Cenozoic assemblages is a result of drawing from species pools with different distributions of abundance (importance) values

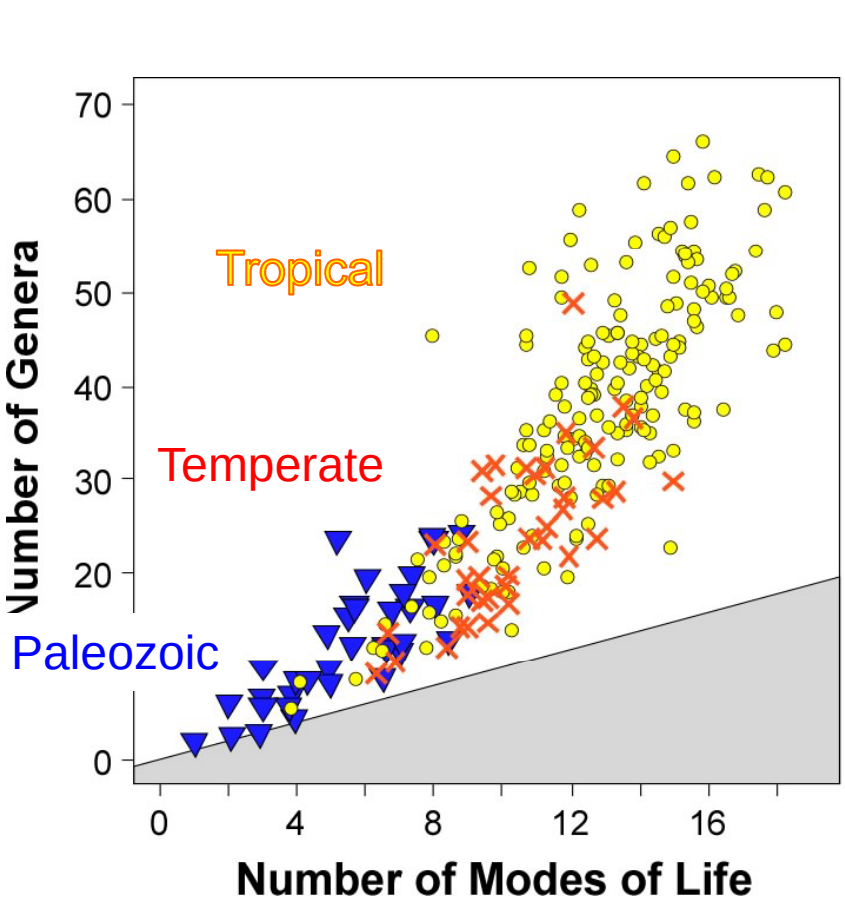


Ecospace Use has Changed

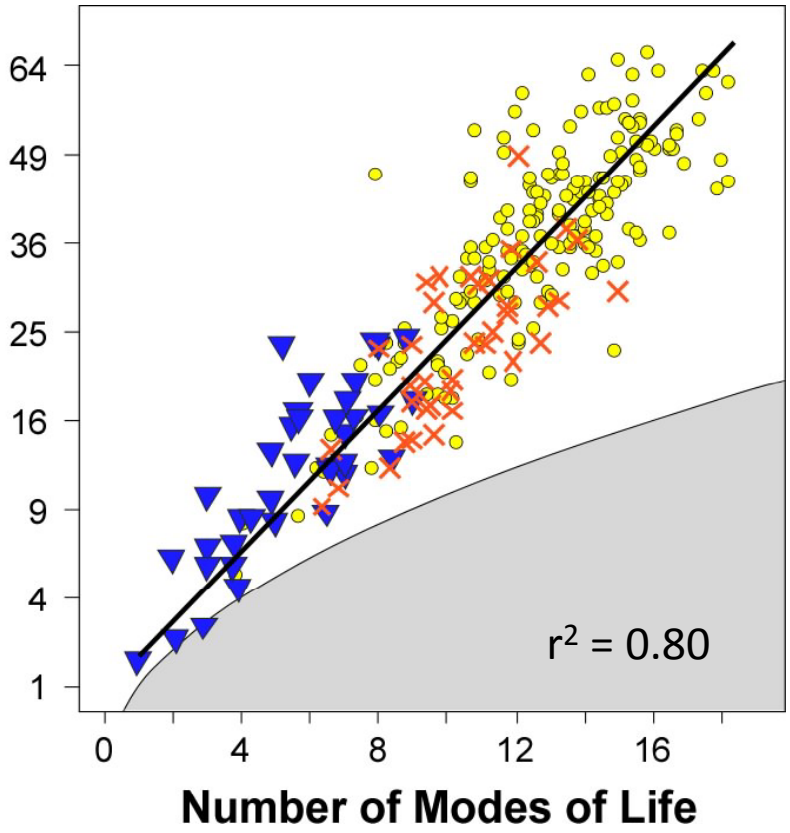


Bush et al. (2007)

Genera vs. Modes of Life in Fossil Assemblages

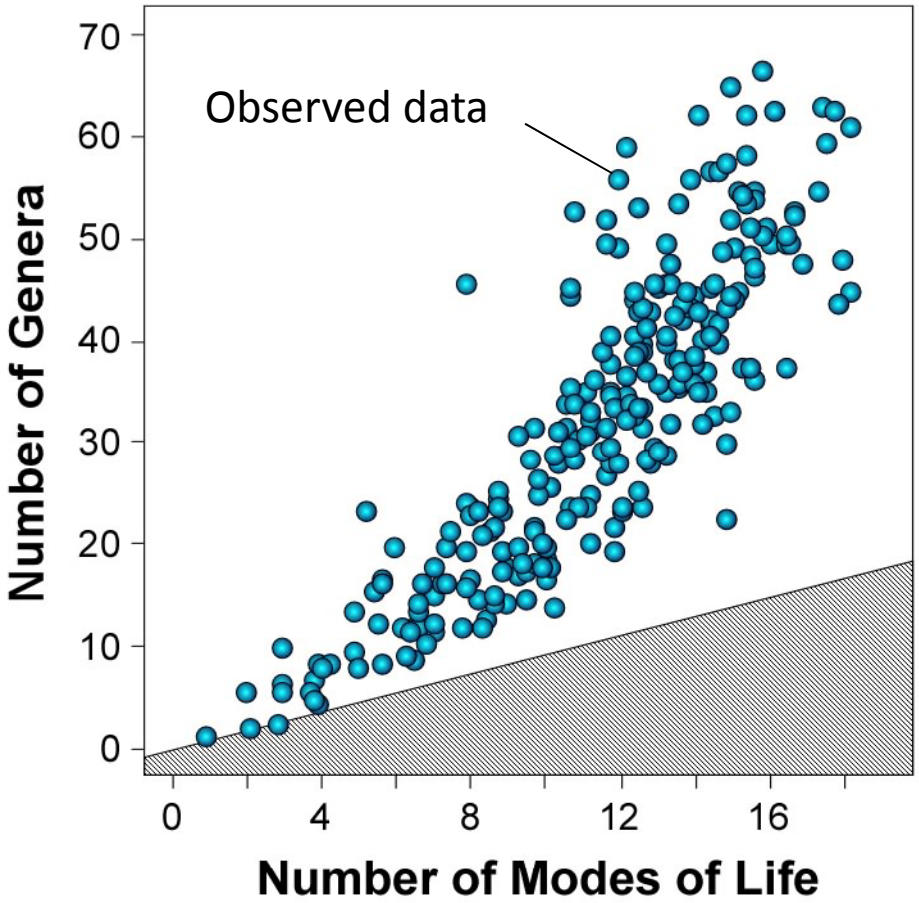


Genera on square-root scale



Bush et al. in preparation

Whence the correlation?



- For each collection, keep the same # of genera and abundances
- Randomly assign modes of life to genera without replacement
- Simulates random ecologic assembly of paleocommunities

Bush et al. in preparation

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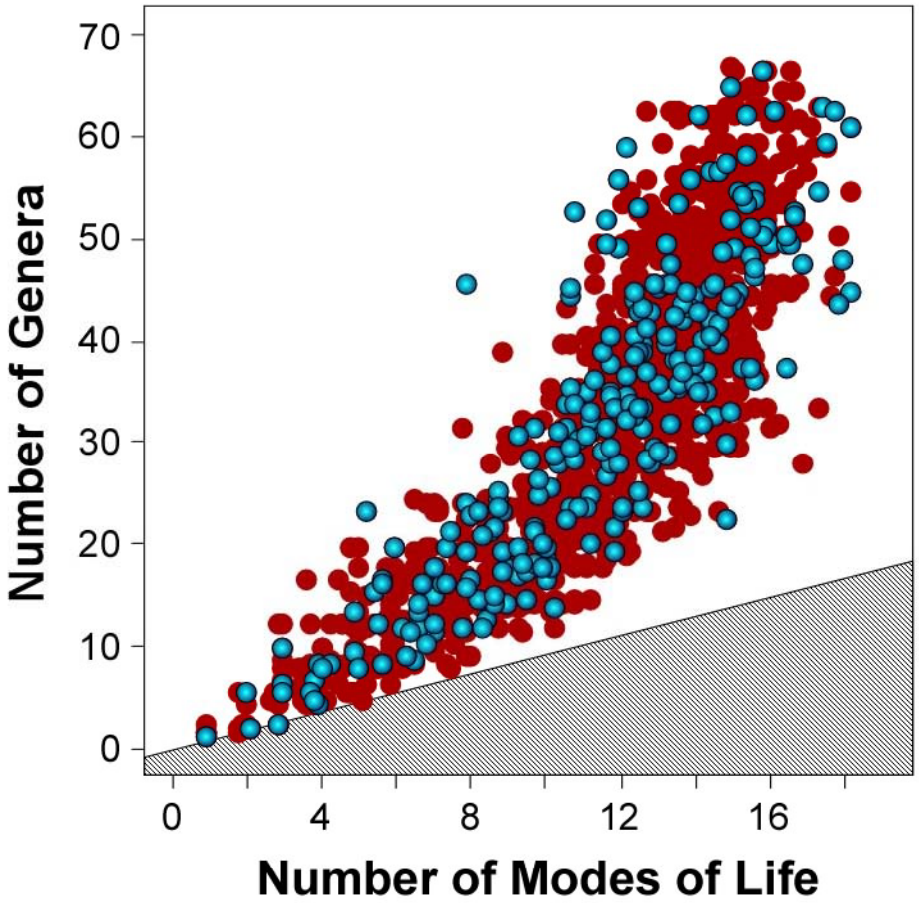

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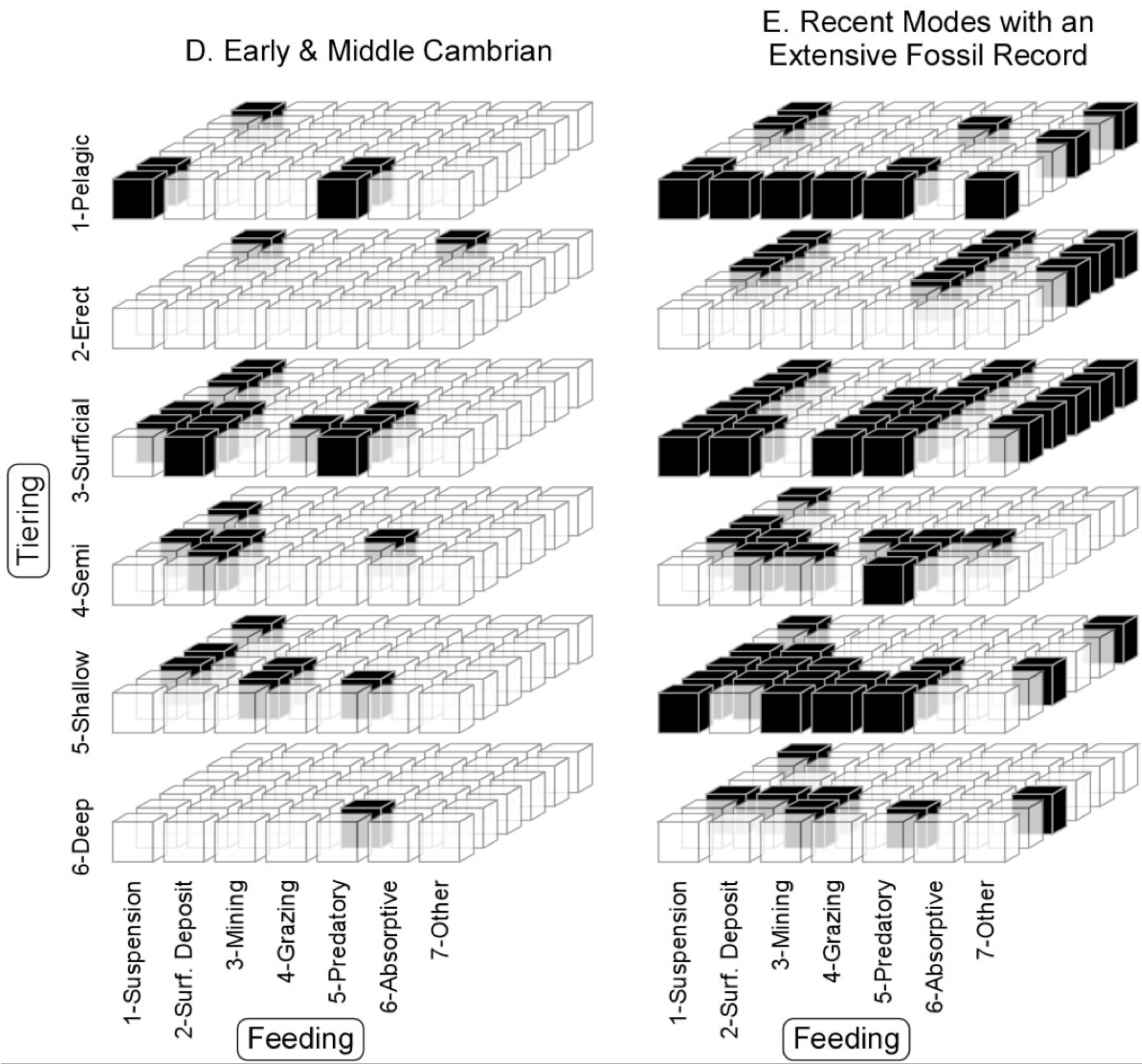
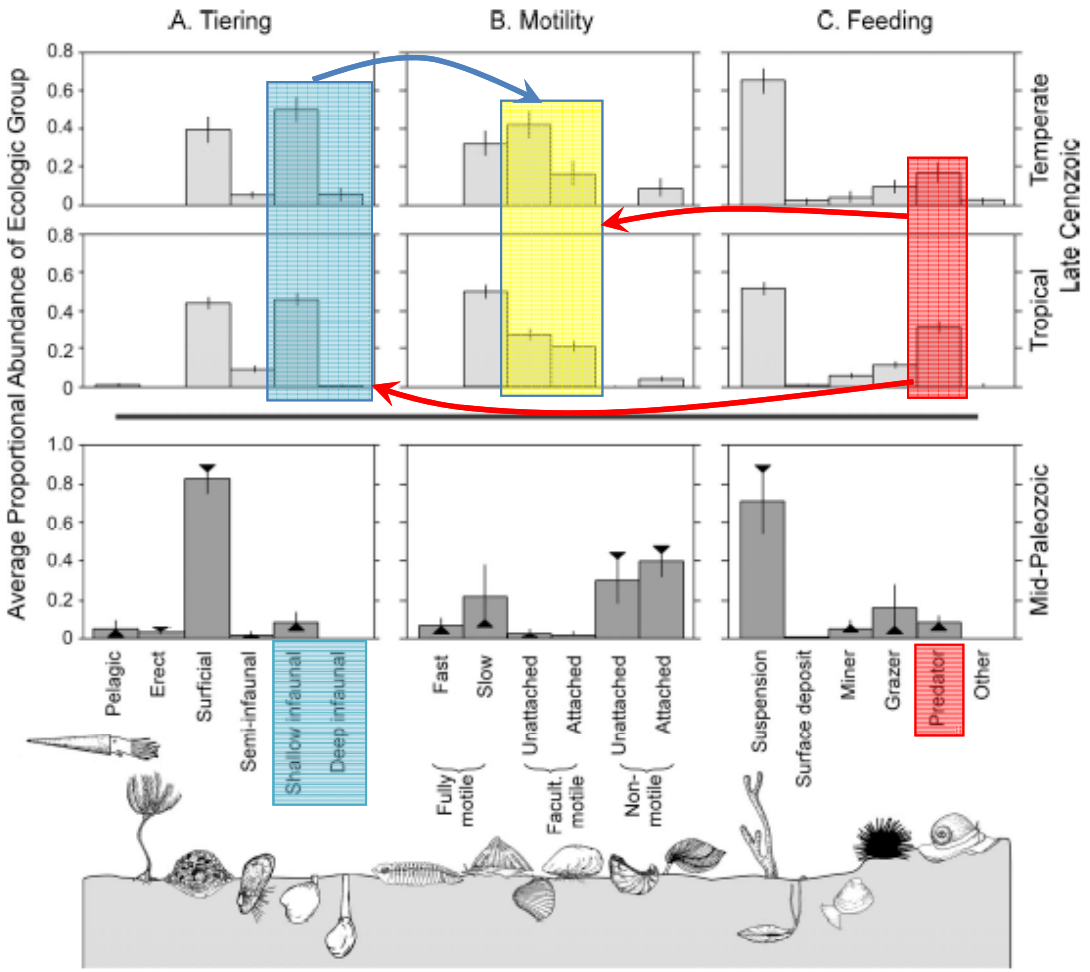
Bush et al. in preparation


D. Early & Middle Cambrian
E. Recent Modes with an Extensive Fossil Record
Tiering
1-Pelagic
2-Erect
3-Surficial
4-Semi
5-Shallow
6-Deep
1-Suspension
2-Surf. Deposit
3-Mining
4-Grazing
5-Predatory
6-Absorptive
7-Other
Feeding
1-Suspension
2-Surf. Deposit
3-Mining
4-Grazing
5-Predatory
6-Absorptive
7-Other
Feeding

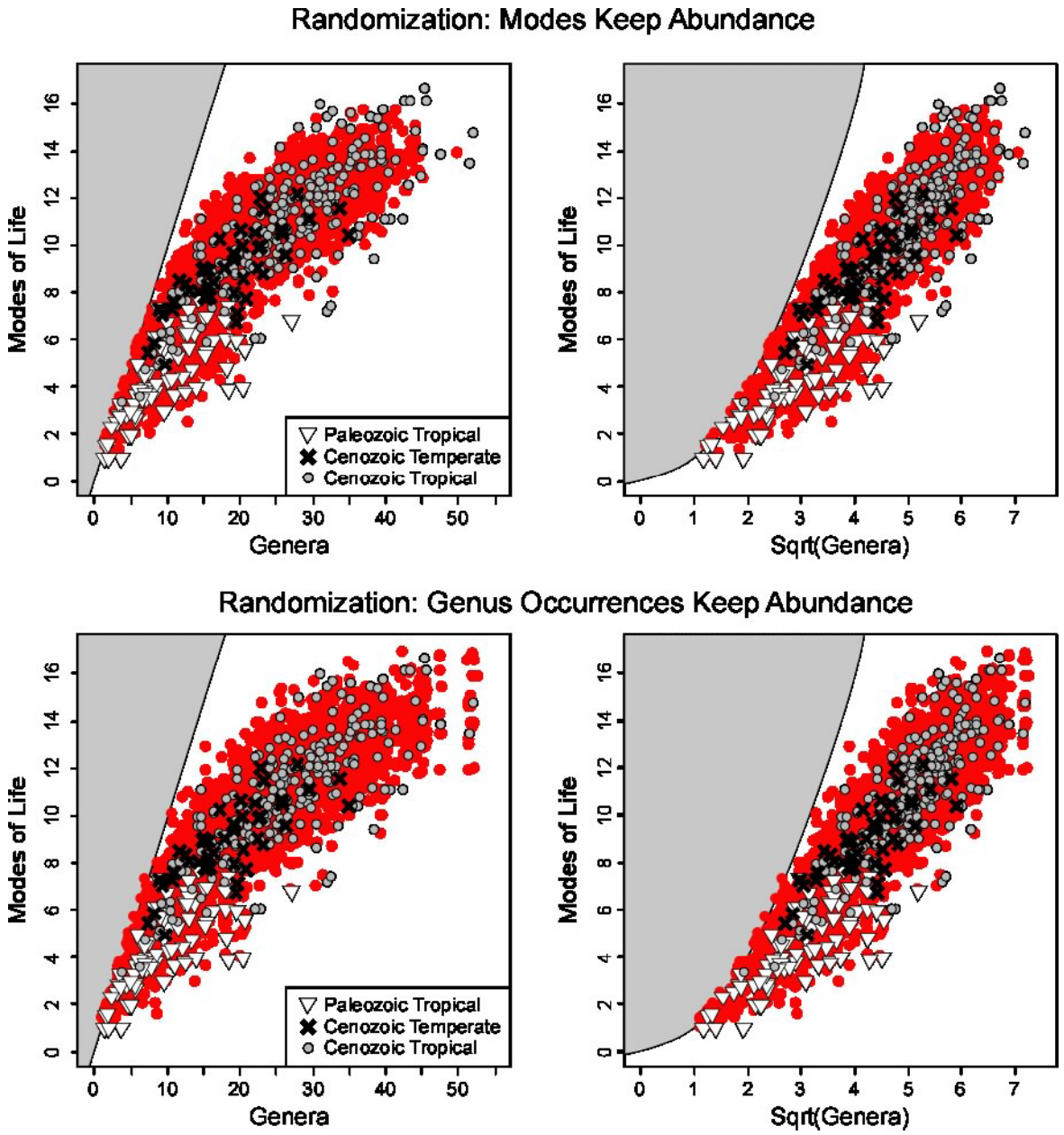
Active burrowing disturbs sediment, requiring disturbed organisms to reorient to function effectively

Many prey organisms tend to move away (flee) or burrow to avoid predators



Predators pursue prey into the sediment if need be

Increased needs have been generated by increased predation (need to escape) and increased infaunal activity (need to resist or recover from disturbance)


Randomization: Modes Keep Abundance
Modes of Life
Genera
Sqrt(Genera)
Paleozoic Tropical
Cenozoic Temperate
Cenozoic Tropical
Randomization: Genus Occurrences Keep Abundance
Modes of Life
Genera
Sqrt(Genera)
Paleozoic Tropical
Cenozoic Temperate
Cenozoic Tropical

Questions raised that will require further research:

What has been the actual course of change, the interval by interval pattern? Is it episodic or continuous?

Are there modifications in ecospace use at major events such as mass extinctions, major geochemical anomalies, climate shifts?

Are there biotic controls on local assemblage structure not visible with this rather coarse parsing of ecospace utilization?

FINI -- thank you for your attention --