

Why are there **so** many species
in the tropics?

Reading: Jurgen Haffer

Number of species



Diversification – *or* – Why are there so many species?

Lecture 16 Recap



James
Valentine



David Raup



James
Valentine

Diversification – *or* – Why are there so many species?

- Valentine postulated that this increasing trend in diversity was due to three main reasons
 1. Increasing specialization of species through time
 2. Increasing number of centers of endemism associated with intensifying latitudinal temperature gradients
 3. Fragmentation of shelf environments due to continental drift



James
Valentine

Diversification – *or* – Why are there so many species?

- Advocated for a **non-equilibrium** model of diversity
- This means that diversity was *not stable through time*, shifts between many higher taxonomic groups with a few generalist species to relatively few higher taxonomic groups with many specialized species



David Raup

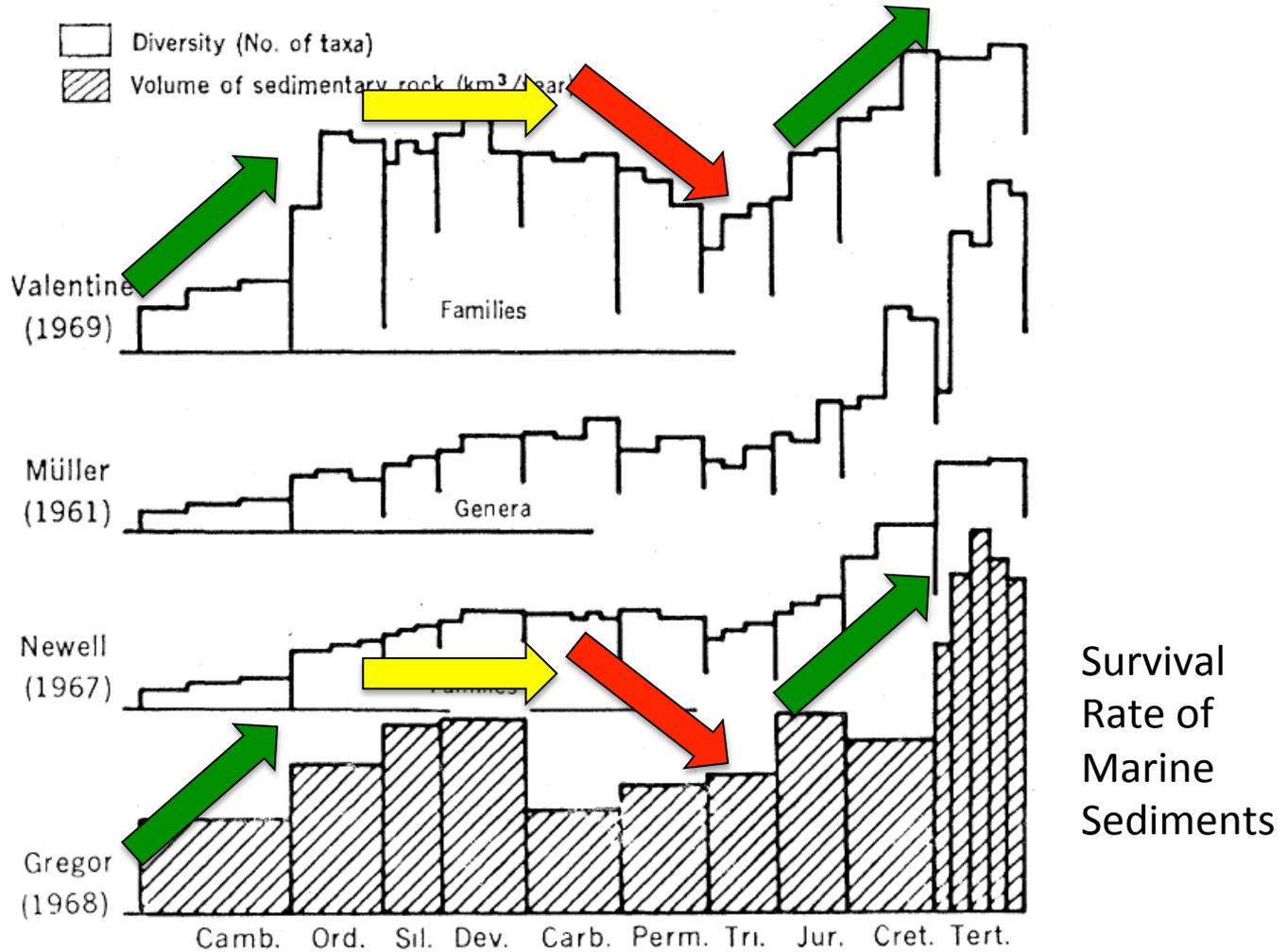
Diversification – *or* – Why are there so many species?

- *Taxonomic Diversity during the Phanerozoic*
- Directly refutes Valentine's methods and conclusions about non-equilibrium diversity
- Advocates for an **equilibrium** model of diversity where diversity changes but will fluctuate around a stable level through time



David Raup

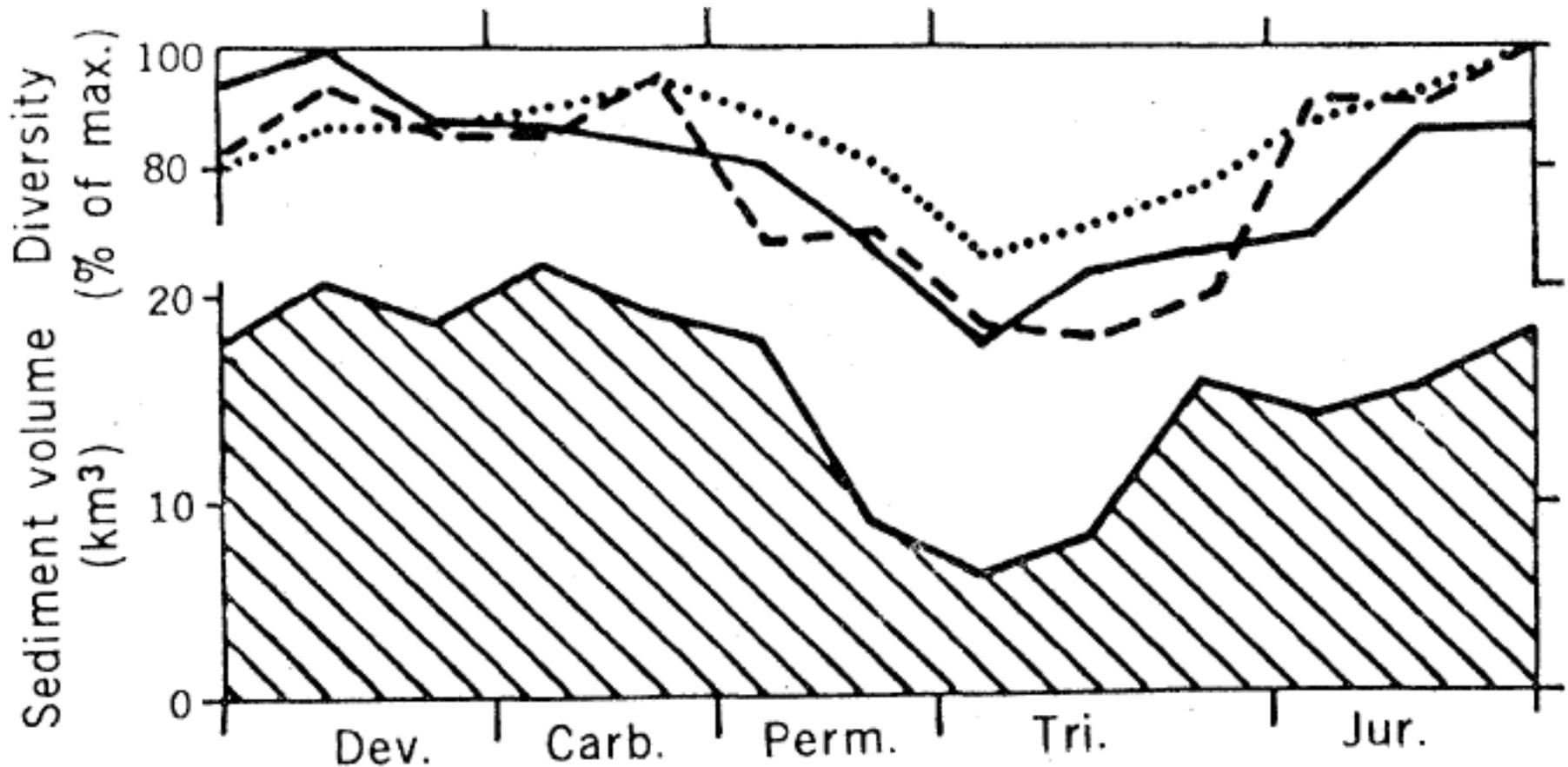
Diversification – or – Why are there so many species?





David Raup

Diversification – or – Why are there so many species?

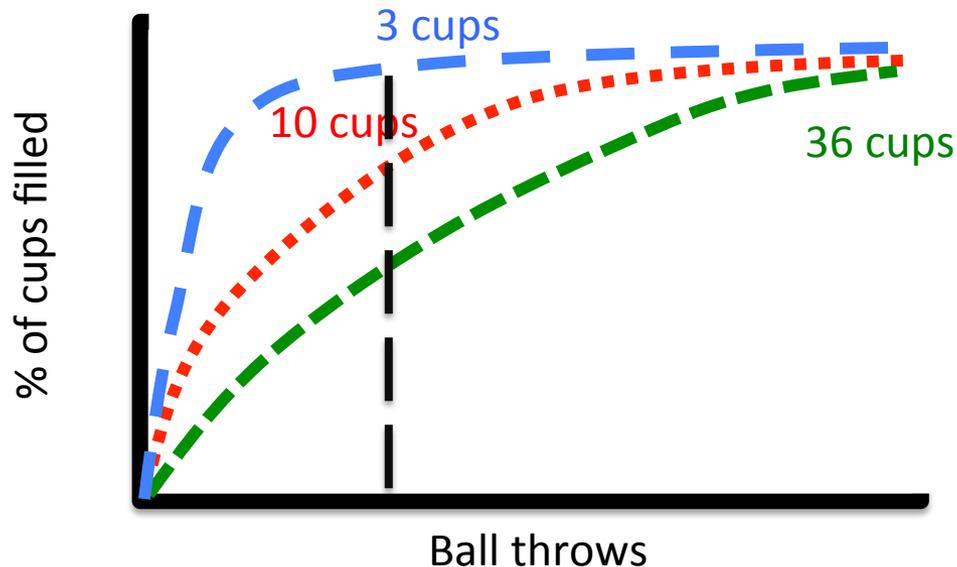




David Raup

Diversification – *or* – Why are there so many species?

- At any given number of geographic areas studied you will tend to find a higher proportion of higher taxonomic ranks than lower taxonomic ranks





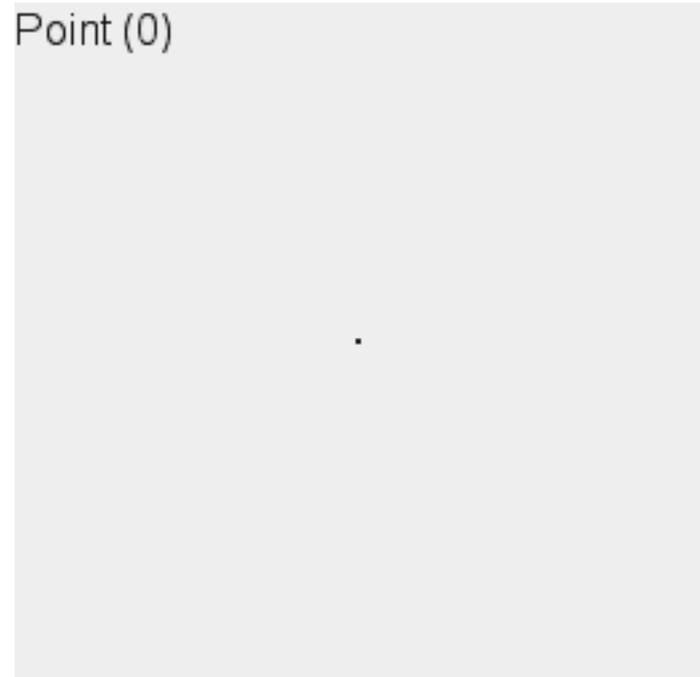
David Raup

Diversification – *or* – Why are there so many species?

- Raup advocated that Valentine's non-equilibrium model could be initial period of diversity and overshoot followed by a decline to an equilibrium state
- The diversity trends were simply artifacts of the temporal biases and sediment volumes of the raw data

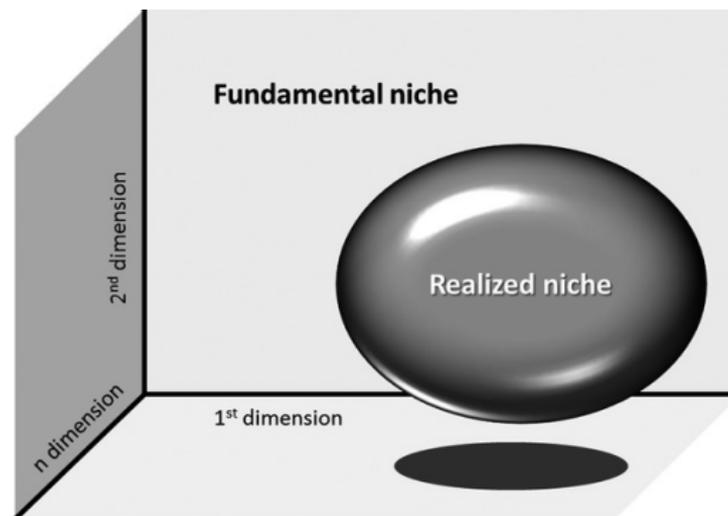
Diversification – *or* – Why are there so many species?

- We observe our surroundings in three dimensions
- But it is important to realize that these spatial dimensions are not what define the universe



Diversification – *or* – Why are there so many species?

- We can extend this thought away from physics and into biogeography
- All species live in physical (geographical space) and niche space (geographical space + ecological space)





Theodosius
Dobzhansky

Diversification – or – Why are there so many species?

- *“The diversity of organisms which live in a given territory is a function of the variety of available habitats. The richer and more diversified the environment becomes, the greater should be the multiformity of the inhabitants. And vice versa: diversity of the inhabitants signifies that the environment is rich in adaptive opportunities.”*

-Dobzhansky



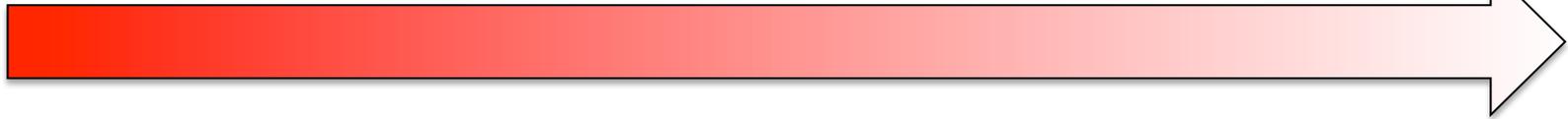
Alexander von Humboldt

Diversification – or – Why are there so many species?

Plant Associations

High

Low



Boreal Forest

Tropical Forest





Theodosius
Dobzhansky

Diversification – or – Why are there so many species?

- *“The greater the diversity of inhabitants in a territory, the more adaptive opportunities exist in it. A tropical forest with its numerous tree species supports many species of insects, each feeding on a single or on several species of plants. On the other hand, the greater the number of competing species in a territory, the fewer become the habitats open for occupancy by each of these species. In the absence of competition a species tends to fill all the habitats that it can make use of abundant opportunity favors adaptive versatility. When competing species are present, each of them is forced to withdraw to those habitats for which it is best adapted and in which it has a net advantage in survival...”*



Theodosius
Dobzhansky

Diversification – or – Why are there so many species?

- *“The presence of many competitors, in biological evolution as well as in human affairs, can be met most successfully by specialization. The diversity of habitats and the diversity of inhabitants which are so characteristic of tropical environments are conflicting forces, the interaction of which will determine the evolutionary fates of tropical organisms.”*

-Dobzhansky



Theodosius
Dobzhansky

Diversification – or – Why are there so many species?

- *“Any organism which lives in a temperate or a cold climate is exposed at different periods of its life cycle or in different generations to sharply different environments. The evolutionary implications of nature's annually recurrent drama of life, death, and resurrection have not been sufficiently appreciated. In order to survive and reproduce, any species must be at least tolerably well adapted to every one of the environments which it regularly meets. No matter how favored a strain may be in summer, it will be eliminated if it is unable to survive winters, and vice versa. Faced with the need of being adapted to diverse environments, the organism may be unable to attain maximum efficiency in any one of them. Changeable environments put the highest premium on versatility rather than on perfection in adaptation.”*

-Dobzhansky



Theodosius
Dobzhansky

Diversification – *or* – Why are there so many species?

- All of these quotes come from a great paper called *Evolution in the Tropics* (posted on the website)
- Dobzhansky viewed the stability of the tropical climate as one of the main drivers of diversification
- Under a stable climate, there is time for mutualism, parasitism and other complex coevolved relationships to emerge (also sympatric speciation)



Jürgen Haffer

Diversification – *or* – Why are there so many species?

- *Speciation in Amazonian Forest Birds*
- Haffer presented a possible mechanism for speciation in Amazonian birds through an allopatric process
- Proposed that speciation was due to several dry periods of the Pleistocene that broke the Amazon rainforest into many smaller forests separated by open, non-forest vegetation



Jürgen Haffer

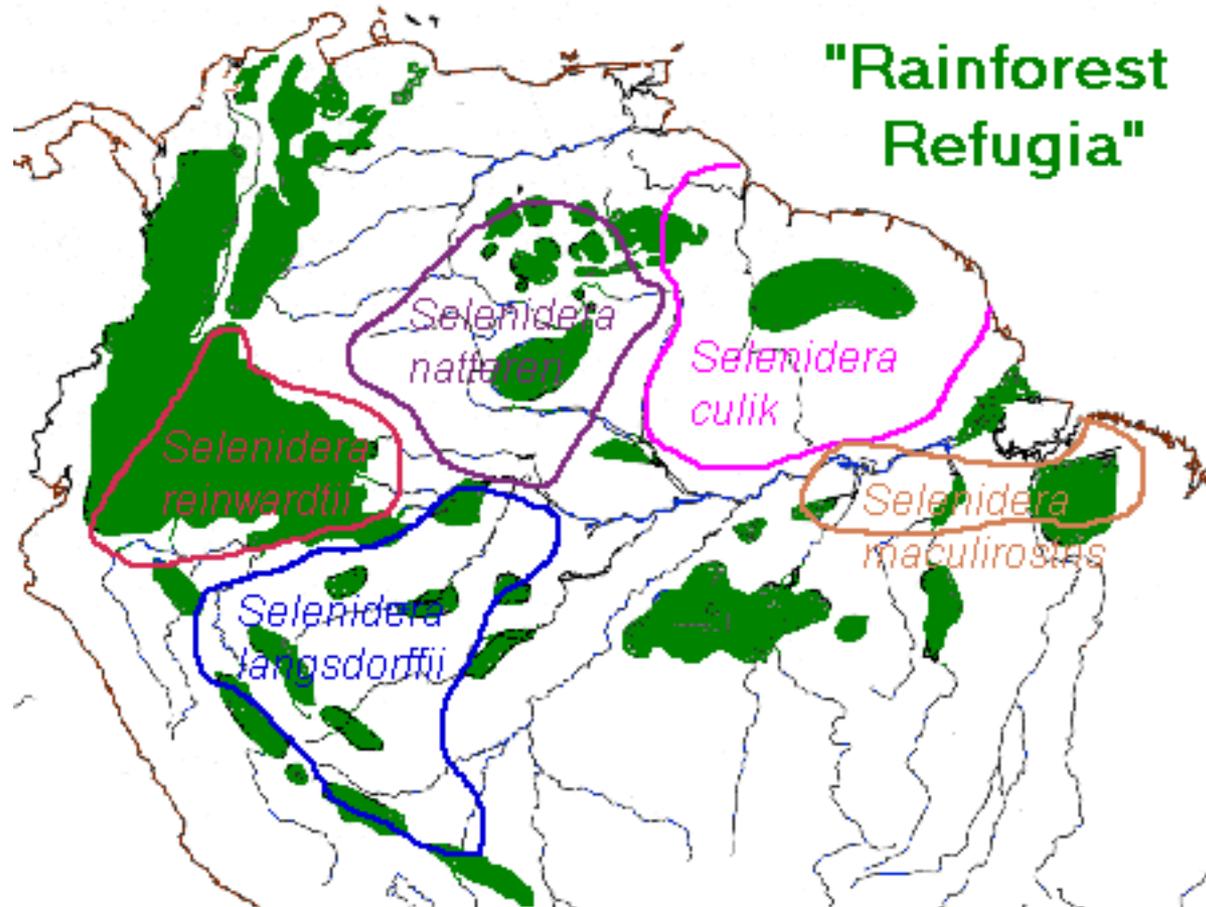
Diversification – or – Why are there so many species?

1. *Known climate fluctuations during the Pleistocene*
2. *Reconstruction of rainforest refugia*
 - *Rainfall patterns*
 - *Current bird distributions (endemic & close habitat associations)*
3. *Bird speciation processes can be quick 20-30 k years*



Jürgen Haffer

Diversification – or – Why are there so many species?



Haffer, J. 1969. Speciation in Amazonian forest birds. *Science* 165: 131-137.



Jürgen Haffer

Diversification – *or* – Why are there so many species?

- Stimulated a number of studies debating the number, location, and extent of rainforest refugia
- Current evidence shows most of the speciation events occurred in the late Pliocene, before the climatic shifts of the Pleistocene
- However, we know far more about the speciation in the tropics thanks to Haffer's hypothesis



Jürgen Haffer

Diversification – *or* – Why are there so many species?

Main Points

- Great debate on whether the diversity of the tropics is because of its stable climate, thus allowing for intricate and complex interactions and the filling of small niche spaces due to competitive exclusion
- Or, due to allopatric speciation due to climatic changes in the past
- Current state of the science places a strong emphasis on sympatric and parapatric speciation in the tropics

Questions on the reading?