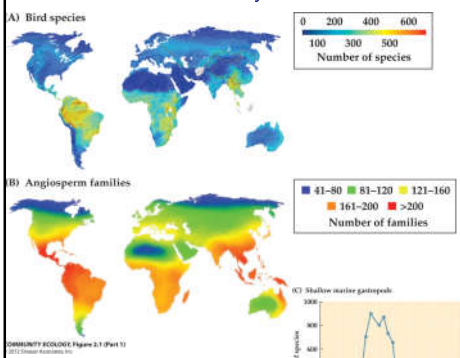
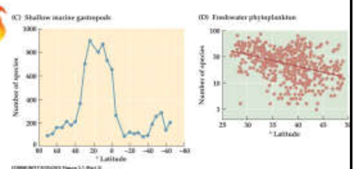
Global Patterns in Diversity





Latitudinal Trends in diversity.

Consistent across groups.

Pattern or process?

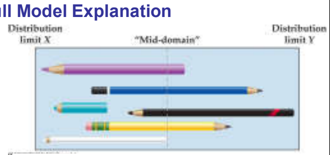
Explanation?

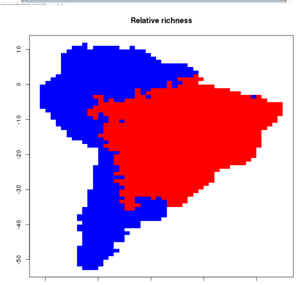
Species Diversity and Latitude

- Potential Explanations
  - Null model
  - Ecological – habitat stability, energetics
  - History – time and area
  - Evolutionary – rates of diversification

Species Diversity and Latitude - Null Model Explanation

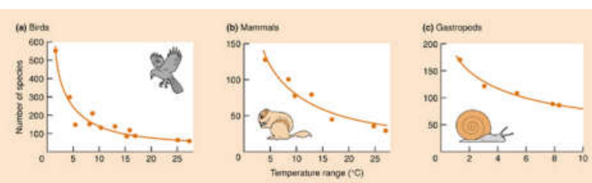
- What are “null models”?
  - Pattern generating model based on randomization of ecological data.
- **Mid-domain effect** – placing species on the globe at random will produce a latitudinal diversity gradient.
- Overall, poor explanatory power. Improves when combined with other explanations.





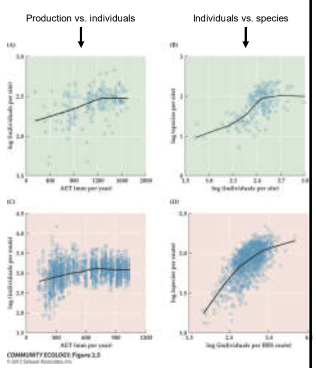
Environmental Stability

- Non-seasonal environment → greater specialization might yield greater diversity
- Seasonal environment → changing climate may facilitate temporal segregation
- General trend of greater diversity in non-seasonal environments, difficult to isolate environmental stability from other mechanisms.
- Exceptions and Caveats
  - seasonality is more than temperature (e.g. wet-dry season in temperature-stable tropical systems)
  - low diversity in some non-seasonal habitats (e.g. tropical mountains)



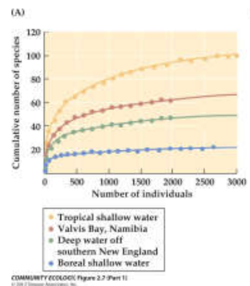
Species Diversity and Latitude – Energy Available

- **Species Energy Hypothesis**
  - Greater energy input results in increased productivity to support more individuals that diversify into more species.
  - Lower latitudes are at or near physiological optima for greater proportion of time, maximizing energy invested in production as opposed to tolerance.
  - Support for more trophic levels, greater diversity within levels



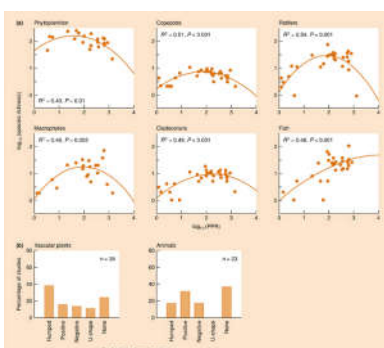
Species Diversity and Latitude – Energy Available

- The number of species per number of individuals increases with temperature (exacerbating latitude-diversity trends)
  - **Species-individual curves**
- Appears that the minimum population size is smaller at warmer temperatures
  - Individuals can allocate more energy to reproduction



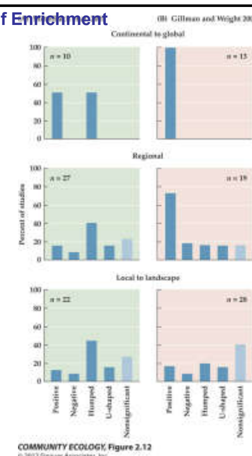
Species Diversity and Latitude - Paradox of Enrichment

- For some communities, at some scales, relationship between productivity and diversity is more complex.
- Low productivity → resources rare, intense competition or insufficient energy.
- High productivity → rapid competitive exclusion.
- Intermediate productivity maximizes diversity.



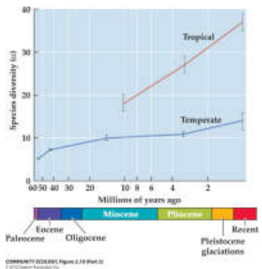
Species Diversity and Latitude - Paradox of Enrichment

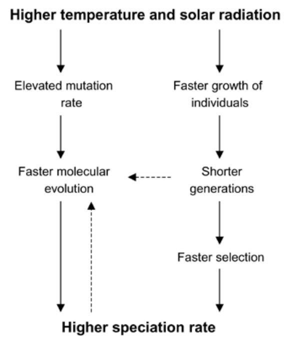
- Overall, this tends to depend on **scale**.
- At larger scales (continental or regional) there appears to be a positive relationship.
- At local scales, hump-shaped distributions tend to dominate.



Species Diversity and Latitude – Diversification Rates

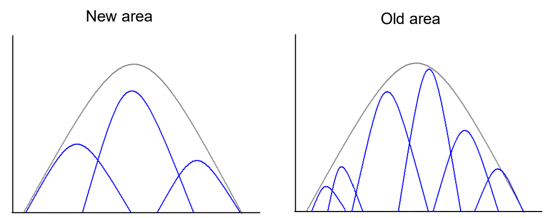
- **Evolutionary Speed Hypothesis**
  - Lower latitudes feature habitats allowing:
    - Faster physiological processes (growth)
    - Faster generation times
    - Greater mutation rates





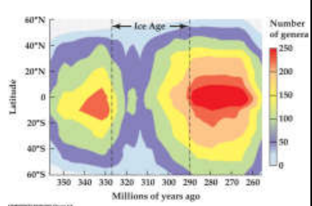
Species Diversity and Latitude – Time and Area

- **Evolutionary Time Hypothesis** - the older a community the greater the opportunity for it to have accumulated species through speciation and/or emigration



Species Diversity and Latitude – Time and Area

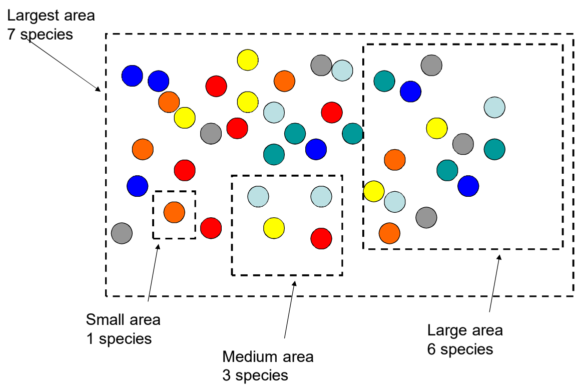
- Large scale disturbances (e.g. ice age) can lead to mass extinction.
- Diversity-latitude trend persists through disturbance
- Areas that are less often disturbed expected to accumulate more species.



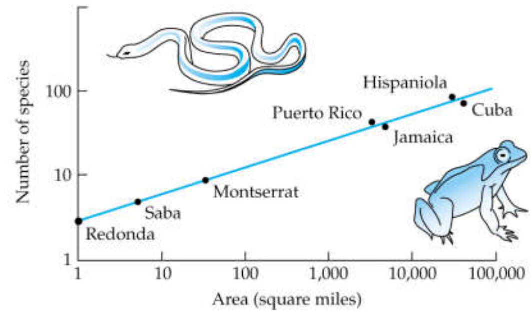
Species Diversity and Latitude

- **Geographic Area Hypothesis** – the shape of the globe results in greater area at the equator. Simple **species-area relationship** results in lower diversity at higher latitudes

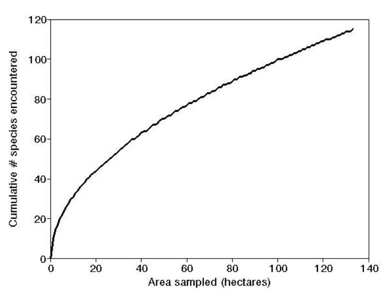
Species Area Relationship



Species Area Relationship on Islands



Species Area Relationship – power law



$$S = Cz^{A}$$

Where:
S=# species
C=ecosystem constant
Z=slope, # species added per unit area
A=area

- *z* values for various ecosystems
- Lower numbers = shallower slopes = greater isolation

$$S = Cz^{A}$$

Table 21.1 Values of the slope *z*, of species–area curves ($\log S = \log C + z \log A$, where *S* is species richness, *A* is area and *C* is a constant giving the number of species when *A* has a value of 1), for arbitrary areas of mainland, oceanic islands and habitat islands. (After Preston, 1962; May, 1975b; Gorman, 1979; Browne, 1981; Matter *et al.*, 2002; Barrett *et al.*, 2003; Storch *et al.*, 2003.)

Taxonomic group	*Location*	*z*
Arbitrary areas of mainland		
Birds	Central Europe	0.09
Flowering plants	England	0.10
Birds	Neoarctic	0.12
Savanna vegetation	Brazil	0.14
Land plants	Britain	0.16
Birds	Neotropics	0.16
Oceanic islands		
Birds	New Zealand islands	0.18
Lizards	Californian islands	0.20
Birds	West Indies	0.24
Birds	East Indies	0.28
Birds	East Central Pacific	0.30
Ants	Melanesia	0.30
Land plants	Galápagos	0.31
Beetles	West Indies	0.34
Mammals	Scandinavian islands	0.35
Habitat islands		
Zooplankton (lakes)	New York State	0.17
Snails (lakes)	New York State	0.23
Fish (lakes)	New York State	0.24
Birds (Paramo vegetation)	Andes	0.29
Mammals (mountains)	Great Basin, USA	0.43
Terrestrial invertebrates (caves)	West Virginia	0.72