History of the # of species

From the fossil record, particularly in shallow marine deposits, one can infer

# of species as a function of time

Characteristic episodes of major extinctions

Most dramatic at the end of the Permian 248 million years ago

96% of marine animal species became extinct

Longevity of a typical species in a marine environment

⇒ 1-10 million years

New species appear other species become extinct
Extinctions in terms of # of families

Note: doesn't look as dramatic as the number of species
Area-Species relationship

An empirical relationship exists between the # of related species and the area on which they live.

Comparison must be between ecologically similar areas.

One finds: within clusters of ecologically similar islands
# of species of birds (ants, reptiles, .) is proportional to the area of the island
to some power $z$ with $0.15 < z < 0.35$

# of species in area $= S = \text{constant} \times (\text{area})^z$
# of species in area = \( S = \text{constant} \times (\text{area})^z \)

**Meaning:** if for an area \( A \) the number of species is known as well as \( z \) (and of course the area) then one can predict for an ecologically similar area \( B \) the # of species in \( B \)!

So we know: \( S_A \), area of \( A \), and \( z \) (assume \( z = 0.3 \)) and also area of \( B \)

**Numerical examples:**
area \( B \) = area \( A \) x 2 then

\[
S_B = \text{constant} \times (\text{area } B)^z = \text{constant} \times (2 \times \text{area } A)^z
\]

\[
= \text{constant} \times (\text{area } A)^z \times 2^z = 2^z S_A = 1.23 \times S_A
\]
## More numbers

<table>
<thead>
<tr>
<th>Area</th>
<th>factor</th>
<th>change</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 x original</td>
<td>1.23</td>
<td>23% increase</td>
</tr>
<tr>
<td>10 x</td>
<td>2.0</td>
<td>100% increase</td>
</tr>
<tr>
<td>0.5 x</td>
<td>0.81</td>
<td>19% decrease</td>
</tr>
<tr>
<td>0.1 x</td>
<td>0.50</td>
<td>50% decrease</td>
</tr>
</tbody>
</table>

Implication?
Area-Species relationship

$z = 0.3$ works for reptiles here.

If island area is 4000 times larger then the number of species increases by a factor: $4000^{0.3} = 12$

log-log plot

⇒ straight line
Tropical rainforest

Attention is focused on the tropical rainforest.

Why?

- Although they cover only 7% of the Earth's land surface, they contain at least 50% of all the species.
- These forests are being destroyed so rapidly that they may mostly disappear within the coming century.

At what rate is the rainforest disappearing?

- Early 1980s ⇒ rainforest down to 60% of its original cover removal at a rate of 75 000 km²/year ⇒ 1%
- 1989 ⇒ rate up to 142 000 km²/year

Corresponds to the size of the contiguous 48 states left with half the size of Florida disappearing every year.
Amazon rainforest

Percentage loss between 1960 and 1990 of tropical forest
Why is the rainforest disappearing and what influences the rate?

Estimates suggest:

- 60% due to subsistence agriculture (people have to survive)
- 21% due to commercial logging
- 12% due to cattle ranching (for fast-food beef)

Situation is expected to deteriorate further

Example: Madagascar has lost 93% of its original forest cover

Rate depends on:
- # of people that need to survive
- how many beef patties are sold in the US
- how much wood from rainforest is imported ...
Satellite image (NASA) of deforestation in the Amazon region (1986).

The pattern of deforestation spreading along roads is obvious in lower half of image.
Deforestation and the Global Carbon Cycle

Plants and soil of the tropical forests hold 460-575 billion metric tons of carbon worldwide with each acre of tropical forest storing about 180 metric tons of carbon.

When a forest is cut and burned to establish cropland and pastures, the carbon that was stored in the tree trunks (wood is about 50% carbon) joins with oxygen and is released into the atmosphere as CO$_2$.

This loss has a profound effect on the global carbon cycle:

¥ From 1850 to 1990, deforestation worldwide (including the US) released 122 billion metric tons of C into the atmosphere, with the current rate approximately 1.6 billion metric tons per year.

¥ Fossil fuel burning releases about 6 billion metric tons per year.

¥ So deforestation makes a significant contribution to increasing CO$_2$ in the atmosphere.
Estimate of Biodiversity loss (Wilson)

¥Use area-species relationship
¥Assume 1.8% loss of forest per year so area decreases to
0.982 x original area
¥Assume $z = 0.3$
¥Calculate $(0.982)^{0.3} = 0.9946$
¥This factor times the original number of species is the remaining number
¥Corresponds to 0.54% loss in the number of species
¥Should apply to those species which are narrowly localized in the forest
¥Assume 5 million species then 27 000 disappear per year
¥Thousands of times the normal rate (1 species per million species per yr)
¥Rate up by 1 000 to 10 000 times
¥Continue this for 50 years and one faces a 25% reduction

COMPARABLE TO THE OTHER MAJOR EXTINCTIONS THAT ARE DOCUMENTED IN THE FOSSIL RECORD

Biologists say: 6th Extinction is taking place right now!!