**Extinction**

“The worst thing that can happen during the 1980s is not energy depletion, economic collapse, limited nuclear war, or conquest by a totalitarian government. As terrible as these catastrophes would be for us, they can be repaired within a few generations. The one process ongoing in the 1980s that will take millions of years to correct is the loss of genetic and species diversity by the destruction of natural habitats. This is the folly that our descendants are least likely to forgive us.”

E.O. Wilson (1985)

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**Some context**

- Estimated that four billion species have evolved on Earth over last 3.5 billion years
- 99% of these are thought to be extinct
- So, is extinction natural?
- Does it vary uniformly through time?

Barnosky et al. (2011; Nature)

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**Family diversity over a long time**

About 1-2 new families added each million years

Fig. 2.5

---

**Mass extinctions**

Groups experiencing mass extinction

- Pleistocene: large mammals and birds
- Cretaceous: reptiles; many marine species including many foraminifera and mollusks
- Triassic: 35% of animal families, including many reptiles and marine mollusks
- Permian: 50% of animal families, including over 90% of marine species; many trees, amphibians, most bryozoans and brachiopods, all trilobites
- Devonian: 30% of animal families, including agnathans and placoderm fishes and many invertebrates
- Ordovician: 50% of animal families, including many trilobites

Bar width represents relative number of living groups

Also see Fig. 2.7

---

**Recorded extinctions since 1600**

<table>
<thead>
<tr>
<th>Taxon</th>
<th># Extinct</th>
<th>% of taxon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mammals</td>
<td>85</td>
<td>2.1</td>
</tr>
<tr>
<td>Birds</td>
<td>113</td>
<td>1.3</td>
</tr>
<tr>
<td>Reptiles</td>
<td>21</td>
<td>0.3</td>
</tr>
<tr>
<td>Amphibians</td>
<td>2</td>
<td>0.05</td>
</tr>
<tr>
<td>Fishes</td>
<td>23</td>
<td>0.1</td>
</tr>
<tr>
<td>Invertebrates</td>
<td>98</td>
<td>0.01</td>
</tr>
<tr>
<td>Angiosperms</td>
<td>384</td>
<td>0.2</td>
</tr>
</tbody>
</table>

= 726 Reid and Miller (1989)

IUCN estimates 915 species to be extinct using their methods
Taxonomic bias?

Clark and May (2002)

Trying to remove the bias

A focus on threats in well-studied regions

McKinney (1999)

Another area of concern

Background extinction rates (1)

• NOT = mass extinctions
• How do you calculate something over such long time scales?
• Often use fossil record to estimate extinctions per million species years, = \( E/\text{MSY} \)
  - Sample calculation:
    - 1 extinction per 10,000 spp. per 100 years = 1 \( E/\text{MSY} \)
    - \( 1 \text{ extinction} / 10,000 \text{ spp} / 100 \text{ yr} = 0.000001 \ E / \text{species year} \)
    - \( 0.000001 \ E / \text{SY} \times 1 \text{ million years} = 1 \ E/\text{MSY} \)
    - Or, if there are 1 million species on the planet expect 1 extinction each year if =1 \( E/\text{MSY} \)

Background extinction rates (2)

• Some data from the fossil record:
  • Mostly marine fauna:
    - 0.1 to 1 \( E/\text{MSY} \)
    - (Ceballos et al. 2015)
  • Mammals:
    - 1.8 \( E/\text{MSY} \)
    - (Barnosky et al. 2011)

And a segue...

Current extinction rates

Table 2. Estimates of extinction rate for various taxonomic groups.

<table>
<thead>
<tr>
<th>Taxonomic group</th>
<th>Estimate (E/MSY)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertebrates</td>
<td>0.1</td>
<td>(Ceballos et al. 2015)</td>
</tr>
<tr>
<td>Fish</td>
<td>0.01</td>
<td>(Lamkin &amp; Miller 2016; BioScience)</td>
</tr>
<tr>
<td>Amphibians</td>
<td>0.001</td>
<td>(Lamkin &amp; Miller 2016; BioScience)</td>
</tr>
<tr>
<td>Reptiles</td>
<td>1</td>
<td>(Lamkin &amp; Miller 2016; BioScience)</td>
</tr>
<tr>
<td>Mammals</td>
<td>0.1</td>
<td>(Lamkin &amp; Miller 2016; BioScience)</td>
</tr>
<tr>
<td>Birds</td>
<td>0.025</td>
<td>(Lamkin &amp; Miller 2016; BioScience)</td>
</tr>
<tr>
<td>Invertebrates</td>
<td>0.001</td>
<td>(Lamkin &amp; Miller 2016; BioScience)</td>
</tr>
</tbody>
</table>

Note: Contemporary extinctions from 1300 through publication year unless otherwise noted. Background rate of comparison may be slightly higher in lower than 1 extinction per million species years (E/MSY).
A new mass extinction? The Anthropocene?

Barnosky et al. (2011; Nature)

Keeping track of vulnerable species

IUCN—The International Union for Conservation of Nature

DATA

IUCN categorization depends on data for at least one of the following:

- Observable reduction in abundance
- Total geographical area occupied by a species
- A predicted decline in abundance
- Number of mature individuals alive
- Probability of the species going extinct in certain number of years or generations

Compare species data to specific thresholds for each category

- e.g., Crit. End. if < 50 mature individuals

What will it take to convince geologists?

Science (2016)

Also see Lewis & Maslin (2015, Nature)

IUCN conservation categories

Hawaiian crow

The proportion of extant (i.e., excluding Extinct) species in The IUCN Red List of Threatened Species. Version 2019.3 assessed in each category for the more comprehensively assessed groups.

Box 3.2, Fig. A
Species characteristics & vulnerability (1)
- Very narrow geographical range
- Specialized niche requirements
- Only one or a few populations
- Population size is small
- Population size is declining

Species characteristics & vulnerability (2)
- Harvested or hunted by people
- Need a large home range
- Large body size

Species characteristics & vulnerability (3)
- Poor dispersers
- Seasonal migrants
- Little genetic variability
- "Pristine" environment
- Form aggregations
- No prior contact with people
- Related species are extinct/threatened

Extinction and climate change
- Thomas et al. (2004)

American crocodile example

From prediction to reality
- Wiens (2016)

Margaritifera margaritifera

Fig. 3.8

Proportion of spp threatened with extinction in the US

Percentage of species


Margaritifera margaritifera

Rabinowitz & rarity; see Table 3.5

Bachman’s warbler

Thomas et al. (2004)

American crocodile example

From prediction to reality

Wiens (2016)