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)

“The Passenger Pigeon was no mere bird, he was a biological storm”.

Aldo Leopold

Martha, the last passenger pigeon (1885 - 1914)
Died in captivity at the Cincinnati Zoo
Picture of study skin by Valerie Hartigan at Smithsonian

Some context

- 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?

Family diversity over a long time

About 1-2 new families added each million years

Mass extinctions

Groups experiencing mass extinction
- Pterosaurs: large mammals and birds
- Cretaceous: reptiles; many marine species including many foraminifers and mollusks
- Triassic: 33% 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 armadillos and placodont fishes and many tetrabranchs
- Ordovician: 30% of animal families, including many tetrabranchs

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>23</td>
<td>0.05</td>
</tr>
<tr>
<td>Fishes</td>
<td>98</td>
<td>0.1</td>
</tr>
<tr>
<td>Invertebrates</td>
<td>384</td>
<td>0.2</td>
</tr>
</tbody>
</table>

= 726
Reid and Miller (1989)
Taxonomic bias in conservation biology?

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
- NOT to be confused with mass extinctions
- How do you calculate something over such long time scales?
- Typically use fossil record to estimate extinctions per million species years, or E/MSY
  - Example:
    - 1 extinction per 10,000 spp. per 100 years = 1 E/MSY
    - Or, if there are 1 million species on the planet expect 1 extinction each year
- Background rates vary:
  - Mostly marine fauna: 0.1 to 1 E/MSY (Ceballos et al. 2015)
  - Mammals: 1.8 E/MSY (Barnosky et al. 2011)

Some variation in E/MSY

Barnosky et al. (2011; Nature)
Current extinction rates

Table 2. Elevation of "highly conservative" and "conservative" median net absolute extinction rates above background rates of 2.6 MY (see table S2 for calculation). For each assessment category, two periods are shown: extinction rates compared from 1300 to the present, and from 1900 to the present.

<table>
<thead>
<tr>
<th>Animal group</th>
<th>Highly conservative</th>
<th>Conservative</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Since 1300</td>
<td>Since 1900</td>
</tr>
<tr>
<td>Vertebrates</td>
<td>8</td>
<td>15</td>
</tr>
<tr>
<td>Mammals</td>
<td>14</td>
<td>28</td>
</tr>
<tr>
<td>Birds</td>
<td>12</td>
<td>24</td>
</tr>
<tr>
<td>Reptiles</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>Amphibians</td>
<td>5</td>
<td>22</td>
</tr>
<tr>
<td>Fishes</td>
<td>5</td>
<td>23</td>
</tr>
</tbody>
</table>

Ceballos et al. (2011; Science Advances)

A new mass extinction? The Anthropocene?

Barnosky et al. (2011; Nature)

What will it take to convince geologists?

The Anthropocene is functionally and stratigraphically distinct from the Holocene

Science (2016)

Keeping track of vulnerable species worldwide

- IUCN—The International Union for Conservation of Nature
- "The IUCN Red List of Threatened Species provides taxonomic, conservation status and distribution information on taxa that have been globally evaluated using the IUCN Red List Categories and Criteria. This system is designed to determine the relative risk of extinction, and the main purpose of the IUCN Red List is to catalogue and highlight those taxa that are facing a higher risk of global extinction (i.e., those listed as Critically Endangered, Endangered and Vulnerable)."

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
The proportion of extant (i.e., excluding Extinct) species in *The IUCN Red List of Threatened Species. Version 2013.2* assessed in each category for the more comprehensively assessed groups.

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