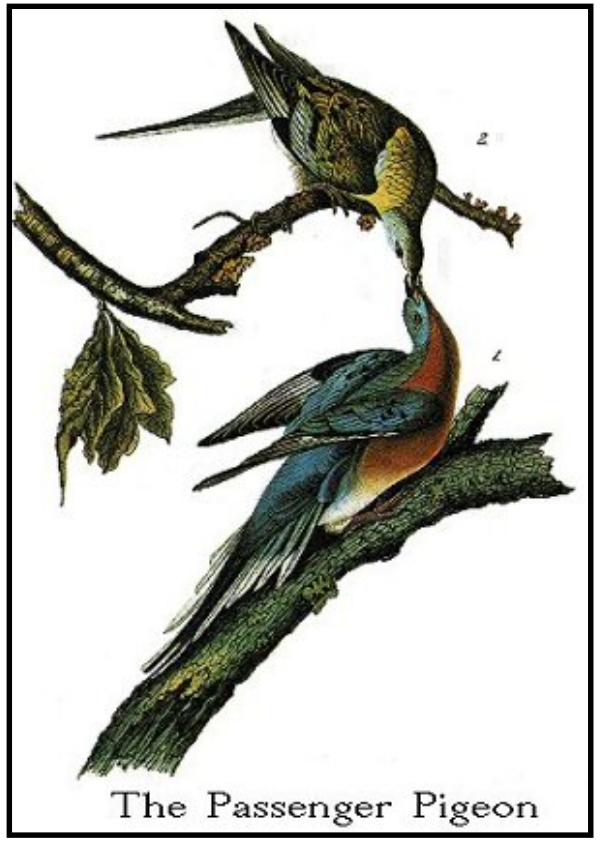
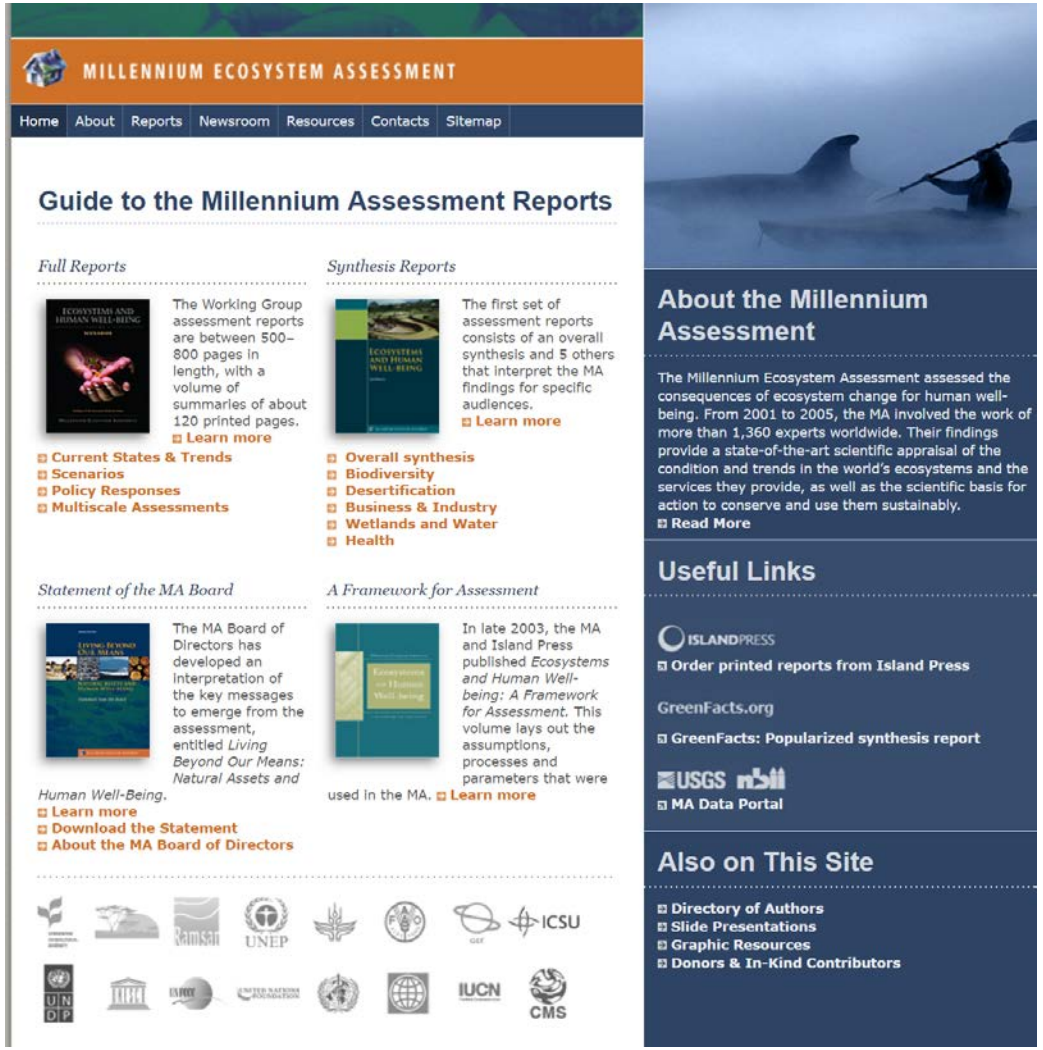
# Knowing the Hazards:
# Extinction and Loss of Ecosystem Services

Class 13

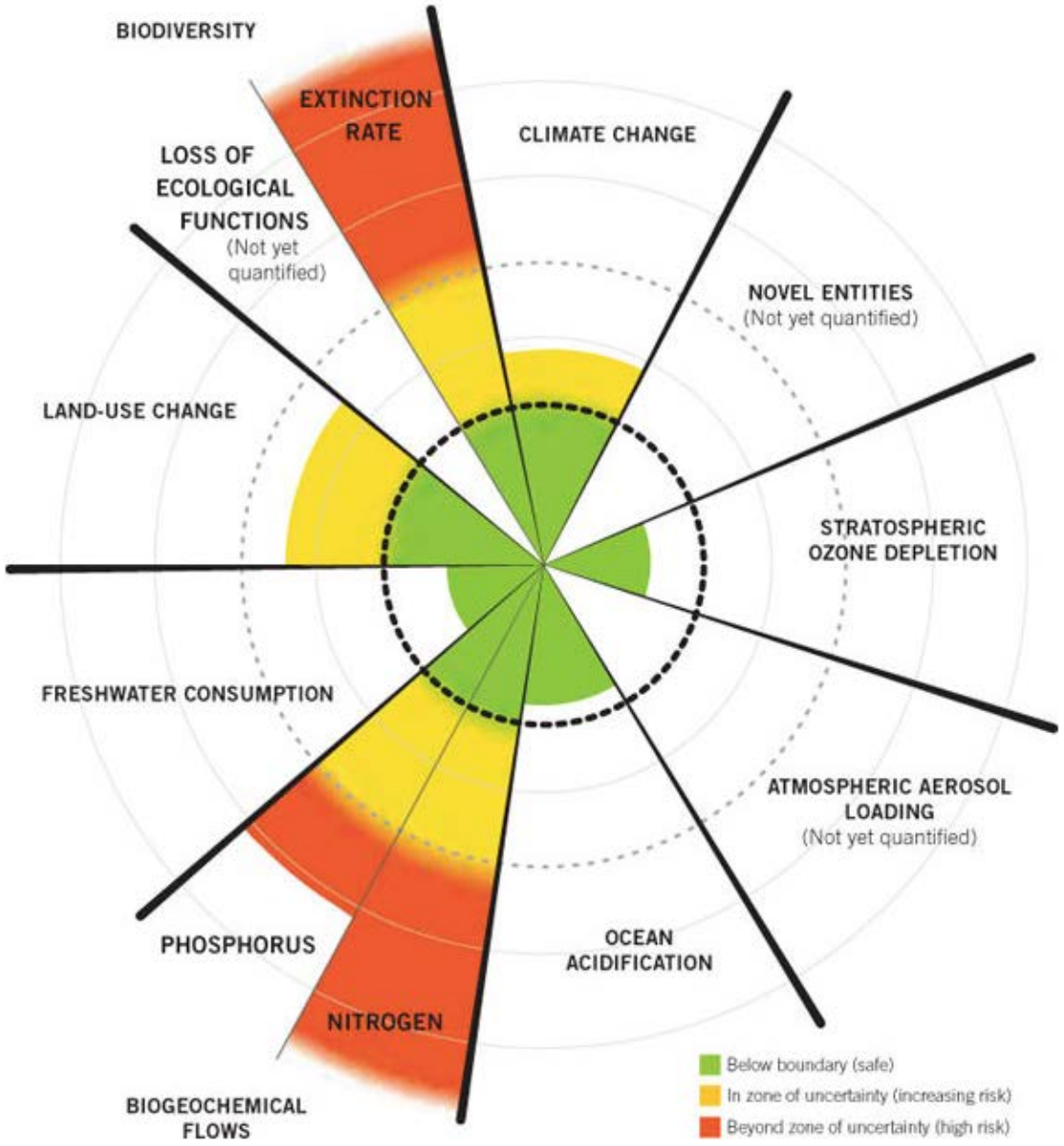


# Critical Ecosystem Services

1. Climate and Biogeochemical Cycles
2. Regulation of Hydrologic Cycle
3. Soils and Erosion
4. Biodiversity and Ecosystem Functions
5. Mobile Links
6. Balance of Diseases Transmission



# Leaving the "Safe Operating Space"

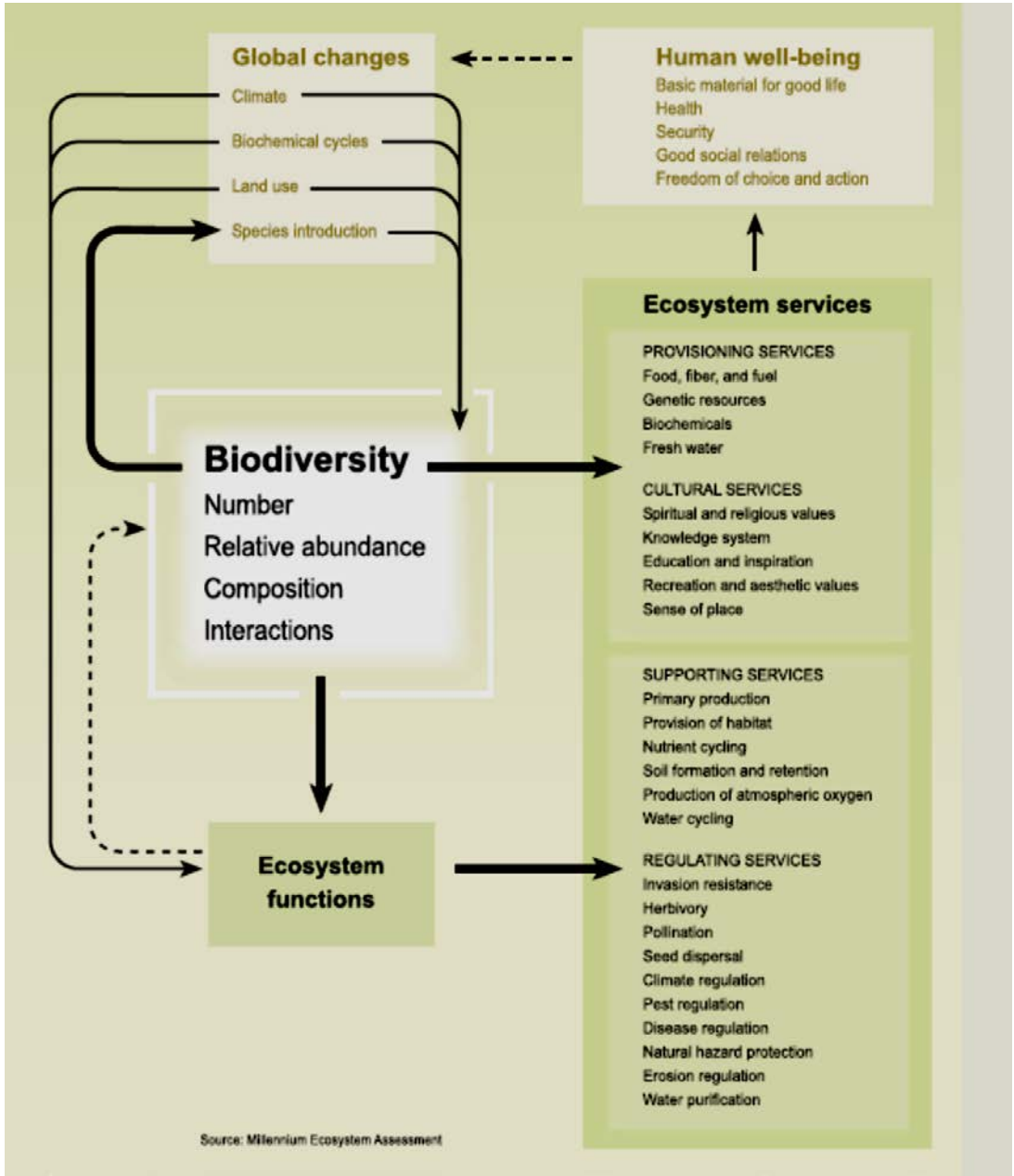


# Biodiversity and Ecosystem Function

- Increased biodiversity improves ecosystem functioning in plant communities (Naeem and Li 1997; Tilman 1997)→ different plant species capture different resources, leading to greater efficiency and higher productivity (Tilman et al. 1996).
- More biodiverse ecosystems are likely to be more stable and more efficient due to the presence of more pathways for energy flow and nutrient recycling.
- Diversity is thought to stabilize overall ecosystem functioning (Chapin et al. 2000; Tilman 1996) and make the ecosystem more resistant to perturbations (Pimm 1984).

# Interactions between Biodiversity, Ecosystem Services and Human

Biodiversity is both, a *response* variable affected by global change drivers and a *factor* modifying ecosystem processes & services and human well-being



# Extinction

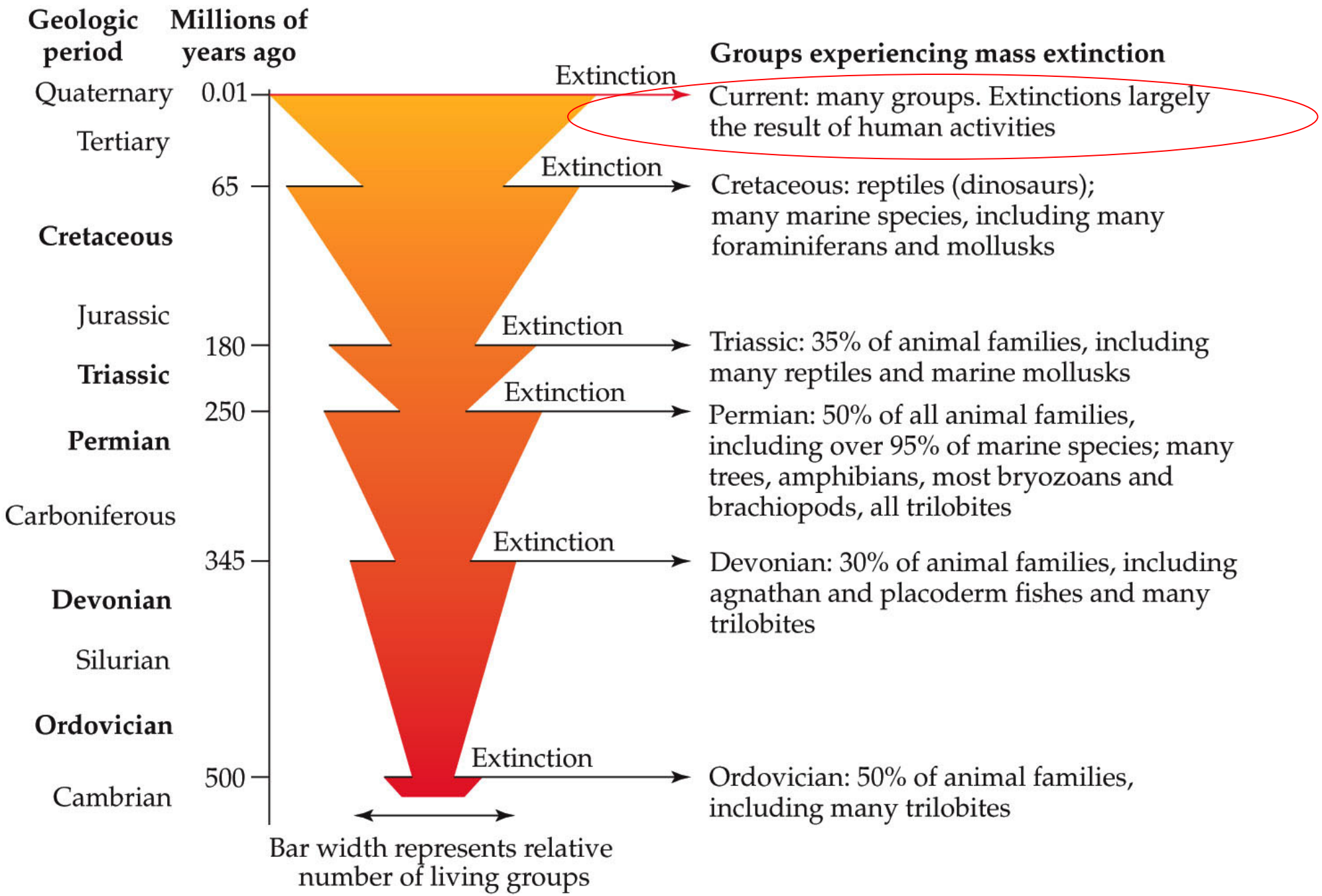
- *"Ecosystems and communities can be degraded, reduced, and damaged but as long as all the original species survive, communities retain its potential to recover"*

- *"The most serious aspect of environmental damage is the extinction of species"*

E.O.Wilson

# Extinction

- **Extinction =** the disappearance of a species from Earth
  - Species last 1-10 million years
- **Extirpation (local extinction) =** the disappearance of a population from a given area, but **not** the entire species globally
  - Can lead to extinction




***PRIMER OF CONSERVATION BIOLOGY 4e*, Figure 5.1**

# What have caused passed mass extinctions?

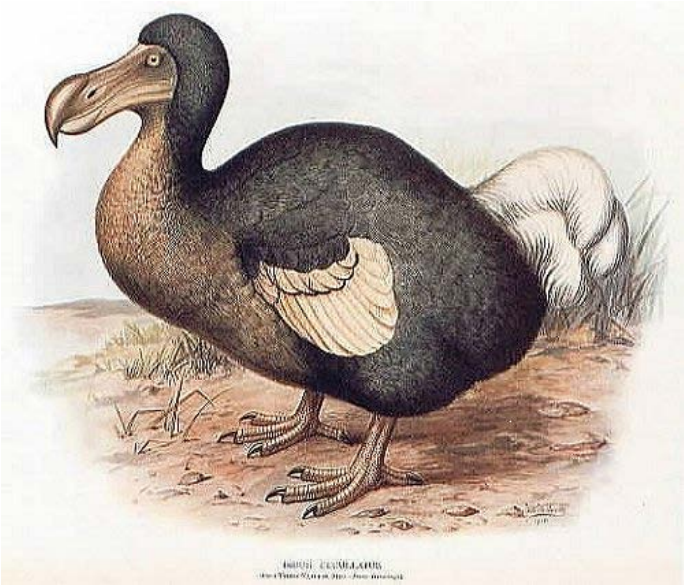
- Volcanogenic-atmospheric kill mechanisms included:
  - ocean acidification,
  - toxic metal poisoning,
  - acid rain,
  - ozone damage

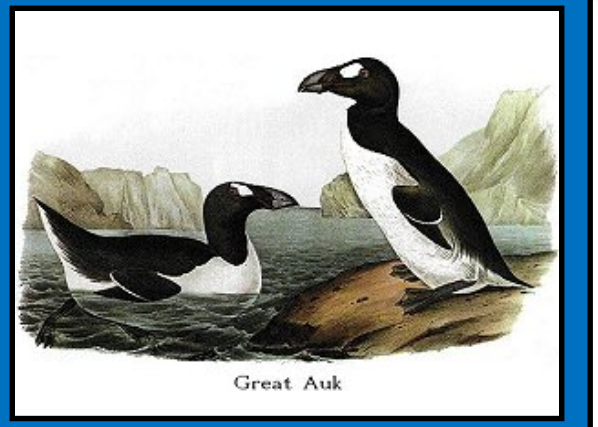
  - increased UV-B radiation,
  - volcanic darkness,
  - cooling and
  - photosynthetic shutdown

*Bond and Grasby, 2016*
https://www.sciencedirect.com/journal/palaeogeography-palaeoclimatology-palaeoecology/vol/478/suppl/C

# Biodiversity loss and species extinction

- **Extinction is a natural process**
  - 99% of all species that ever lived are now extinct
  - *It's a matter of the rate!*
- **Background rate of extinction**
  - 0.1 extinction per million species-years (E/MSY) (Pimm et al., 2014)
    - (revised from 1E/MSY, Pimm et al., 1995)
  - each year 1 species out of every 10 million goes extinct
  - 1 bird species extinction per 1,000 years



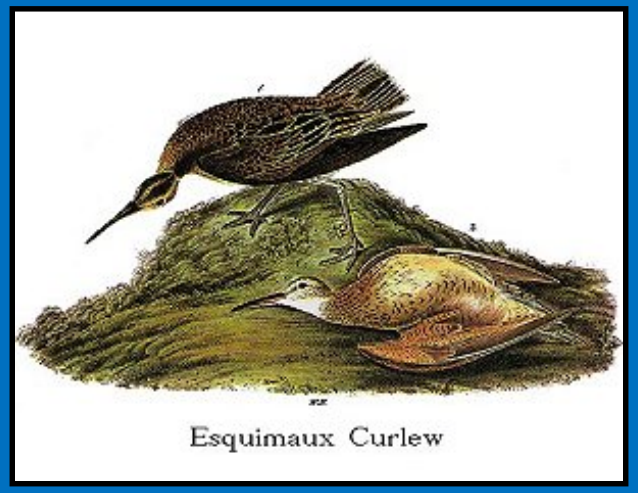


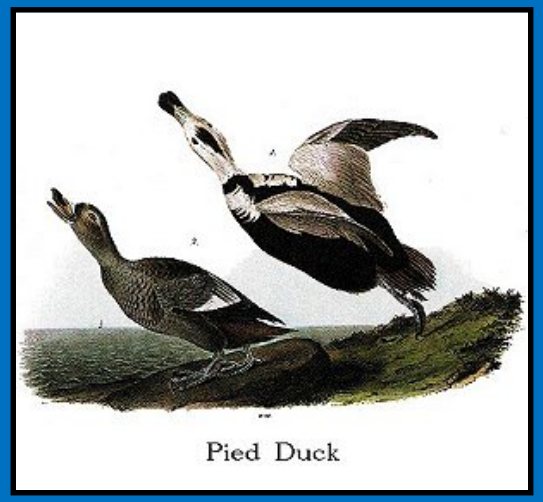


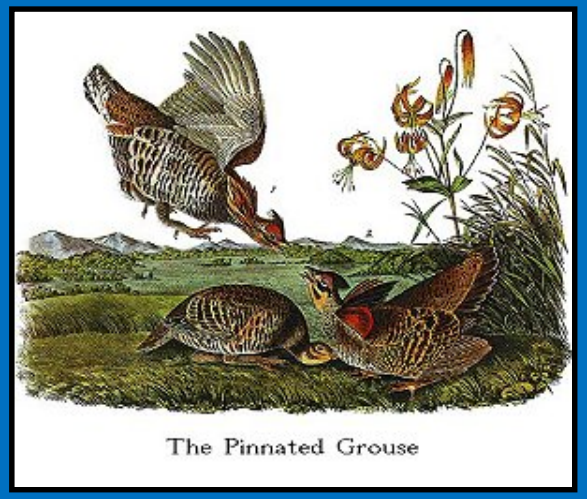


# North American birds that have become extinct

## since being painted by John James Audubon, 1827-1839



# During the time of this class…

- 3-5 species will go extinct
- 25.5 $km^2$ (~ 5 football fields) of the tropical rainforests will be cut
- 17,500 people will be added to the world population

# Extinction is a natural process, but …

- Humans profoundly affect *rates* of extinction
- Present extinction rate ~100 E/MSY
  - x1,000> than background rate of 0.1 E/MSY

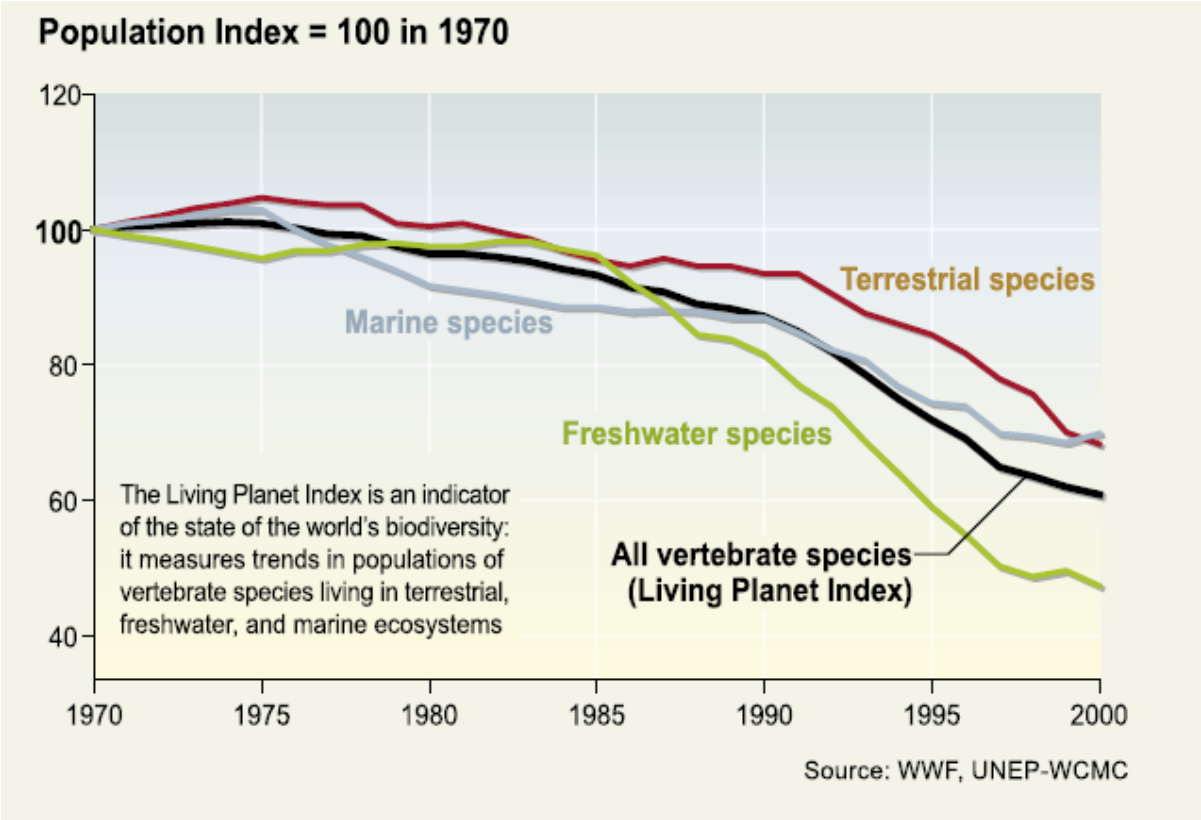
- Local rates from regions can be much higher:
  - 132 E/MSY for *all birds* after 1900
  - 305 E/MSY for *fish* in NA rivers and lakes
  - 954 E/MSY for the NA freshwater *gastropods*
  - likely >1,000 E/MSY for *cichlid fishes* in Africa's Lake Victoria

# Current Impact on Biodiversity

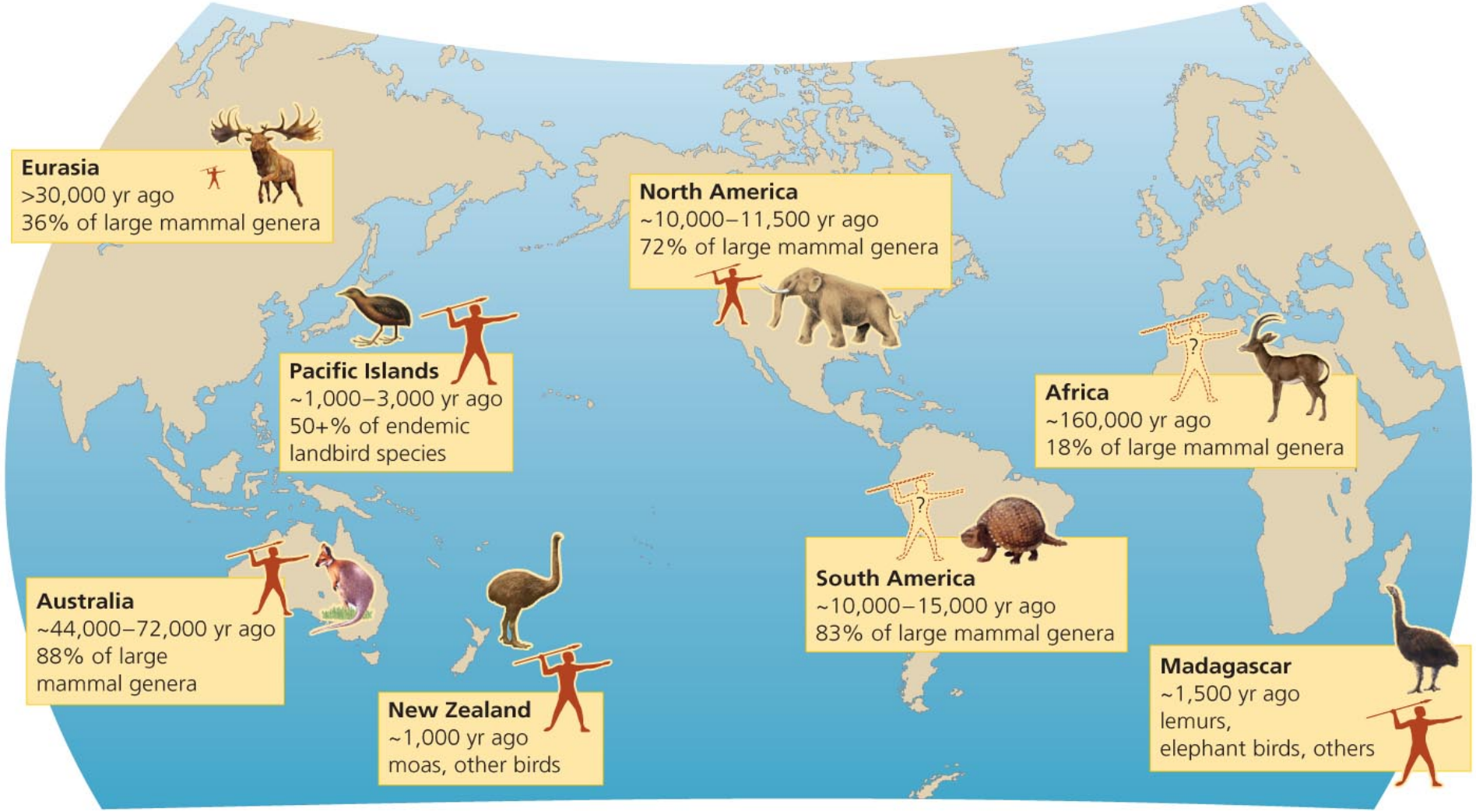
- **Changes in biodiversity and in ecosystems are almost always caused by multiple, interacting drivers.**

- *The Living Planet Index* currently incorporates data on the **abundance of vertebrate** 555 terrestrial spp, 323 freshwater spp, and 267 marine spp around the world.

- While the index fell by some 40% between 1970 and 2000, the terrestrial index fell by about 30%, the freshwater index by about 50%, and the marine index by around 30% over the same period.



# Humans are causing this mass extinction

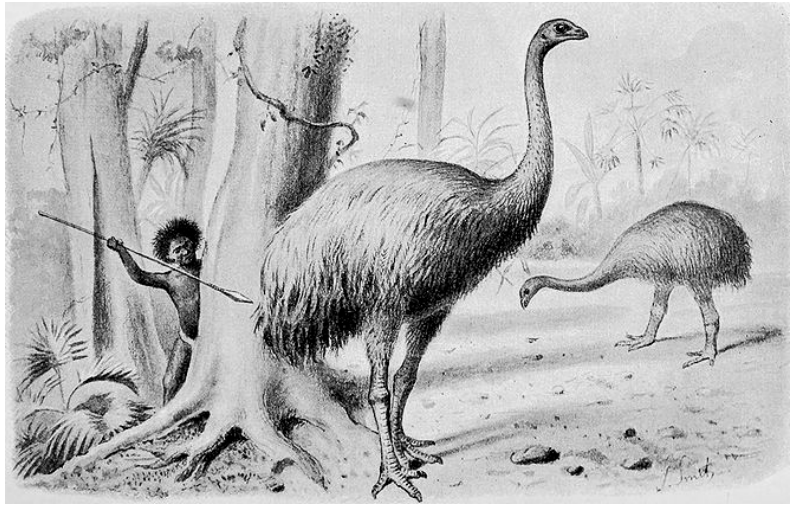





*Extinctions followed human arrival on islands and continents*

# Extinction on Islands

- Highest extinction rates during historic times have occurred on **islands**.
  - 90% of bird extinction
  - Madagascar: 40% of  large mammals
  - Hawaii: 70-90 bird spp extinct
  - - 57 spp. = 42% of birds in New Zealand went extinct, including 11 spp. of moas
  - Pasific Islands: ~1,000 bird spp = 1 extinction every few years = 100 E/MSY



# Extinction on Islands


- Highest extinction rates during historic times have occurred on **islands**. *Why*?
  - Small land area
  - Small populations
  - Small number of populations
  - Many endemic spp.
  - Limited (if any) natural predators → nobody evolved defenses

# Extinction on Islands

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*Can we simply solve the problem by protecting all islands?*

**NO!**

*Currently it has shifted to rapid increase in extinction on continents*

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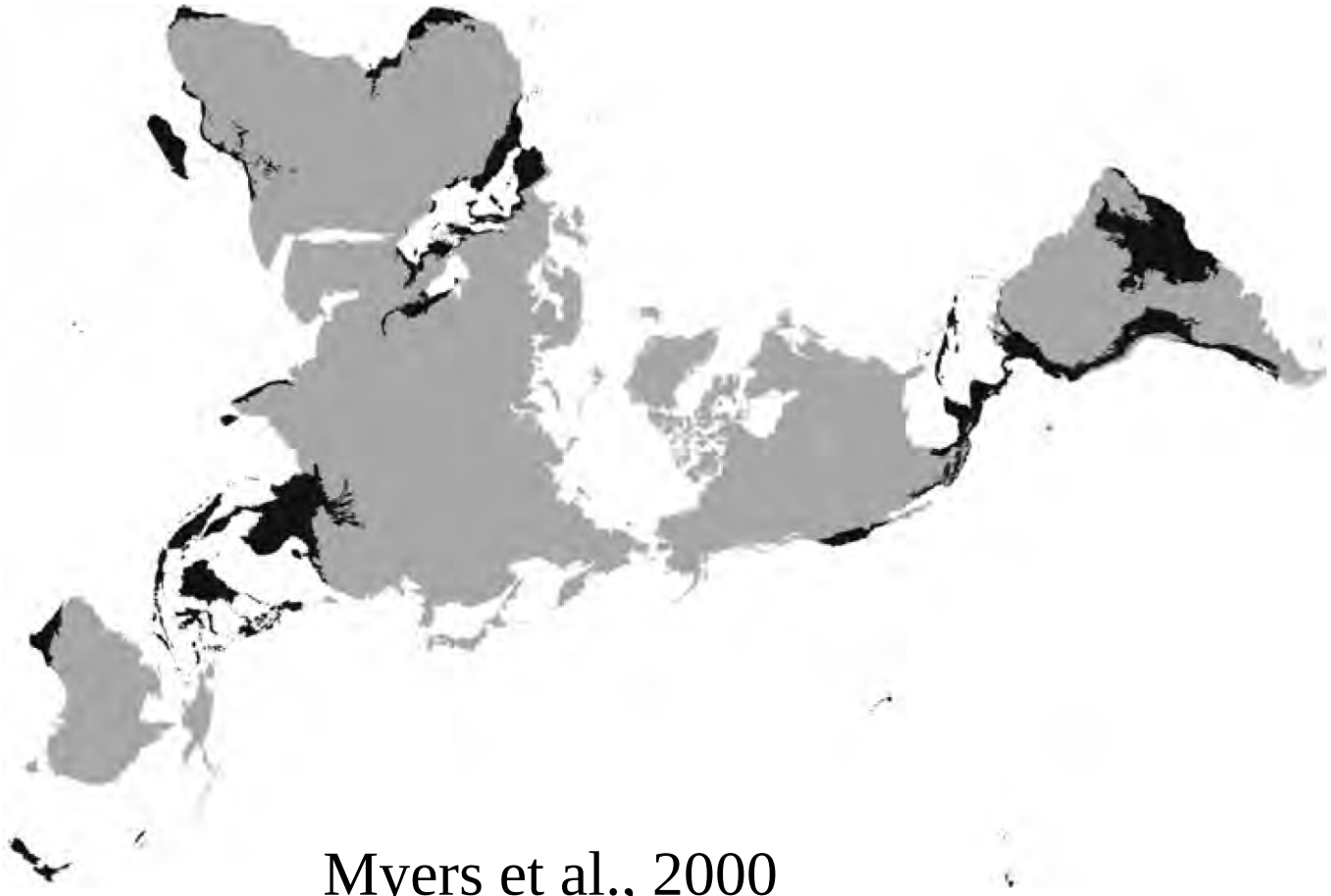
- Extinction occurs when the environment changes <u>rapidly →</u> Natural selection can not keep up

# Where are spp becoming extinct?

- **Myers' Hotspots** = 25 areas with 1,000 endemic plants (many spp with small ranges) and <30% of remaining natural vegetation



Myers et al., 2000

Hotspots have higher human population density and population growth rate (Cincotta et al., 2000)

Similarly, large fraction of marine spp have small ranges (except corals) and they collide with high human impact

# Major Causes of Biodiversity Loss

1. Habitat Change
   - Habitat Loss
   - Degradation
   - Fragmentation
2. Pollution
3. Overharvesting (=overexploitation)
4. Invasive Species
5. Climate Change

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- ¾ of bird spp-- 1,250 spp-- in hotspots will go extinct this century (Pimm & Raven, 2000)
- At current rates of deforestation, most of the Amazon will be gone by mid-century (Laurance et al., 2001)

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Overall expectations of species moving poleward, to higher elevations, or to deeper depths to remain in their climate envelopes.

- Thomas et al., 2004 estimate 15-37% of spp are threatened by climate change within the next 50 years for a mid-range warming scenario
- 7-24% of plant spp will become extinct
- Lower rates in the ocean because of the greater freedom of movement

# Main Drivers Impact on Biodiversity

Causes for biodiversity lost are changing

# Climate Change impact on Biodiversity

- Climate change is projected to exacerbate the loss of biodiversity and increase the risk of extinction for many species, especially those already at risk due to factors such as low population numbers, restricted or patchy habitats, and limited climatic ranges (medium to high certainty).
- Water availability and quality are projected to decrease in many arid and semiarid regions (high certainty).
- The risk of floods and droughts is projected to increase (high certainty).
- The biomass production is projected to decrease in some regions (high certainty).
- Agricultural productivity is projected to decrease in the tropics and sub-tropics for almost any amount of warming (low to medium certainty), and there are projected adverse effects on fisheries.
- Projected changes in climate during XXI century are very likely to be without precedent during at least the past 10,000 years and, combined with land use change and the spread of exotic or alien species, are likely to limit both the capability of species to migrate and the ability of species to persist in fragmented habitats.