

EEB 2208: LECTURE TOPIC 7

CAUSES OF POPULATION DECLINE

Reading for this lecture:

Primack: Chapter 8

Optional reading (articles containing information that I will refer to in lecture):

- Wilcove, et al. 1998. Quantifying threats to imperiled species in the United States. *Bioscience* 48:607-615. On-line at: http://www.edf.org/documents/836_bioscience.pdf
- Davies, et al. 2006. Human impacts and the global distribution of extinction. *Proceedings of the Royal Society B: Biological Sciences*, 273 (1598): 2127-2133. On-line at: http://www.epa.gov/ncer/biodiversity/pubs/proc_vol237_2127.pdf
- Owens, I.P.F. and P.M. Bennett. 2000. Ecological basis of extinction risk in birds: Habitat loss versus human persecution and introduced predators. *Proc. Nat. Acad. Sci.* 97:12144-12148. On-line at: <http://www.pnas.org/content/97/22/12144.full.pdf+html>

1. The process of extinction

A) EXTINCTIONS TAKE TIME TO OCCUR

- i) First a couple of truisms (they should be pretty obvious, but are often forgotten). All extinctions begin with population declines – and it can take a long time for a population to decline enough for it to go extinct. Also, ANY population decline will cause extinctions (at least at a local scale).
- ii) Various systems exist to classify populations according to how close they are to extinction. Thus, terms such as “threatened” and “endangered” have come to have very specific (and often legal) meanings. Globally the most important of these systems is that used by the IUCN (see Primack).
- iii) In most such schemes, species are evaluated based on some combination of their population size, the size of their range, whether their populations are declining, and any known threats.

B) EXAMPLE: THE DEMISE OF THE HEATH HEN

- i) The heath hen was a subspecies of the greater prairie-chicken (a bird that can still be found today – although it is declining too – in parts of the Midwest).
- ii) When Europeans arrived in North America in the 1600s the heath hen was widely distributed and common in open shrubby habitats (pine barrens, scrub-oak plains) from Maine to Virginia.
- iii) Populations began to decline, probably because it was widely hunted for food and because its habitat declined as land was converted to agriculture.
- iv) By the 1870s it was only found on Martha’s Vineyard, Massachusetts. By 1907, there were only 50 left and a 1600 acre reserve was set aside for them. This protection worked well and the population increased to 2000 birds in the next 8 years.
- v) But, in 1916 a big fire destroyed much of the remaining habitat. This was followed by harsh weather and an influx of goshawks, a hawk that preyed on heath hens, in the following winter. To top it all off a new poultry disease was introduced to the island with domesticated turkeys. This combination of events decimated the heath hen population and by 1932 they were extinct.

2. Why do species decline in numbers?

Note that this is not an exhaustive list, just a number of key issues. We will revisit many of these things in more detail later in the course.

A) ISOLATED CATASTROPHIC EVENTS

- i) Examples include predators that appear just for a short time, isolated outbreaks of a disease, or extreme weather events – the last part of the heath hen story provides a good example.
- ii) Species most at risk are those that already have small populations, and those that have low reproductive rates (and are thus unable to recover from a big population change very rapidly).

B) LONG-TERM ECOLOGICAL CHANGE

- i) Many, many possible examples of this: the introduction and spread of an alien competitor in an area, or the arrival of a new disease or predator that becomes established
- ii) Species most likely to be affected include specialists (which may be less able to withstand the changing conditions) and those with a narrow range (few places where they can escape the change).

C) LOSS OF SPECIES INTEGRITY

- i) Example: Hybridization with an introduced species changes the make-up of a species and threatens its existence as a distinct species. This is especially common in certain fish (e.g., trout).
- ii) Species most likely to be affected are those without pre-mating isolation barriers. (In some cases, individuals of one species may actually prefer to mate with individuals of another species – e.g., spotted owls, American black ducks.)

D) HABITAT DESTRUCTION

- i) Can be caused by human disturbance or natural events (e.g., hurricanes, volcanoes, etc.). For example, red-cockaded woodpeckers have declined over a long period due to human destruction of old growth forests in the southeastern US. But, natural events also play a role (especially when a population is already small) and in 1989 over half of the woodpeckers in the world's second largest population were killed after Hurricane Hugo devastated the Francis Marion National Forest in South Carolina.
- ii) Species most at risk include those with narrow distributions and habitat specialists – but all species are ultimately vulnerable to habitat loss.

E) HABITAT FRAGMENTATION

- i) Caused by habitat destruction, road building, altering hydrology, etc. E.g., flattened musk turtle in Alabama is threatened by fragmentation of aquatic systems as rivers are dammed, and water flows changed so as to cause areas to dry up.
- ii) Species most vulnerable include poor dispersers (unable to cross barriers between fragments), species requiring multiple habitats (less able to travel between them), and habitat specialists.

F) USED BY HUMANS

- i) Greed (making money), status (trophy-hunting), and need (food, maybe medicine in some cases) can all cause people to exploit populations of other organisms.
- ii) Species most at risk include big organisms, species that are found in places that humans can easily get to, and habitat specialists.

G) DISRUPTION OF BEHAVIOR

- i) Many examples exist, but they tend to be fairly specific to certain species. For some species complex social interactions – sometimes including large groups of individuals – are needed for them to come into breeding condition. Another specific example involves baby sea turtles which are attracted to beachfront lighting, which often prevents them from finding their way to the ocean.
- ii) Species affected in this way are likely to have complex social behavior, but it is often hard to predict when specific behaviors will cause a problem.

H) INCREASED GENETIC HOMOZYGOSITY

- i) Can cause (and be caused by) population reduction. Often exists in a population when there has been a “bottleneck” (i.e., the population has been reduced to a very small size at some point in the past – this population reduction will cause the loss of much genetic variation, and the “fixation” of alleles – in evolutionary biology this is referred to as a “founder effect”).
- ii) Tends to affect small populations, populations with a low reproductive rate, and populations in which the sex ratio of breeding individuals is highly skewed (i.e., many more individuals of one sex).
- iii) A major consequence of reduced genetic variation is inbreeding depression, which can impair species survival and reproduction. For example, in several mammal species kept in captivity, researchers have found that juvenile survival is lower for inbred individuals than for others.

I) POLLUTION

- i) Many forms of pollution can also affect populations, either by killing individuals outright, or by affecting their ability to reproduce.
- ii) A recent example is the dramatic decline of several species of vultures in India and nearby countries. A painkiller (diclofenac) routinely used to treat livestock has caused populations to decline by as much as 95% within only 10 years. Subsequent research has shown that the magnitude of the threat may be so great that captive breeding is needed to prevent the species from becoming extinct. In India, the painkiller has been banned and alternatives are now available at a similar price.

3. Which threats are most important?

A) EXAMPLES

- i) **Causes of freshwater fish extinctions.** 1 in 5 species of freshwater fish worldwide is considered to be extinct or in serious decline. The main causes of declines are: habitat loss (affects 73% of species), displacement by introduced species (68%), chemical pollution (38%), hybridization (38%), and over-harvest (15%). (Note, that these % would be very different for salt-water fish: e.g., over-harvesting would probably rank much higher).
- ii) **U.S. endangered species.** Habitat loss or degradation ranks as the most important, affecting >80% of endangered plants and invertebrates, and >90% of endangered vertebrates. Alien species (less so for inverts) and pollution (less so for plants) each affect about half of all endangered species. Over-exploitation affects about a quarter of endangered animals, and about 1 in 10 endangered plants. Disease also affects a fair number of endangered animals. Note that the differences among taxonomic groups may simply be artifacts of our state of knowledge – e.g., the lack of any endangered invertebrates known to be affected by disease may simply be because we don’t spend a lot of time studying disease in invertebrates.
- iii) **Threatened birds.** Over a thousand species of birds have been classified as threatened. The main threats vary among different families. Habitat loss affects 70% and human persecution or introduced predators affect 35%. About a quarter of species are affected by both things. When species characteristics are considered, it turns out that species affected by habitat loss tend to be small and specialized in their requirements. Species affected by persecution are big (“good eatin’!”) and have long generation times (meaning that altering adult survival has a big impact on population persistence).

B) IMPORTANT GENERALITIES

- i) Habitat loss and change is consistently the thing that affects most threatened species.
- ii) Many species are affected by several different types of threat.
- iii) Extinction is usually the result of a combination of factors. Some of these may cause the initial decline (usually things that result in a long term change of conditions, such as habitat loss), but others may be the things that finish a species off (e.g., various catastrophes). Think about this in the context of the heath hen example given above.