EEB 2208: TOPIC 6

EXTINCTION PATTERNS

Background for this topic
Primack: Chapter 8
Sodhi and Ehlich: Chapter 10

1. How can you tell if something is extinct?

A) UNFORTUNATELY, ONE CAN'T VERY EASILY (AT LEAST NOT FOR CERTAIN)

i) As Hermione Granger pointed out to Xenophilius Lovegood (while discussing the Resurrection Stone; Rowling. 2007. Harry Potter 7:334) it is essentially impossible to prove that something does not exist. This same problem applies to assessing extinction.

ii) Consequently, conservation biologists have had to develop criteria for deciding when the probability of extinction is sufficiently high for us to assume that extinction has happened. None of these methods are perfect.

B) TIME-BASED CRITERIA

i) One approach used for many years, and still frequently referred to and used by some, is to declare a species extinct if it has not been recorded for a given number of years. Frequently 50 years is used, leading to the so-called "50-year rule".

ii) Several problems with this approach have been identified: (a) The number of years is arbitrary. (b) The time-span is based on a time-scale relevant to human lives, meaning that its relevance may vary among different types of organisms (50 years is probably not bad for species that live only a few years, but what about a tree species in which individuals could live for 100s of years?). (c) There are plenty of species that have not been seen for several decades only to be "rediscovered".

C) SEARCH-BASED CRITERIA

i) Given criticism of the "50-year rule", the IUCN (International Union for Conservation of Nature) adopted a definition based on both a lack of verified records and the search effort expended looking for a species.

ii) Their definition is: "… **no reasonable doubt** that the last individual has died. A taxon is presumed Extinct when **exhaustive surveys** in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), **throughout its historic range** have failed to record an individual" (bold is my emphasis).

iii) A problem with this definition is that its requirements are so restrictive that, for many species, it would be impossible to ever achieve this level of certainty. In other words, the burden of proof is so severe that it makes it very difficult ever to call something extinct. (Xenophilius would have approved.)

D) STATISTICAL CRITERIA

i) Given that one can never be absolutely certain about an extinction (e.g., how can I prove there is no plesiosaur in Loch Ness?), and that there is always some chance of persistence (though vanishingly small in the case of Nessie), various methods have been developed to estimate just how probable it is that a species survives.

ii) One group of methods looks at "gaps" in the record of sightings. Inconspicuous species, with long periods of no sightings between confirmed records, are quite likely to persist for a while after the "last" confirmed observation. On the other hand, if a species is seen almost every year for a long time and then is seen no more, it is quite likely to be extinct.

iii) Using these methods, it is possible to take the pattern of sightings and "gaps" with no sightings and estimate (a) when a species went extinct, (b) how certain one can be about that date, and (c) the probability that the species is extant.

2. Extinction rates vary

A) IT IS NOT ALL DOOM AND GLOOM

i) In much of this set of notes, and the last one, I stress the many extinctions that are happening. But, it is important to know that it is possible for species to avoid extinction, and for local populations to recover (as long as a species is not globally extinct).

ii) Extinction does not happen immediately, but is a process that occurs over a variable (and often quite long) period of time. Many species persist even after habitat has been altered or reduced, and many continue to be found in remnant patches. In fact, it has been estimated that only about half of all the extinctions that one would eventually expect to happen will occur in the first 50 years after an area is impacted. This phenomenon of delayed extinction has been referred to as an "**extinction debt**" – although some extinctions are expected they will not occur until sometime in the future.

iii) In one sense this means that the situation may be worse than it seems because you will not see all the extinctions immediately. But, at the same time, this debt might help buy time to reverse certain changes and prevent anticipated extinctions before it is too late.

iv) Consequently, declines can be reversed and extinctions avoided. At least in theory they can. More on this later in the course; for now, back to the doom …

B) SINGAPORE (Brook et al. 2003)

i) One study examined the amount of extinction and patterns of extinction on the island of Singapore. In Singapore, more than 95% of the natural vegetation (mostly forest) had been destroyed in the previous ~180 years.

ii) The researchers estimated that up to 73% of all species in the groups of organisms they looked at have been extirpated from the island. Unlike the previous estimates of extinction rate I have given you, most of these extinctions have actually been documented. Those that have not are based on estimating which species were probably already extinct before they were ever recorded on the island (i.e., species that we know existed in nearby Malaysia, and that would have been capable of getting to Singapore). Thus, this is a much better estimate than those we have talked about previously.

iii) Among the remaining species, many are functionally (and ecologically) extinct (the "living dead") because so few individuals remain that the species will probably disappear soon. For example, at the time the paper was written there were only about 15 banded leaf monkeys and 5 white-bellied woodpeckers left.

iv) The study looked at 9 different groups of organisms. Likely extinction rates were high for all groups, but there was variation among groups both in the number of documented extinctions and in the likely total number of extinctions.

v) Extinction rates also varied among habitats. For example, 33% of forest interior species have definitely gone extinct, while only about 7% of the species found in open habitat or along forest edges have disappeared. Among fish, more than half of the forest species are gone, while all of the open habitat species remain.

vi) Body size was also important – for birds, extinction rates were higher for large species than for small.

vii) In addition to all the extinctions, the researchers found that 77% of the remaining species are threatened.

viii) Although only about 0.25% (i.e., $1/400^{th}$) of the total land area is protected, they estimated that the loss of these reserves would cause the number of future extinctions to double.

ix) Finally, they noted that the reserve system has no "redundancy." By this they mean that most species are protected in only one place. So, if that site goes, the species will disappear completely. For example, a quarter of all the remaining fish and decapod species occur in just one 5 ha reserve (this is an area smaller than the cemetery across the road from TLS).

3. What makes species vulnerable to extinction?

A) SMALL POPULATIONS

i) Small populations are at higher risk than large populations.

ii) This should be no surprise since they are "rare" in the classic sense of there not being very many of them.

iii) When the population is small even random events are likely to have an effect – for example when there are 10 individuals it is more likely that all will fail to breed in the same year than when there are 10,000 individuals.

iv) Another example is that when populations are small it becomes increasingly likely that the remaining individuals will simply fail to find each other.

v) Also, genetic problems become more likely as population size decreases. This is because there is less genetic variation overall (simply because there are fewer individuals) and because each individual is more likely to have to mate with a close relative (thus causing inbreeding). More on this topic later in the course.

B) SMALL GEOGRAPHIC RANGE

i) Species with a narrow geographic range are at higher risk than those found over a broad area – this is another form of rarity. Globally they are rare because you cannot find them in many places, but where they do occur they might be quite numerous.

ii) These species are especially vulnerable to catastrophic events that occur in a single place – e.g., things like an oil or chemical spill, or a disease outbreak – because the whole population would be affected.

iii) Also, these species typically have nowhere to go if their habitat changes.
iv) Often narrow range species are referred to as "endemics". Strictly speaking this is not an appropriate use of the word (in fact, all species – not just those with narrow ranges – are endemic to somewhere), but you should be aware that in conservation settings people use the term in this way.

C) POPULATION SIZE FLUCTUATES A LOT
i) Populations that fluctuate in size a lot are generally at greater risk than similarly-sized populations that are more stable. This is simply because wild fluctuations mean that the population is likely to get close to zero more often.
ii) This problem is especially great for species that already have low numbers.

D) HABITAT SPECIALISTS
i) Species that use some specialized habitat or other resource are generally more vulnerable than generalist species, simply because they have fewer options if the resource disappears.
ii) This is especially so if they specialize on a rare or limited resource.

E) SPECIES IN SYMBIOTIC RELATIONSHIPS
i) Symbiotic species (those that rely on some other species to survive) are highly vulnerable, because the loss of the species they have a symbiotic relationship with will mean certain extinction. These species can be thought of as extreme specialists.
ii) Scenarios of this type are sometimes referred to as "**chains of extinction**," because one extinction inevitably leads to others.
iii) For example, many parasites specialize on a single host species; some plants are pollinated only by a single species of insect; etc., etc.
iv) One recent estimate (Koh et al. 2004) suggests that about 500 extinctions in well-known groups of organisms have probably led to about 200 "co-extinctions" of entirely dependent species. This same study looked at about 9500 species listed as endangered and estimated that there are at least another 6300 dependent species that will also go extinct if all the endangered species are lost.

F) LARGE SPECIES
i) Large species tend to be vulnerable because they require large areas to support populations that have a good chance of persisting; this in turn is often because individuals require large home ranges.
ii) This pattern is probably more true for animals than for plants, although large plants may still need more space (and nutrients, etc.) than smaller ones.
iii) Large species are also typically more vulnerable to exploitation (i.e., people tend to hunt mammals and birds, but not insects or zooplankton) and large trees are often more likely to be cut down than smaller ones.

G) SPECIES WITH LOW REPRODUCTIVE RATES
i) Species with low reproductive rates tend to be at risk because it takes them a long time to recover from population declines.
ii) Low reproductive rates can arise because few young are produced at each breeding attempt, individuals take several years to reach reproductive maturity, or because individuals breed infrequently.

iii) For example, albatrosses do not breed until they are 5-12 years old, lay only one egg at a time, and do not breed every year.

iv) A low reproductive rate in and of itself need not be a problem, as long as an organism lives for a long enough time to still produce a number of offspring. E.g., albatrosses can live several decades. But if survival rates drop – as has happened to albatrosses as a result of modern fishing practices – then their low reproductive rate creates a problem.

H) SPECIES WITH COMPLEX LIFE-HISTORIES

i) A complex life-history can increase the risk of extinction because it often means that there are more things (or more places) that a species relies upon.

ii) Example: Species that use multiple habitats run a greater risk, because it only takes something bad happening in one of those habitats for the species to be at risk.

iii) Example: Species that migrate long distances are also vulnerable, because they need suitable habitat in lots of places. Imagine trying to protect a bird that needs breeding habitat in Arctic Canada, wintering habitat in southern South America, and migratory stop-over habitat at various sites in between. Compare that to a small plant that never goes anywhere.

I) SPECIES THAT ARE POOR DISPERSERS

i) Organisms that cannot move around easily are often more vulnerable than those that have greater dispersal abilities. This is simply because the ability to move can help an organism to get away from threats or to colonize additional habitat patches.

ii) Example: There are many species of tree snails on islands in the Pacific that are restricted to very small areas (partly because they live on islands, partly because snails don’t get around a lot). Many of these species are at great risk of extinction.

J) SPECIES THAT LIVE ON ISLANDS

i) Species that live on islands generally are much more vulnerable than those on the mainland. This pattern arises, partly, because island species have many of the traits I have discussed above (e.g., small populations, narrow range, limited dispersal ability, etc.).

ii) In addition, islands tend to have high speciation rates and have a lot more species that meet these criteria than would an equivalent area of the mainland.

iii) Finally, island communities tend to be “impoverished” compared to mainland communities – fewer predators, fewer parasites, and perhaps fewer competitors. Thus, island species often have not evolved the ability to deal with potential threats in the way that mainland species have. So, dodos were naïve to the threat of predators and reportedly let early sailors club and eat them out of existence. More generally, there is a greater chance that when new species are introduced to an island (usually by humans) the newcomers will have a large impact on the natives.

4. Extinctions can still be very hard to predict

A) A CAUTIONARY TALE: THE PASSENGER PIGEON

i) Having said all of the above, you might think that it is pretty easy to determine which species are most vulnerable to extinction – and to a large extent this is probably true. But, it is also true that it is possible for pretty much ANY species to be driven to extinction, even those that you least expect.

ii) The passenger pigeon provides an important example of this.

B) THESE BIRDS SHOULD NOT HAVE GONE EXINCT

i) Passenger pigeons used to occur throughout the eastern US. People have speculated that they were once one of the most numerous species of land bird on Earth. Less than 200 years ago, the eminent ornithologist Alexander Wilson reported seeing flocks that he estimated contained 2 BILLION (this is not a typo) passenger pigeons. Maybe he overestimated, but these flocks were reported to be 2-3 miles wide and 300 MILES long, and could darken the skies for days as they passed overhead. That's a lot of pigeons.

ii) Nonetheless, by the end of the century they were extinct in the wild, and in 1914 the last one in captivity died.

iii) This was a species with a huge population, a broad geographic range, not (as far as we know) an extreme specialist, not especially large, not an especially low reproductive rate, not a poor disperser, not a species that lives on an island, and so on. Little about this species would lead you to predict that it would go extinct so rapidly.

C) SO HOW DID IT HAPPEN?

i) Well, they were hunted a lot – both for food and because they were seen as a crop pest.

ii) Their habitat was destroyed (forests were cut down).

iii) There is also some suggestion that they needed to be in big groups to survive and breed successfully, and that once populations dipped below a certain level there was no way for them to recover.

For more on passenger pigeon, check out the link here.