EEB 2208: LECTURE TOPIC 10

INVASIVE SPECIES & DISEASE

Reading for this lecture

Primack: Chapter 10 (second half).
Discussion reading: Gibson et al. 2013. Near-complete extinction of native small mammal fauna 25 years after forest fragmentation. Science 341:1508-1510. On-line at:
http://www.montana.edu/hansen/documents/bio515_13/Gibson%20et%20al.%202013.pdf
Movie: Watch the movie cane toads (on YouTube in 5 parts – link on the web site to the first part.)

1. What are invasive species?

A) DEFINITIONS

i) **Native** – applies to a species that is found within its natural range.
ii) **Introduced** – applies to species that have been moved to a new area (usually by humans).
iii) **Exotic** or **alien** – applies to species when found outside of their natural range (i.e., after being introduced).
iv) The terms "non-native", "introduced", "exotic" and "alien" are often used interchangeably.
v) **Invasive** – species that spread rapidly, and undergo explosive population increases, such that they dominate a community. Usually things that are called "invasive" cause some problem (from the perspective of humans). Usually invasive species are also introduced, but sometimes the term is used for species that are native to an area.

B) WHY ARE INTRODUCTIONS/INVASIVES A PROBLEM?

i) Because they alter species interactions, often to the detriment of native species.
ii) For example, invasive species can affect other species by preying upon them, by out-competing them, by causing disease, etc. They also can have effects indirectly, e.g., by altering the way in which the ecosystem functions. For example, beavers have been introduced into southern Chile – what kind of consequences do you think this would have given what I've told you in earlier lectures?
iii) Note that the interactions among native species can change dramatically as a result of human activities, creating effects that are similar to those of introduced invasive species. Examples, to think about include: removing a key predator and allowing its prey to increase dramatically (e.g., wiping out wolves resulted in a big increase in coyotes and other medium sized predators); increasing the food available for some species (e.g., waste grain in the farm-belt has caused massive increases in various geese populations); altering the habitat (e.g., cowbirds, discussed in a previous lecture, have increased because of forest fragmentation and increased cattle populations).

C) BUT, INTRODUCTIONS ARE NOT ALWAYS A PROBLEM

i) Most fail and only a very small proportion of all introduced species become invasive. But, a small proportion of a big number of introductions can still result in a lot of invasive species.

ii) For a species to become invasive it must overcome three (big) challenges: (a) it must get somewhere new (which means somehow being transported there), (b) it must become established once it has arrived (which requires conditions conducive to avoiding rapid extinction), and (c) it must undergo explosive population growth. At each of these steps, most species fail.

iii) In some cases, introductions can be beneficial, for example:
- Some very rare species have been introduced to new areas where they do not face the threats that exist in their native range.
- Sometimes introduced species provide valuable habitat for threatened species.
- Some species are introduced for very specific purposes that are considered valuable (maybe even necessary) for humans – e.g., nearly all agricultural crops are introduced somewhere.

D) CAN WE PREDICT WHICH SPECIES WILL BE INVASIVE?

i) In a very general sense we can determine which species are likely to become invasive. Successful invaders have a host of typical characteristics:
- abundant in original range
- short generation times
- larger than most relatives
- habitat generalist
- **polyphagous** (diet generalist)
- much genetic variability
- fertilized female able to colonize
- associated with humans
- disturbed habitat users

ii) Not all invasives have all of these features, but most probably have at least a few. Why might each of the things listed help species to become invasive?

iii) Even though there are a host of biological characteristics that are correlated with invasion success, there are many exceptions, and many invasions that cannot be explained as easily as we would like.

iv) Some of the things that influence invasion success have nothing to do with the biological characteristics of the organisms. For example, one of the best studies of what it is that allows a species to become established after being introduced looked at introduced birds in New Zealand. This study was especially good because there were very detailed records about the earliest stage of the invasion (something we typically know little about). In this study, none of the biological factors considered helped to predict which species would become established. But, two other variables did correlate with the success of a species. Species for which a lot of individuals were released, or for which there had been multiple attempts at introduction were most likely to become established.

v) Another study of 600 bird introductions around the world showed a similar result: that the primary factor influencing whether introductions were successful was the "**propagule pressure**", or introduction effort.

2. Why do people move species to new areas?

A) FOOD

i) Example: The lakes of the Rift Valley in East Africa have incredibly high fish diversity. This small area contains as many fish species as all

of Europe and North America combined. The Nile perch, however, was introduced to provide food for the people who lived in the area. This species is a voracious predator and has contributed to the widespread loss of many fish species. In Lake Victoria there were 300 species of cichlid fish before Nile perch was introduced. Now there are fewer than 100 species.

ii) Example: European rabbits were introduced to Australia as a source of food. But, the population rapidly took off (they bred like rabbits), and within a few decades they had spread across the entire continent and numbered in the hundreds of millions.

B) AESTHETIC REASONS

i) Example: Eurasian starlings (and many other species) have been introduced into North America and other places around the world. Originally, these birds were introduced by organized groups that wanted to populate the New World with familiar species from home – some of these societies had the goal of trying to introduce all the birds mentioned in Shakespeare's plays. In many places, starlings have become very common and now compete with native species for nest sites (starlings nest in tree cavities, which usually occur in limited numbers) and maybe also for food. In North America, about 100 birds were initially released in New York City. Now there are estimated to be well over 100 million, and they occur across the entire continent.

ii) Example: Species brought in as pets can also wreck havoc on native populations. In one especially dramatic example, the cat belonging to a local lighthouse keeper is thought to have largely wiped out an entire species: the Stephen's Island wren, which was found only on a small island near New Zealand.

iii) Many (probably most) invasive plants were initially introduced as plantings in peoples' gardens (or other ornamental settings). Most species grown in gardens have stayed in gardens, but many have not.

iv) Example: Purple loosestrife is a species that you can easily find around Storrs (e.g., Mirror Lake). It is a very attractive plant and is consequently favored as a garden ornamental, but it tends to take over wetlands completely, out-competing all other species. It is now a dominant wetland plant in many parts of North America.

v) Other invasive plants include: a) Kudzu, which is now found in the southeastern US and which completely overgrows everything it encounters. b) Tamarix (also known as salt cedar), which is introduced into the deserts of the southwest and helps to displace native trees, while also lowering the water table and making it harder for native species to survive (but – to complicate matters – also providing habitat for rare birds such as the southwestern willow flycatcher). c) Many, many others, e.g., see the UConn-based Invasive Plant Atlas of New England (IPANE) project http://www.eddmaps.org/ipane/.

C) ACCIDENTAL TRANSPORT

i) Example: The brown tree snake is an Australasian species that was introduced to the island of Guam (in the Pacific) after World War II. It is thought to have got there accidentally, probably by stowing away on military aircraft. After a period of rarity, the population suddenly exploded with the result that there were snakes everywhere. Coincident with this population increase, all species of forest birds and other vertebrates (including some found nowhere else in the world) began to decline. Now many of the bird species are all gone from the island; predation by the snakes is thought to be the primary reason.

ii) One major way in which aquatic species get transported around the world is in the ballast water that large ships take on-board. This water may be taken onto a ship in one part of the world, and then discharged (along with all the organisms it contains) thousands of miles away. It has been estimated that 40,000 gallons of foreign ballast water is discharged into US waters every minute.

iii) Many other routes for accidental transport exist. These include: via the mail, on airplanes (see above), in the dirt on someone's boots (seeds, fungal spores), in shipped products (e.g., various forest insect pests probably get around in wood shipments), etc., etc.

3. Do all invasions involve introduced species?

A) "INVASIVE" POPULATION GROWTH DUE TO HUMAN ACTIVITES

i) Most species that are termed invasive are introduced. But sometimes the term is used for native species that have expanded their ranges (e.g., brown-headed cowbirds, which have spread into the Northeast following forest loss and fragmentation), or that have simply undergone massive population growth.

ii) Example: An example of the latter, involves two species of North American geese – snow and Ross's geese (collectively: "white" geese). These birds breed in the Arctic and winter in the US. Their populations have steadily increased in recent decades, largely because of increased food at wintering/migration sites, which tend to be agricultural areas where there is now a lot of spilled grain available after harvest (e.g., California, mid-West, Gulf Coast). Predation during these periods is also lower than it was historically (both because there is much less human hunting and because many natural predators have declined). A consequence of these population increases is widespread damage to Arctic breeding grounds, where the geese overgraze the tundra. For instance, it has been estimated that 65% of the inter-tidal habitat in southern and western Hudson Bay has been badly damaged by these geese. In addition to having harmful effects on the plant species that live in these areas, this grazing affects many other species of animal that live in this habitat.

iii) Can you think of any similar New England examples? Hint: there's a very well known one involving a forest herbivore.

4. Solutions

A) EARLY DETECTION

Once invasive species are established it is very difficult to get rid of them. Even when it is possible, it can be expensive. Consequently, the best solution to the problem is to prevent establishment and spread in the first place.

i) Doing this is not easy and requires controls to movement and methods for early detection.

ii) Projects like IPANE can help us to better understand patterns and mechanisms of spread, which can help to determine which species are likely to be problems, and where they are likely to become invasive. These projects also help train large numbers of people who can then look for early signs of spread into new areas.

B) BIOLOGICAL CONTROL

i) Once introduced species have become widespread and extremely common, mechanical (e.g., pulling up plants) and chemical (e.g., herbicides) control are difficult to implement.

ii) At this stage, one of the few options is the use of some biological agent (usually introduced from elsewhere). Typically, these agents are a herbivore, predator, or parasite that specializes on the invasive species.

iii) A common argument for doing this is that an important thing that allows a species to become invasive is that it is "released" from the effects of key predators or parasites that keep its population in check in its native range. So, the argument goes, bringing in the predator will help control the invasive.

iv) The history of biological control, however, is checkered. Some attempts have been very successful, but others have turned into complete environmental disasters.

v) Example: The prickly pear cactus, which became invasive after being introduced to Australia, was effectively controlled by the introduction of *Cactoblastis* moths which feed on the cactus. This moth, however, has subsequently become invasive itself (e.g., in the southern US where it is impacting various native cacti).

vi) Example: Mongoose were introduced to Hawaii (and elsewhere) to help control the (introduced) rats that had become very abundant in sugar cane (also introduced) fields. Unfortunately, mongooses are diurnal while rats are nocturnal – so it didn't work! Not only did the mongoose not control the rats, but they started to prey on native bird species that they could find during the day instead. Today mongooses are the subject of major predator control programs (designed to protect native species) in many parts of Hawaii.

vii) In general, biological control is most likely to work (and to not cause other problems) when the species brought in has a very specific effect on only the species that needs to be controlled (specialist herbivores and parasites are good examples). Extensive testing prior to release is consequently an important part of most modern biological control programs. As a result, these programs are generally more effective than some of those in the past.

5. Disease

A) INTRODUCTION

i) Diseases affect a relatively small proportion of endangered species, compared to most of the things we have talked out. Nonetheless, 1 in 10 endangered vertebrates in the US are affected by disease. It is quite likely that the very low percentages for invertebrates and plants are a result of our poor knowledge of disease in these groups.

ii) Probably the greatest threats come from emerging new diseases. Very often these will be diseases that are also introduced species.

iii) Changing conditions can also result in new outbreaks of diseases that have been present in an area for a long time. For example, if changes in habitat availability concentrate individuals into a small area, the rate of transmission is likely to go up, making a large outbreak more likely.

iv) The effects of existing diseases in an area can also be amplified by the fact that a species has become endangered through other means. For example, if a species is so rare that it must be brought into captivity, then it is likely to be exposed to diseases that it might not otherwise encounter. As populations decrease in size, they are likely to become more inbred (especially if in captivity), which might make them more vulnerable to disease. In fact, simply by having a small population a species is increasingly vulnerable to a disease outbreak, just because there are fewer individuals that are likely to have the genetic ability, overall good health, or simply good luck, to avoid succumbing to the disease.

B) EMERGING DISEASES

i) Example: Chytrid disease in amphibians was only discovered in the late 1990s, but has rapidly spread worldwide and has caused rapid declines of many different species.

ii) Example: Devil Facial Tumor Disease in Tasmanian devils was also discovered only in the 1990s. The disease is a cancer that can be transmitted from one individual to another (via bites during fighting). All devils that get the cancer die and it is predicted that the disease will have spread throughout the entire range by the end of the decade. In areas where DFTD is present there have been declines of up to 90%.

iii) Example: A century ago, the American chestnut was a dominant tree in eastern forests. Now it is almost entirely gone, due to the introduction of a fungal disease that kills mature trees. Chestnut blight was introduced to North America from Asia in 1904. It rapidly spread throughout the range of the tree in only a few decades. Chestnuts persist, but only in isolated places or as root sprouts.

C) CONTROLLING DISEASE

i) In some cases it is possible to address disease problems through direct intervention.

ii) Example: The Ethiopian wolf has a small population and has suffered serious declines due to rabies. Researchers, however, have shown that it should be possible to slow the spread of the disease by vaccinating as few as 30% of the animals in the population. The trick is to identify when/where outbreaks occur and then target those individuals that are most likely to contribute to disease spread (i.e., basic biological knowledge about the population is needed).

iii) This study is important because vaccinating entire populations is often impractical, but the research suggests that it is not always necessary.