EEB 2208: LECTURE TOPIC 10

INVASIVE SPECIES

Reading for this lecture

Primack: Chapter 10.
Discussion paper (for 22 Feb): Ransom et al. 2007. Cascading effects of the loss of apex predatory sharks from a Coastal Ocean. Science 315:1846-1850.
On-line at: http://www.sciencemag.org/cgi/reprint/315/5820/1846.pdf

Optional supplemental reading: Cassey et al. 2004. Global patterns of introduction effort and establishment success in birds. Proceedings of the Royal Society of London, Series B, 271, S405-408.
On-line at: http://www.jstor.org/stable/4143021

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) 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.
ii) Most introductions also 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.

iii) 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.

D) CAN WE PREDICT WHICH SPECIES WILL BE INVASIVE?

i) In a very gross sense we can determine which species are likely to become invasive. Successful invaders have a host of typical characteristics:

Successful invaders	Unsuccessful
abundant in original range	rare
polyphagous (eats lots of things)	monophagous
short generation times	long
much genetic variability	little
fertilized female able to colonize	not
larger than most relatives	smaller
associated with humans	not
habitat / environmental generalist	specialist
disturbed habitat users	not

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

iii) Even though there are a host of biological characteristics that are good predictors of 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 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. See Cassey et al. 2004 reference (above).

2. Why do people move species to new areas?

A) HUNTING/FISHING

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 been blamed for 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 …. OK you get it), 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 various 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 major 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, a single cat (belonging to the local lighthouse keeper) wiped out an entire species: the Stephen's Island wren, which was found only on a small island near New Zealand.

C) HORTICULTURE/AGRICULTURE

i) 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.

ii) A few examples of invasive plants include: Kudzu, which is now found in the southeastern US and which completely overgrows everything it encounters. Tamarisk (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.

iii) Finally, purple loosestrife is a species that you can easily find around Storrs (even on campus). 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.

D) 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 on the island (including some found nowhere else in the world) began to decline. Now they 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 critters it contains) thousands of miles away. It is 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.

E) INCIDENTAL INVASIONS DUE TO HUMAN ACTIVITES

i) Explosive population growth of "white" geese : Most species that are termed invasive are introduced. But sometimes the term is used for native species that have expanded their ranges (e.g., like brown-headed cowbirds, which we discussed in a previous lecture), or that have simply undergone massive population growth. An example of the latter, involves two species of North American geese – snow and Ross's geese. These birds breed in the Arctic and winter in the southern US (in California, and along the Gulf and Atlantic coasts). Their populations have steadily increased in recent decades, largely because of increased food availability at wintering/migration sites, which tend to be agricultural areas where there is now a lot of spilled grain available after harvest. Predation during these periods is also higher than it was historically (both because there is much less human hunting, but also because many natural predators have declined).

ii) 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.

F) BIOLOGICAL CONTROL

i) Another reason for introducing a species to an area is to try to undo the results of a previous introduction. Frequently, attempts have been made to control invasive species using biology. A common argument is that a key 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.

ii) The history of biological control is very checkered – with many complete failures. For 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, mongoose 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 species that they could find during the day instead – these included several native wetland birds and their young. Today mongoose are the subject of major predator control programs (designed to protect native species) in may parts of Hawaii.

iii) Biological control is not always a disaster. In some cases it has worked very well – e.g. 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.

iv) 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 the species that needs to be controlled. Extensive testing prior to release is consequently an important part of many biological control programs today.

3. Invasive species in Connecticut

i) If there is time I'll end this topic by talking, briefly about a couple of projects focused on invasive species in CT.

ii) One looks at the way in which introduced birds interact with introduced plants, potentially to the mutual benefit of both.

iii) The other is the Invasive Plant Atlas of New England (IPANE) project, which aims to map the distributions of invasive plants throughout the region, and to better understand patterns and mechanisms of spread in introduced plants. More information on this project can be found at: http://nbii-nin.ciesin.columbia.edu/ipane/