

Threats to terrestrial ecosystems in the 21st century (2 of 2)

1a. Habitat fragmentation: general effects

Effects of habitat fragmentation from the Amazon

- Most small terrestrial mammals won't cross 80-meter swaths of pasture between forest fragments (although habitat generalists, like some possums, will).
- Carrion and dung beetles in 1 and 10 ha fragments isolated by more than 350 m for 2 or more years, are represented by fewer species, sparser populations, and smaller individuals than in nearby continuous forest. Decrease in density of these beetles is correlated with decrease in decomposition rate of dung and carrion.
- Deep-forest euglossine (stingless) bee species will not cross a clearing of 100-meters, thus isolating bees in such fragments, and the orchids that they pollinate as well.

Why do bees matter?

- The presence of forest-bee species in coffee plantations within 1 km of forest fragments increases coffee yield by 20%, and improves coffee quality by reducing the frequency of small, misshapen seeds by 27%.
- On one Costa Rican farm, during 2000-2003, these "pollination services" from adjacent forest fragments increased the value of the annual crop by \$62,000, or 7%.
- Cutting those fragments and turning them over to cattle grazing would yield only \$24,000 / year, total. (Source: Ricketts *et al.* 2004. Economic value of tropical forest to coffee production. *PNAS*, **101**, 12579-12582.)

Habitat fragmentation: more effects from the Amazon

- Small mammals have *greater* species richness, individual abundance, and total biomass in small fragments than in continuous forest.
- Vertical distribution of mammals changes in fragments: greater biomass of mammals are in the trees in continuous forest, but on the ground in fragments.
- Same pattern holds for insect abundance and foliage density: in continuous forest, insects and leaves are denser in the canopy, in fragments, insects and leaves are more abundant in the understory. (Ref: Bierregaard *et al.* 1992. The biological dynamics of tropical forest fragments. *BioScience* 42:859-866.)

1b. Habitat fragmentation: causes

1c. Habitat fragmentation: implications for conservation

2a. Harvest for food: bushmeat

- Example: Chimps in Africa
 - ◊ Hunters have guns, chimps don't, and chimps are social and deeply bonded to one another, so will stay to protect individuals that are hurt or killed—thus, whole families are easily killed in short order.
 - ◊ Up to 10 tons of African bushmeat pass through Heathrow every day.
- Additional unobvious problems: Orphans often result from the hunting of families, which produces the opportunity for selling into the pet trade.

2b. Harvest for pet trade

- Why? Western desire for the exotic.
- Example: parrots all over the world.
 - ◊ 1/3 of world's 300 parrot species are currently threatened with extinction due to collection for pet trade, in combination with habitat loss (from Worldwatch Institute, *Winged Messengers: The Decline of Birds*)
 - ◊ In neotropical parrots, poaching of nests is a significantly greater cause of mortality than natural causes (Wright *et al.* 2001. *Nest Poaching in Neotropical Parrots*. *Conservation Biology*. 15:710-720.)
- Additional unobvious problems: Money rarely ends up in hands of local (indigenous) people, so local economies are not helped. The Western pet industry makes the profits.

Illegal pet trade in Madagascar

- Leaf-tailed gekkos (*Uroplatus*)
- Poison frogs (*Mantella*)
- Boas (*Boa*, aka *Sanzinia*)
- Micro-chameleons (*Brookesia*)

3. Non-anthropogenic disturbances

Intermediate Disturbance Hypothesis

- Intermediate levels of disturbance (e.g. regular but infrequent hurricanes on the Mosquito coast of Central America) produce the highest levels of species richness.
- Higher levels of disturbance (e.g. the effects of the tsunami on ecosystems around Banda Aceh) are a stress that wipes out species; while lower levels of disturbance encourage a few superior competitors to rise to dominance (that is, competitive exclusion rules the day).
- This is a popular, if not extremely well-supported, hypothesis (Connell, J. H. 1978. Diversity in tropical rain forests and coral reefs. *Science* 199: 1302-10.). Disturbance level is only one of many factors that may influence species richness. Others include...?

4. Invasive Species: Defining terms & process: see figure 1 from Duncan *et al.*, 2003.

Official U.S. definitions from Executive Order 13112 signed by Clinton on 2/3/99 are:

Alien species: with respect to a particular ecosystem, any species, including its seeds, eggs, spores, or other biological material capable of propagating that species, that is not native to that ecosystem (equivalent term in the scientific lit: ***introduced spp.***)

Invasive species: an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health.

Several terms are often used interchangeably, including exotic, invasive, introduced, & alien species.

4b. Invasibility

- Species can be invasive, or out-competed by invasive species, and there ought to be knowable parameters of species that allow us to predict how invasive, or susceptible to invasion, particular species are.
- Ecosystems cannot themselves be invasive (because they are not an evolved entity--that is, their constituent parts do not have "shared fate."). But ecosystems may have traits that make them more or less susceptible to invasion.
- Duncan *et al.* (2003:78) thus identify three main factors that affect the likelihood of establishment of a species:
 1. characteristics of the introduced species,
 2. features of the introduction location, and
 3. factors associated with the particular introduction event (e.g. # of individuals released).

Ecosystem invasibility: observations

- Temperate ecosystems are highly invasible.
- Islands are highly invasible (although Duncan *et al* 2003 find little evidence in birds).
- The tropics don't experience massive invasions from the temperate zone (specialists being better competitors than generalists), but tropical species can invade other tropical habitats.
- Tropical species succeed in temperate zones when protected from abiotic pressures (e.g. cold); temperate species succeed in the tropics when protected from biotic pressures (e.g. competition).

Invasibility: the natural enemies hypothesis (aka: enemy release hypothesis).

- Introduced species are without their co-evolved suite of predators/ herbivores, competitors, and pathogens. Therefore, they will outcompete native species that are still living their normal lives.
- **Evidence:** St. John's Wort (*Hypericum perforatum*) is native to Europe but widespread in N. America. In America, it generally occurs at higher densities, experiences lower mortality, and shows less evidence of herbivore damage. However: overall population size was not significantly different between ranges, and plants in N. America were smaller, on average, than those in Europe (which may affect fecundity, although this wasn't tested).
- **Conclusion** from this empirical example: herbivore pressure is lower in the non-native habitat, but ecological dominance and/or success of the introduced species may not be affected by this. (Source: Vila *et al.*, 2005. Evidence for the enemy release hypothesis in *Hypericum perforatum*. *Oecologia* 142(3): 474-479.)

Invasibility: allelopathy

- Definition: the chemical inhibition of one organism by another. Specifically, the production and release of chemical substances by one species that inhibit the growth of other species (usually refers to plants).
- Hypothesis: A variant of the natural enemies hypothesis: chemicals secreted by introduced species are more likely to be effective at inhibiting growth or reproduction of native species because there is no history during which the native species could evolve resistance.

- General evidence: invaders often establish monocultures where diverse communities once flourished (rare in “natural” communities).
- Specific evidence: *Centaurea diffusa* (a Eurasian forb now in Western N. America) produces chemicals that inhibit Phosphorus uptake in N. American species, but its native neighbors show no effects. (Source: Hierro & Callaway, 2003. Allelopathy & exotic plant invasion. *Plant & Soil* 256: 29-39.)

Invasibility: the evolution of increased competitive ability hypothesis

- **Hypothesis:** Introduced species will evolve to outcompete natives in their new homes.
- **Predictions** for the EICA include: organisms will lose defenses no longer necessary in their new environment, and shunt those resources to increased competitive ability. Put another way: there is a trade-off between growth and defense, and the organisms are moving along the trade-off line.
- For plants, this could mean larger size, faster growth, or greater reproductive capacity.
- **Supporting evidence** from Chinese tallow trees (*Sapium sebiferum*): introduced individuals show faster growth and less investment in phytochemicals that deter herbivory.

4c: Examples of species introductions

- *Hydrilla* and Manatees in the Panama Canal
- Lizards in the Bahamas
- Poison frogs in Costa Rica

Motives of ecotourism

- Touted by its proponents as a way to increase awareness among the lay public of the beauty and utility of ecosystems.
- If not shaped by knowledge of ecosystem function, though, it has the potential to greatly disturb the habitats it purports to have an interest in saving.
- Ecotourism providers are in business, and therefore have a profit motive. While they cannot attract ecotourists to wholly destroyed ecosystems, they can attract non-savvy ecotourists (which is most of us) to artificially hyped ecosystems, which are more dramatic and appealing, if neither sustainable nor “natural.”

Ecotourism (or, humans as invasive species)

- Ecotourists visit pristine or nominally intact forests and potentially change the ecosystem.
- Benefits of tropical ecotourism are touted as bringing revenues from rich industrialized countries to financially poor, biologically rich countries.
- If the ecotour companies are not based in the vacation destinations, though, local economies are not helped, and destruction of local habitats matters little to the industry.
- Keep the money local in as many ways as possible to allow ecotourism to help local people and economies.