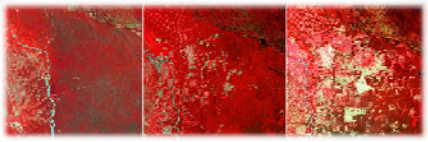


Fragmentation

The Greatest Cause of Global Amphibian Declines

Cathy Nipper

What is Fragmentation?

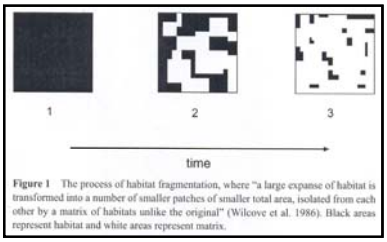
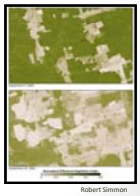


Figure 1 The process of habitat fragmentation, where "a large expanse of habitat is transformed into a number of smaller patches of smaller total area, isolated from each other by a matrix of habitats unlike the original" (Wilcove et al. 1986). Black areas represent habitat and white areas represent matrix.



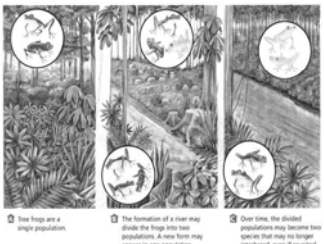
Robert Simmon

Rondonia, Brazil,

Types of Habitat Fragmentation

Natural

- Water bodies, mountains, deserts, elevation changes



Anthropogenic

- Conversion of one vegetation type to another: roads, power lines, development, land clearing, fences, buildings e.g.
- Causes a lag time between changes to amphibian habitat and a species-specific response
- Creates conditions by which species have not evolutionarily adapted

Effects of Fragmentation

- Physical barriers prevent many amphibians from successfully dispersing among the multiple habitat patches they need to access in order to fulfill critical life cycle processes (Cushman 2006)
- Isolation of small populations which may have problems with population fluctuations, genetic deterioration, and habitat changes

Edge Effects

- The edge of an area provides a buffer between two different types of habitats and can alter microclimatic conditions
- Often, more fragmented forests have more edges adjacent to pasture or other suboptimal amphibian habitat
- The negative effects of such habitat disturbance may penetrate into the interior of small forest fragments (Wells 2007)

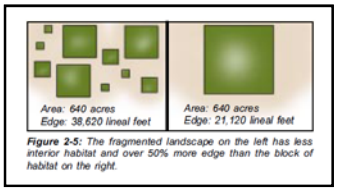


Figure 2-5: *The fragmented landscape on the left has less interior habitat and over 50% more edge than the block of habitat on the right.*

"Despite the frightening nature of emerging diseases such as chytridiomycosis, the most immediate threat to amphibians throughout the world remains the wholesale degradation, fragmentation, and outright destruction of habitats, especially tropical forests" (Wells 2007)

"Habitat loss, fragmentation and degradation, which often result from urbanisation, currently impact 88% of threatened amphibians and are therefore among the greatest threats to amphibians populations" (Hamer & McDonnell 2008)

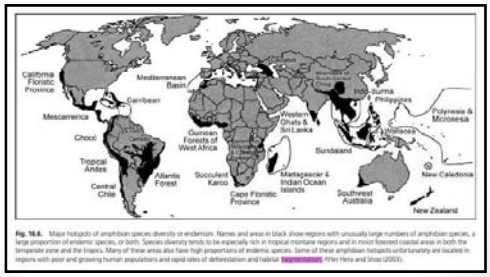


Fig. 16.6. Major hotspots of amphibian species diversity or endemism. Names and areas in black show regions with unusually large numbers of amphibian species, a large proportion of endemic species, or both. Species diversity tends to be especially rich in tropical montane regions and in moist forested coastal areas in both the temperate zone and the tropics. Many of these areas also have high proportions of endemic species. Some of these amphibian hotspots unfortunately are located in regions with poor and growing human populations and rapid rates of deforestation and habitat fragmentation. After Hero and Shea (2003).

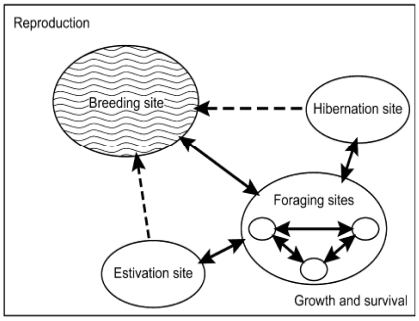
Fragmentation: Madagascar

- Nearly all amphibian species are endemic & species diversity is high
- With increasing fragmentation of the remaining forested regions, there is the potential for a large assemblage of unique amphibians to disappear (Wells 2007)

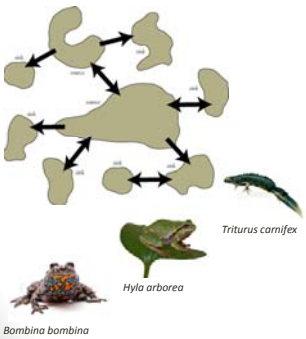
Fragmentation: Vulnerability

- Narrow habitat tolerances: movement is limited by physiological constraints of thermal requirements and water retention.
- Small body size & limited movement
- Many populations are structured as meta-populations (patchy networks)
- Inhibiting or discouraging amphibian dispersal reduces the ability of these networks of populations to function
- High vulnerability to death when moving across roads and through inhospitable terrain

Amphibians: Complex Life Cycles



Europe: Evidence for Negative Effects on Populations in Fragmented Landscapes



- Many widespread European species exist in local meta-populations that depend on a network of breeding ponds
- Periodic extinctions of small populations are balanced by re-colonization from larger populations nearby
- Pond breeding sites become surrounded by inhospitable habitat
- Results in increased mortality increased likelihood of extinction of small populations that are not replenished by migrants from nearby ponds

(Wells 2007)

Fragmentation Effects: Habitat Isolation by Barriers

Increases

-Mortality

-Patch isolation

-Risk of demographic, stochastic and genetic events

-Extinction risk by reducing demographic and genetic input from immigrants

Reduces

-Dispersal

-Genetic diversity

-Patch size patches

-The chance of decolonization after extinction

(Cushman 2006)

Habitat Fragmentation Effects: Alters Population Viability

Decrease in Habitat Availability +

Increase in Isolation of Each Remaining Habitat Patch=

- Reduces population size
- Reduces immigration from other populations
- Impedes demographic rescue effects
- Favours genetic drift and inbreeding
- Inbreeding results in stress and populations less capable of adjusting to new situations
- Loss of rare alleles and a reduction of heterozygosity following bottenecks
- Erosion of genetic diversity & alteration or reduction of fitness
- Inhibits the ability of a population to respond to rapid environmental changes

Studies Comparing Genetic Variation and/or Gene Flow in Fragmented *Versus* Non-Fragmented Landscapes in Populations of the Same Species:

- Arens *et al*. (2004) compared genetic diversity in moor frog (*Rana arvalis)* populations in two areas fragmented by roads and agriculture, but differing in time since the establishment and intensity of barriers. Higher genetic differentiation and lower genetic diversity was documented among sub-populations in the most intensively cultivated area.

- Anderson *et al.* (2007) provided evidence of how fragmentation has contributed to bottlenecking and subsequent inbreeding in the European tree frog *Hyla arborea.*

- Lesbarreres et al. (2003) documented profound genetic structuring and significantly lower genetic variation in sub-populations of agile frog (*Rana dalmatina)* sampled on either side of a highway, compared to populations sampled far from trafficked roads.

- Hitching and Beebee (1997) showed lower genetic diversity and twice the differentiation among urban common frog (*Rana temporaria)* populations compared to populations from rural habitat, despite study sites in the urban setting being in greater proximity.

- Ficetola et al. (2010) showed that the genetic signal in *Rana latastei* was jointly shaped by postglacial colonization patterns and recent fragmentation, but that fitness, in this case hatching success, was only affected by the latter.

Fragmentation: Indirect Influences

- **Global Warming:**

-Trees that proliferate in fragments contain less biomass, and thereby store less carbon, than do the original rainforest trees they replace

-Forest fragmentation is likely to result in warmer, drier conditions in the remaining forest fragments , increasing catastrophic fire events

- **Roads:**

- Converts interior habitat into edge habitat

- **Exploitation:**

-Introduced edge effects increase human disturbances and opportunities for human interaction or exploitation

- **Introduced Predators:**

-Forest species that exploit edge often dramatically increase in fragmented landscapes

- **Competition:**

-Intensifies interspecific competition when fragmentation causes limitations for space, food, and shelter

-Ecological changes in fragmentation can favor certain competitors over others

- **Cattle:**

-Acts with fragmentation in a way that increases habitat degradation

- **Insecticides:**

-Elevated forest edge temperatures results in tree trunk insect population buildups

- **Fertilizers:**

- Farmers with smaller fragmented landholdings increase the application of fertilizers in attempt to increase the productivity of the land

- **Herbicides**

-Increased use to combat the introduction & invasion of non-native, weedy plants in openings and edges

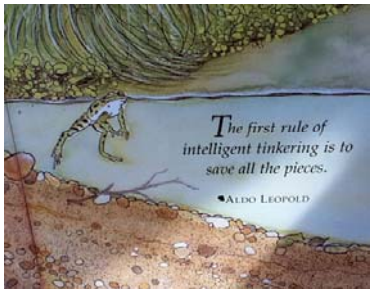
Fragmentation: Synergistic Effects

- Isolated populations that have reduced genetic heterozygosity because of natural genetic bottlenecks or habitat fragmentation also may be at risk from newly arriving pathogens such as ranavirus (Pearman and Garner 2005).
- Because amphibians rely on thermoregulation to maintain homeostasis, changes in temperature and humidity along gradients of natural vegetation can affect their immune responses to pathogens (Wells 2007)
- Habitat change also increases stress hormone production, therefore decreasing host immune capacity and increasing susceptibility to disease in non-natural environments (Wells 2007)
- The negative effects of various pollutants, pathogens and increased UV-B radiation are magnified in individuals with little genetic variability (Allentoft & O'Brien 2010)

Summary: Fragmentation

- Anthropogenic fragmentation increases the loss of genetic diversity in amphibians
- Loss of genetic diversity can affect a population's ability to respond to environmental changes and maximizes the effects of other threats
- Natural habitats are increasingly being fragmented by human activities
- Fragmentation is the greatest cause of global amphibian decline

Questions?



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