ESRM 350

Habitat Loss and Fragmentation

Autumn 2016

“Let's start indoors. Let's start by imagining a fine Persian carpet and a hunting knife. The carpet is twelve feet by eighteen, say. That gives us 216 square feet of continuous woven material. Is the knife razor sharp? If not, we hone it. We set about cutting the carpet into thirty-six equal pieces, total them up--and find that, lo, there's still nearly 216 square feet of recognizably carpet like stuff. But what does it amount to? Have we got thirty-six nice Persian throw rugs? No. All we're left with is three dozen ragged fragments, each one worthless and commencing to come apart.”

- David Quammen, *Song of the Dodo*

Habitat Loss

- Process by which an area is rendered *functionally* unable to support a species
  - can be overt
    - physical transformation of an area from usable to unusable form (e.g., via agriculture, logging, fire, volcanic eruption)
  - or subtle
    - alteration of a key resource or condition (e.g., introduction of a pollutant or invasive species; elimination of a vital prey species)
    - implication?

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  - or subtle
    - alteration of a key resource or condition (e.g., introduction of a pollutant or invasive species; elimination of a vital prey species)
    - implication? Habitat loss can occur without large-scale changes to land cover (easy for us to miss)

Overt Habitat Loss

- To this point, generally regarded as the top cause of animal species endangerment (extinctions and declines)
  - Why?

Table 1. Numbers of species affected by different threats believed to be responsible for causing population declines[a]

Causes of decline	All species [930]	Plants [602]	Birds [68]
Direct human habitat destruction and fragmentation, including logging, road building and diversion of water	497	233	48
Exploitation (hunting, fishing and collecting) and poisoning and/or trapping	90	19	11
Fire and changes in fire regime	102	92	1
Pollution (herbicides, pesticides, oil spills, etc.)	32	4	5
Invasive alien predators and herbivores	131	73	39
Alien plants: competition and indirect habitat effects	431	410	19
Competition with exotic animals (excluding feral and domestic animals)[b]	67	0	14
Feral pigs (herbivory, predation, competition and/or habitat effects)	268	257	8
Grazing and/or trampling by domestic and feral cattle, goats, sheep, horses and burros	327	295	13
Hybridization with alien species	22	5	0
Diseases (including alien and native species)	33	3	23
Parasites (physiological and behavioral)	3	0	2
Other or unknown	169	134	8

Gurevitch and Padilla (2004) *TREE*

Overt Habitat Loss

- To this point, generally regarded as the top cause of animal species endangerment (extinctions and declines)
  - Why? Effects are widespread and often permanent (or at least difficult to reverse in the short term)

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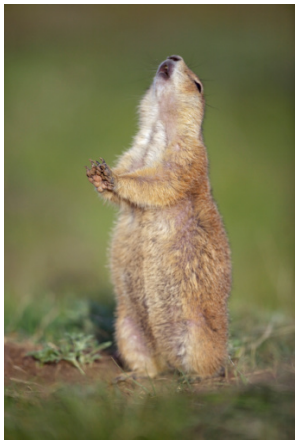
Case Study: Black-Tailed Prairie Dog

- Colonial rodent (ground squirrel) native to the North American plains
  - colonies can be huge: 1000s (millions?)
  - divided into small family groups, or coteries
    - adult male, one or more adult females, offspring
  - facultative hibernators (only when winter conditions are harsh)
- Key prey species for raptors, snakes, and black-footed ferrets
  - prairie dogs communicate threats from these predators using alarm calls
  - calls are functionally referential (identify predator species and threat level)

Black-tailed prairie dog
(*Cynomys ludovicianus*)

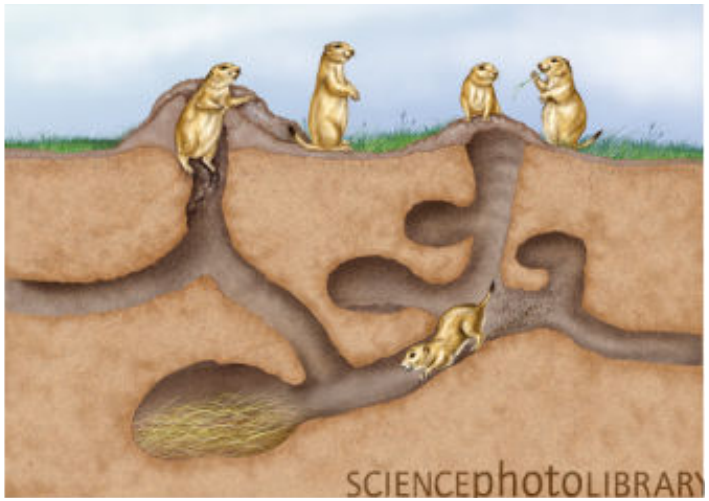


"Jump-yip", or all clear, call

http://dsc.discovery.com/tv-shows/north-america/videos/brave-prairie-dog-confronts-snake.htm

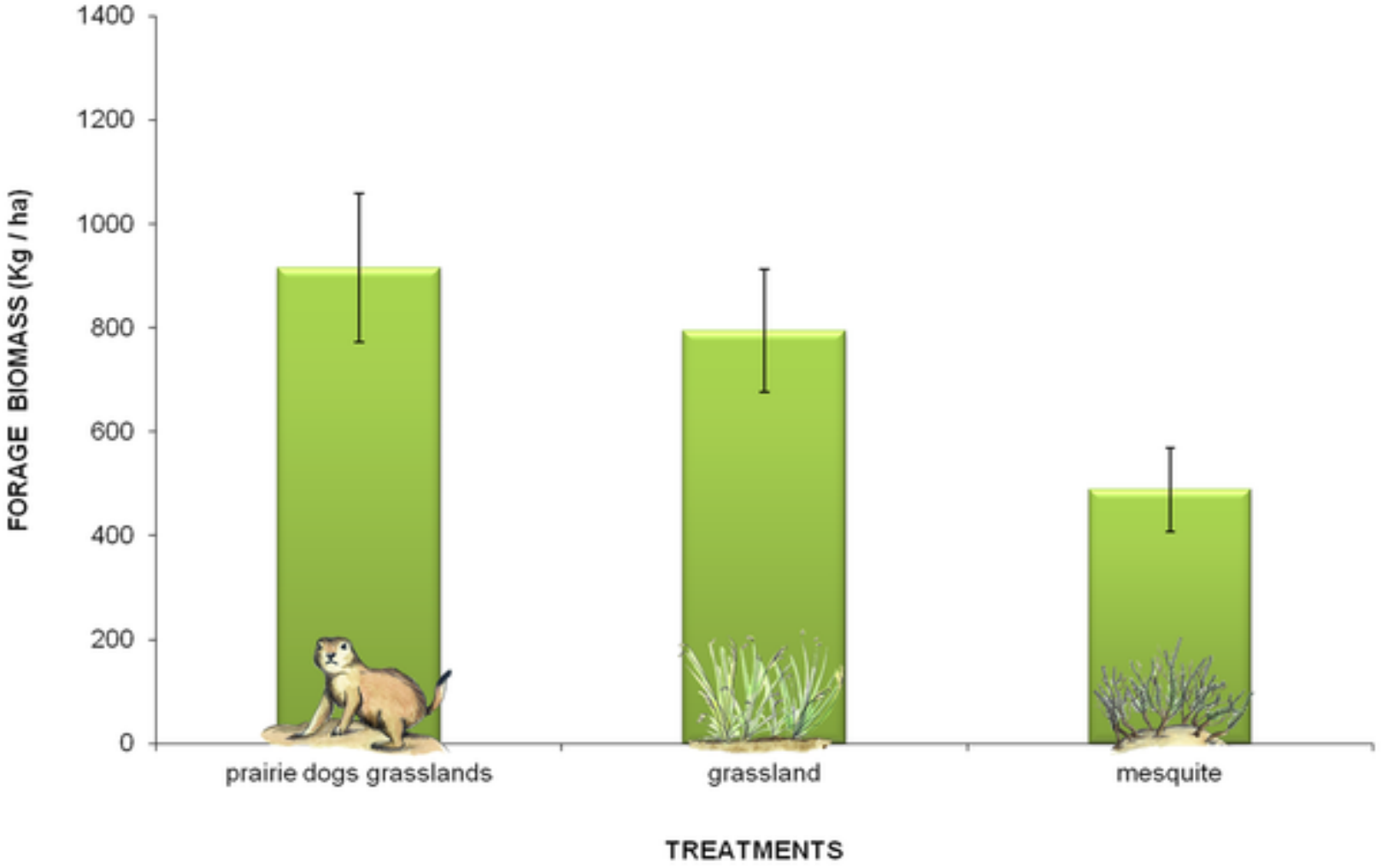
Case Study: Black-Tailed Prairie Dog

- Prairie **ecosystem engineers** – physically modify the landscape in ways that affect other species
  - burrows hydrate the soil, promoting productivity
  - trim down tall prairie grasses, allowing a diversity of shorter grasses and forbs that would normally be shaded out to flourish
    - bison, pronghorn, elk choose prairie dog colonies for foraging over other areas
  - burrows are home for black-footed ferrets, burrowing owls, snakes, spiders



Davidson et al. (2012) *Frontiers in Ecology and the Environment*

Figure 6. Forage availability among treatments in the Janos region, Chihuahua, Mexico.



Martínez-Estévez et al. (2013) Prairie Dog Decline Reduces the Supply of Ecosystem Services and Leads to Desertification of Semiarid Grasslands. PLoS ONE

Prairie Dog Habitat Loss

Currently occupy most of this range, ***but*** only 2% of this area (40 million ha historically to about 766,400 ha today)

Why the decline?

http://www.iucnredlist.org/details/6091/0

Prairie Dog Habitat Loss

Currently occupy most of this range, ***but*** only 2% of this area (40 million ha historically to about 766,400 ha today)

Why the decline?

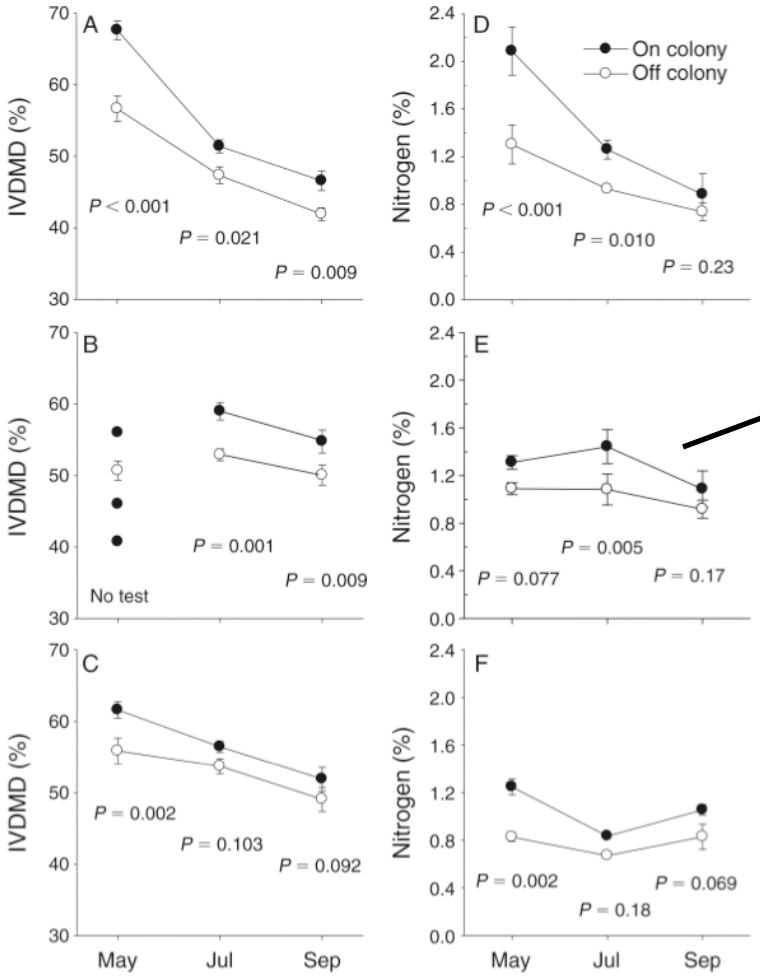
Habitat conversion into agricultural land

Trapped, poisoned, shot in remaining prairie

- considered threat to, and competitor with, livestock

http://www.iucnredlist.org/details/6091/0

Prairie Dogs vs. Livestock



Forage nutrition higher on prairie dog colonies

FIG. 5. Seasonal variation in the in vitro dry matter digestibility (IVDMD) and nitrogen concentration of forage (current-season's growth plus residual standing dead) on active prairie dog colonies and off-colony sites with no prairie dogs present in the past decade. Measurements are from (A, D) the Buffalo Gap National Grassland (northern mixed prairie), (B, E) the Pawnee National Grassland (shortgrass steppe), and (C, F) the Comanche National Grassland (shortgrass steppe). Error bars show ±SE.

Augustine and Springer (2012) *Ecol Appl*

Lessons

- IUCN lists black-tailed prairie dog as “least concern” because of large range, remaining numbers (millions)
  - large geographic ranges can mask habitat loss
- Black-tailed prairie dog recovery will require efforts to combat both overt and subtle habitat loss

http://www.iucnredlist.org/details/6091/0

Habitat Fragmentation

- The breaking apart of continuous habitat
- Fragmentation creates landscapes where habitat is confined in
  - more patches (versus large, continuous patches)
  - smaller patches
  - more isolated patches

Habitat loss can have variable effects on fragmentation

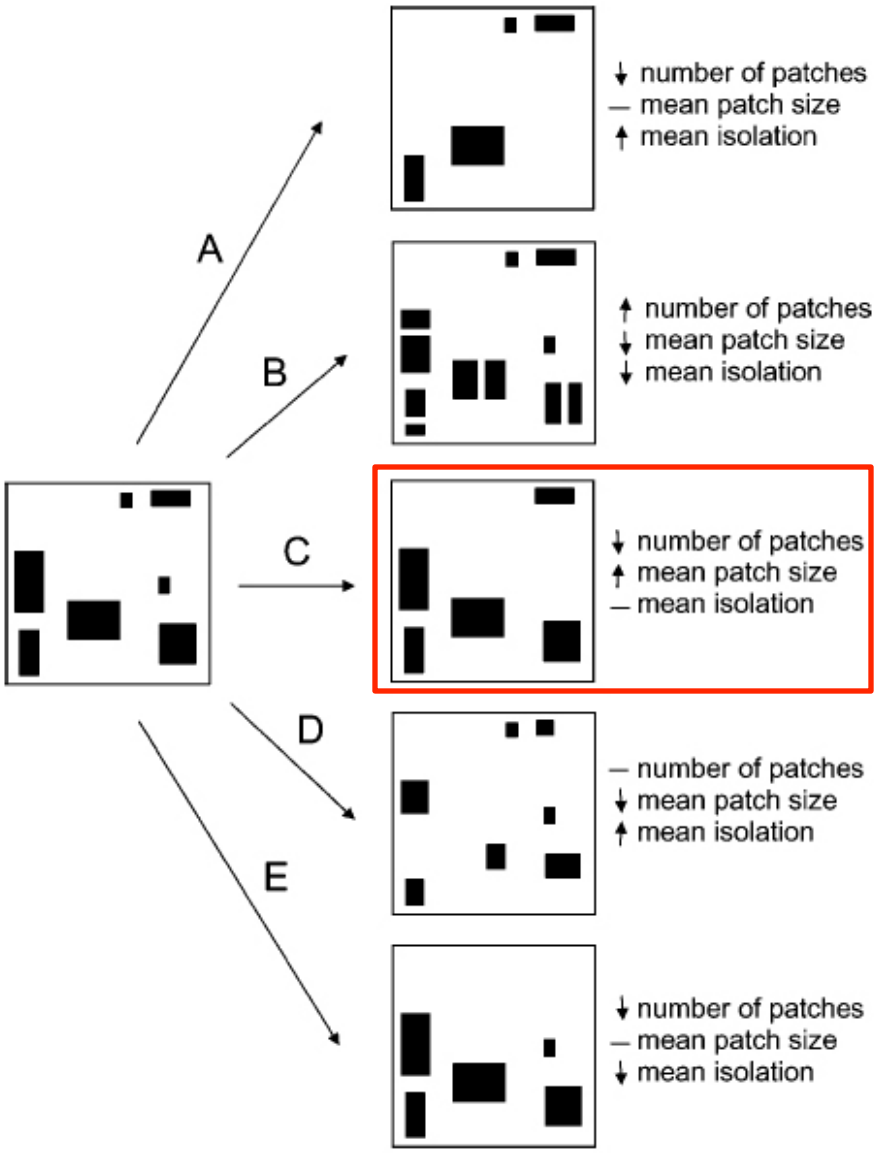


Figure 2 Illustration of habitat loss resulting in some, but not all, of the other three expected effects of habitat fragmentation on landscape pattern. Expected effects are (*a*) an increase in the number of patches, (*b*) a decrease in mean patch size, and (*c*) an increase in mean patch isolation (nearest neighbor distance). Actual changes are indicated by arrows.

Effects of Fragmentation on Wildlife

- Fragmentation can threaten population persistence by
  - diminishing the size of habitat patches
  - isolating patches of habitat
  - creating edge effects

Theory of Island Biogeography

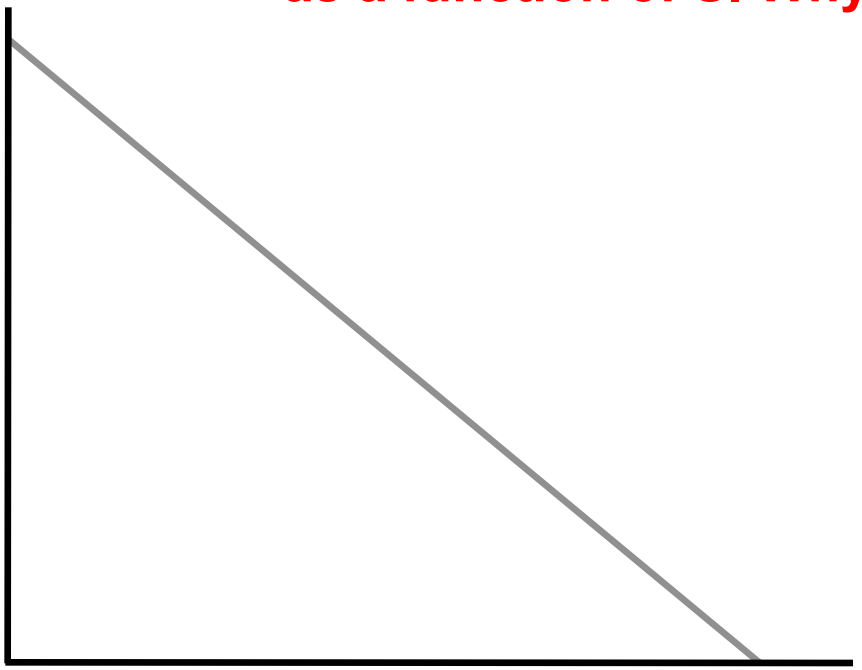
- the number of species on any island reflects a balance between the rate at which new species colonize it and the rate at which populations of established species become extinct
  - can substitute isolated patches of habitat for islands

MacArthur and Wilson (1963) *Evolution*

Theory of Island Biogeography

Immigration rate declines as a function of S. Why?

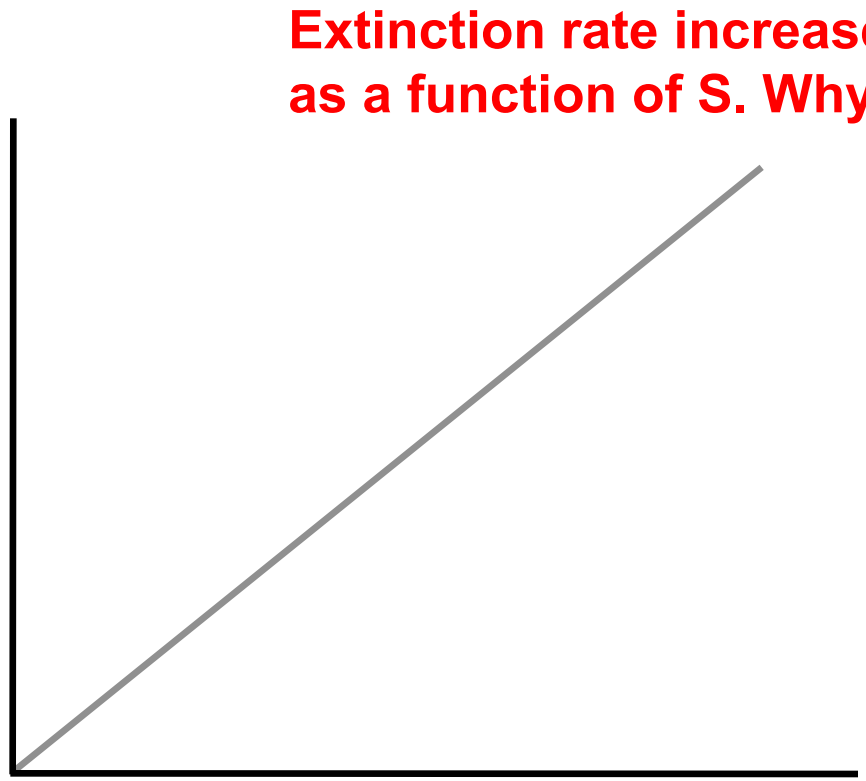
Immigration rate
(*e.g.*, new species per yr)



Number of species (S)

MacArthur and Wilson (1963) *Evolution*

Theory of Island Biogeography



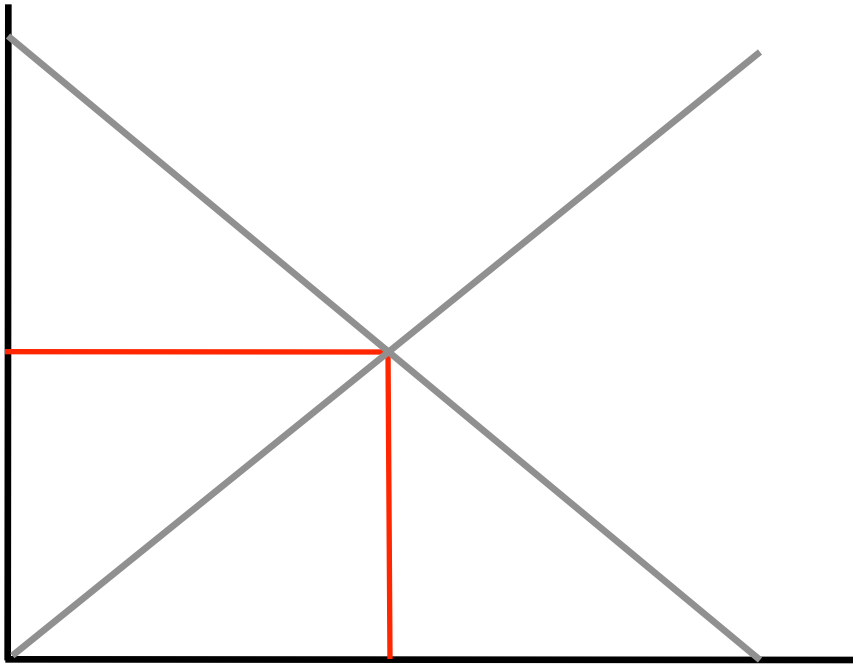
MacArthur and Wilson (1963) *Evolution*

Theory of Island Biogeography

Immigration rate
(*e.g.*, new species per yr)

Turn-over rate (T)

Extinction rate
(*e.g.*, number of species per yr)



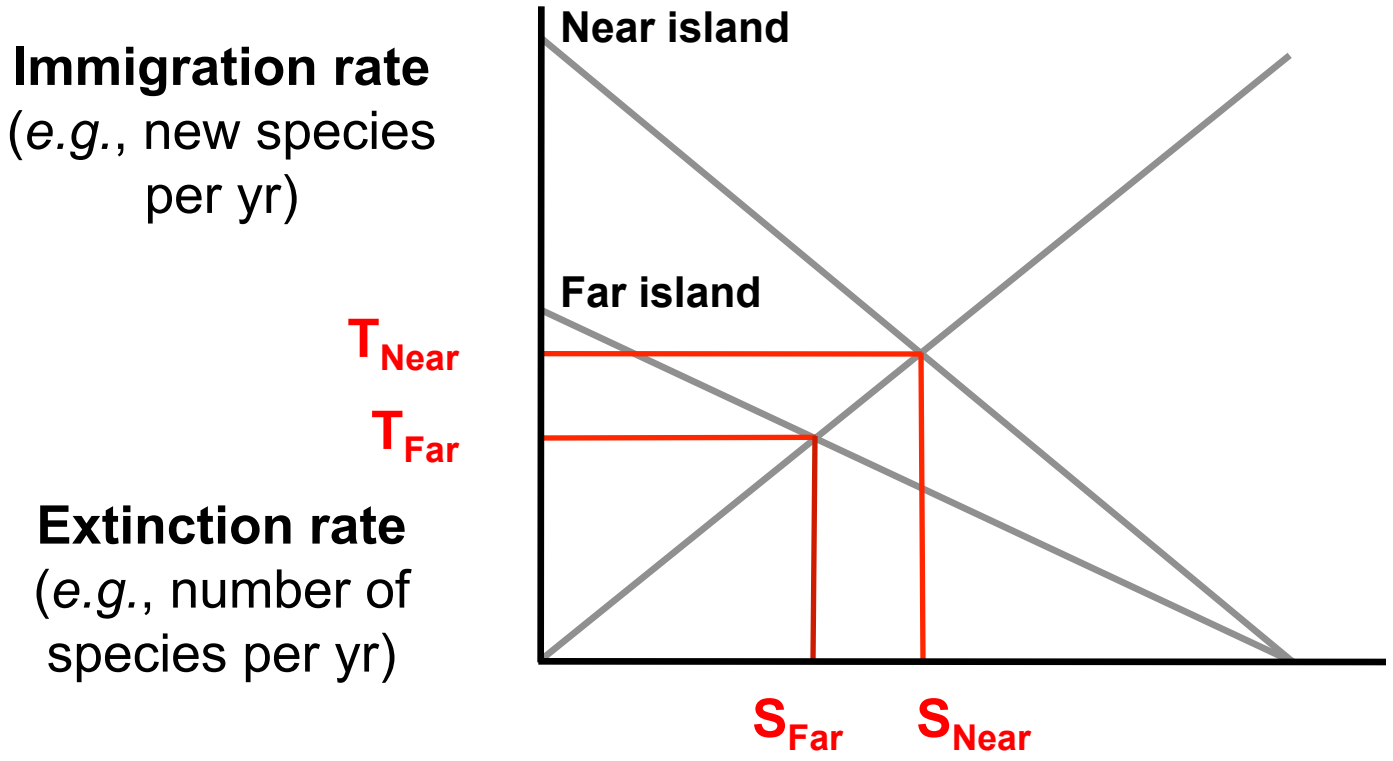
Equilibrium
S

Number of species (S)

MacArthur and Wilson (1963) *Evolution*

Theory of Island Biogeography

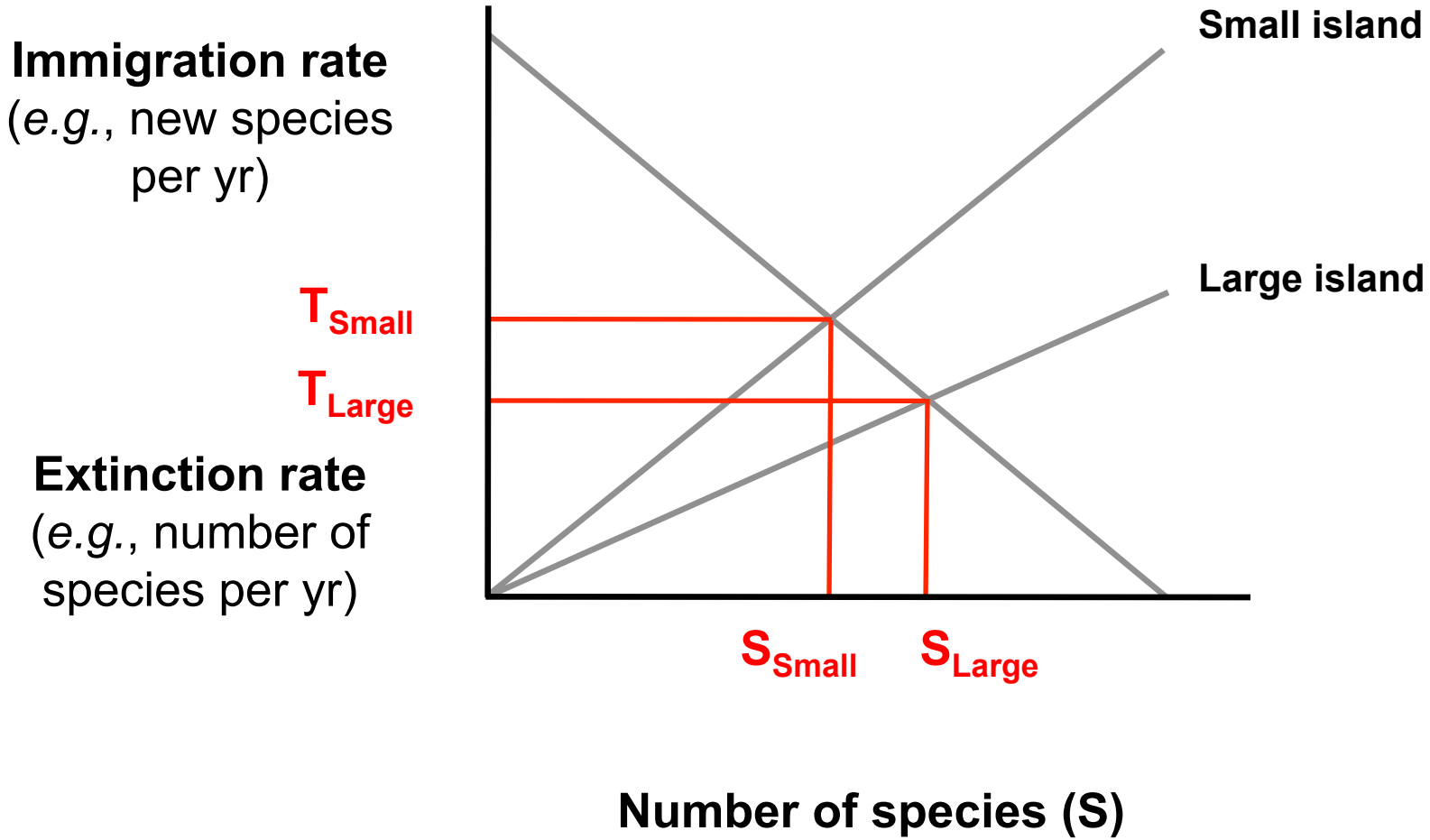
The probability of immigration for each species varies with island isolation? Why?



MacArthur and Wilson (1963) *Evolution*

Theory of Island Biogeography

Why does the probability of extinction for each species vary with island size?



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Theory of Island Biogeography

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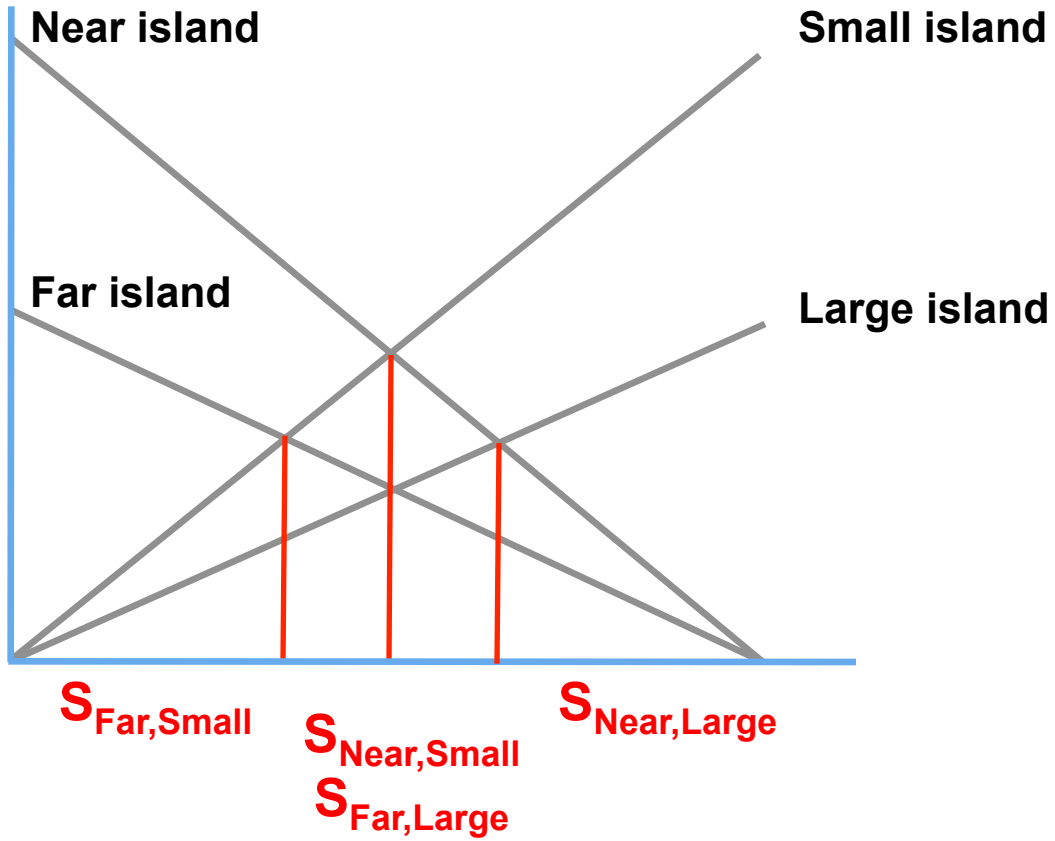
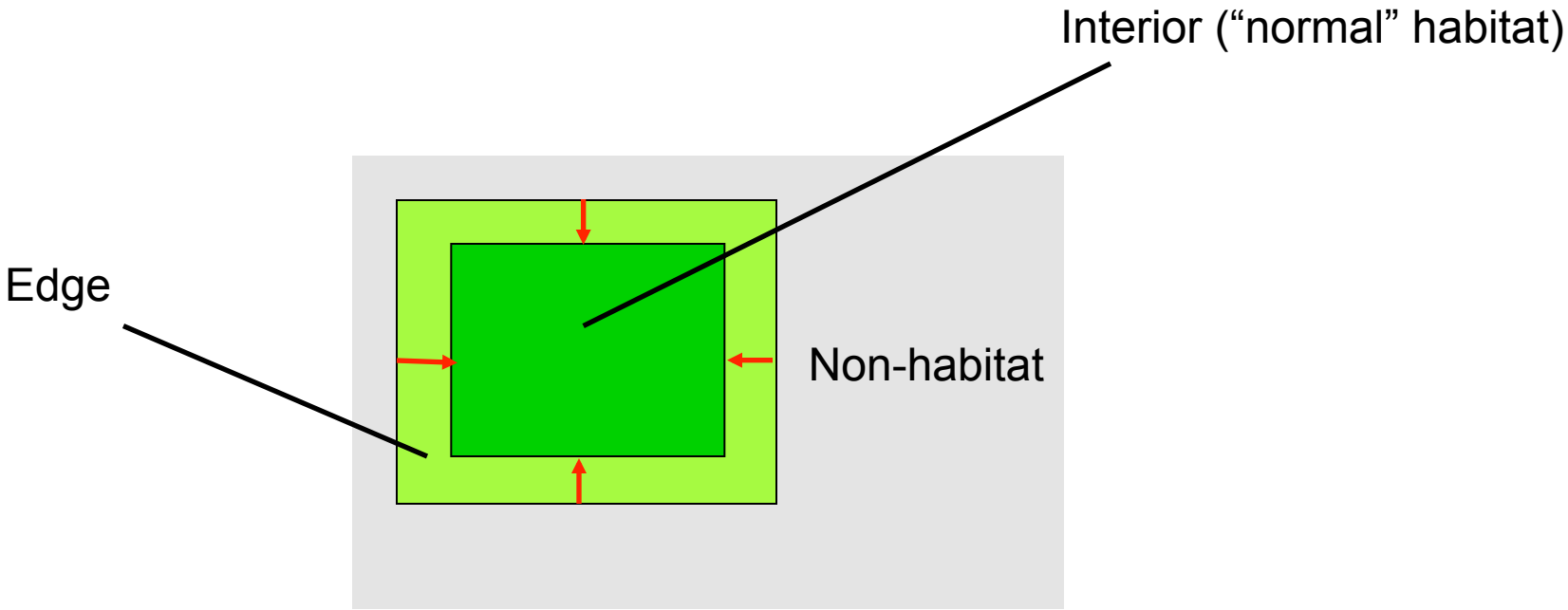


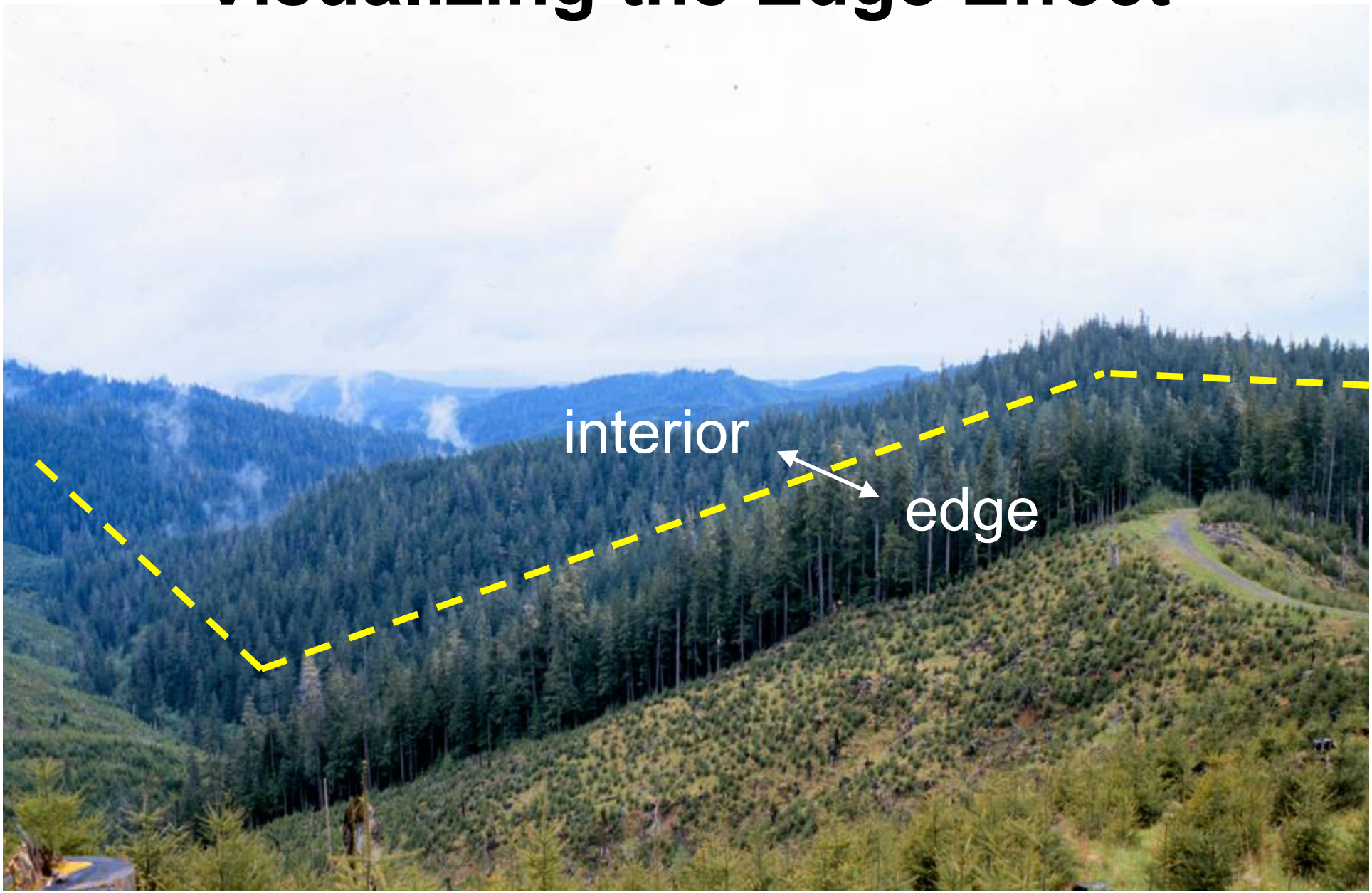
MacArthur and Wilson (1963) *Evolution*

The Edge Effect

- Harm to populations that occurs when negative impacts of non-habitat extend into habitat patch
  - Edge effects can render effective habitat patch size smaller



Visualizing the Edge Effect



Case Study: Nest Parasitism Along the Edge

- Brown-headed cowbird
  - *Molothrus ater*

- Once confined to grasslands
  - now widespread (benefit from human disturbance)
- Parasitize nests of other birds
  - Parents of other species raise their young
  - Parents' own young die (starve)
  - Cowbird nest parasitism especially common along forest edges (don't penetrate into forest interior)

Observations of 21 species of open-nesting passerines breeding in contiguous field and forest habitats at Rose Lake Wildlife Research Area, Michigan, were made during 1974 and 1975.

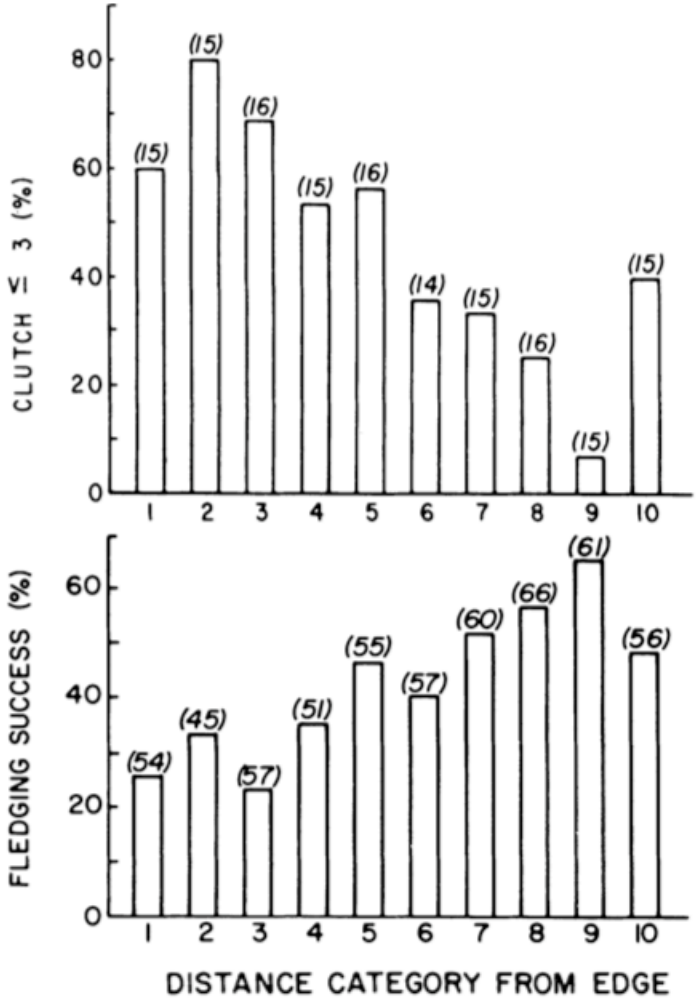


FIG. 3. Relationship of different nest variables with distance from the habitat discontinuity. Distances covered by each distance category are as follows: (1) 0.0–0.82 m; (2) 0.82–2.19 m; (3) 2.19–4.34 m; (4) 4.34–6.86 m; (5) 6.86–10.06 m; (6) 10.06–14.18 m; (7) 14.18–26.74 m; (8) 26.74–46.24 m; (9) 46.24–65.58 m; and (10) 65.58–123.00 m. Sample sizes are in parentheses.

Gates and Gysel (1978) *Ecology*