Lecture 11, 27 Sept 2005

Conservation Biology
ECOL 406R/506R
University of Arizona
Fall 2005

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Conservation Biology 406R/506R

1. Donlan article
2. Role Playing Feedback
3. Exams back Thursday
4. Lab Friday, meet at ECE206
5. Paradigms and Theories (Ch5)

(Pleistocene) Re-wilding of North America

Donlan et al. 2005, Nature, 436:913-914.

1. What happened about 13k yrs ago in N. America?
2. Are there really no apparent costs to restoring Bolson's tortoise?
3. How do you predict African cheetahs and US mountain lions would interact?
4. Is this paper about "playing God"? Are we a natural force in the evolution of life on this planet?

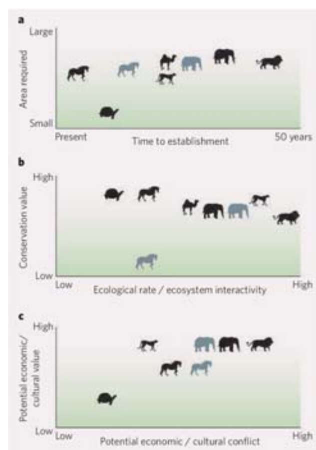


Figure 1 | Pleistocene re-wilding in North America. Symbols represent horses (*Equus caballus* and *E. asinus* in black; *E. przewalskii* and *E. hemionus* in grey), Bolson tortoises, camelids, cheetahs, Asian (grey) and African (black) elephants, and lions. **a**, The likely timescale and area required to restore proxies for extinct large vertebrates. **b**, Conservation value and ecological role (interactivity with other species) on the landscape. **c**, Potential economic/cultural value versus potential conflict.

Sonoran Desert Conservation Plan
Role Playing Exercise (in class 8 September 2005)

Interest Groups for role-playing exercise:

Developers
(Andrew Galassi, Christine Schirmer, Chad Radford, Jennifer Oas)

Ranchers
(Tony Dee, Ariel Tinney, Emily Butler, Lisa Felix)

Center for Biological Diversity
(Brendan Cook, Stacy Skopp, Matt Cole, Kimberly Mars)

U.S. Fish and Wildlife Service
(Aaron Poe, Gabrielle Lehmicke, Linette Ancha, Kathryn Marlor)

Miners
(Erin Deely, Sarah White, Brooke LaFlamme, Justin Schneider)

Panel to Report Recommendations to Pima Co. / Pima County Board of Supervisors
(Nicolas Ramos-Lara,, Natasha Pierce, Jenny Bauman, Samantha Redmon)

Written Assignment

1. Which interest group, if any, "won the debate"? Why? Which interest group fared poorly in your eyes? Why?

2. What information was missing that you think the Advisory Panel would need to make a reasonable recommendation to the citizens and government of Pima County?

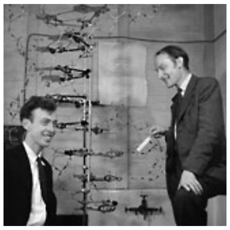
3. What information would your specific group like to have had in order to make your case and represent your point of view?

4. How is the ESA relevant (both positively and negatively) to the SDCP?

5. Please comment on the efficacy of this role-playing exercise.

Chapter 5 (Paradigms...)

- Genetic Diversity (MVP, PVA)
- Island Biogeography
- Metapopulations
- Habitat Heterogeneity
- Disturbance



Chap 6 – Genetics of Conservation Biology

Genetic Diversity

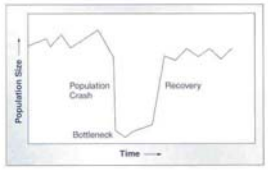


Figure 5.2
A graphical representation of population size before, during, and after a population bottleneck.

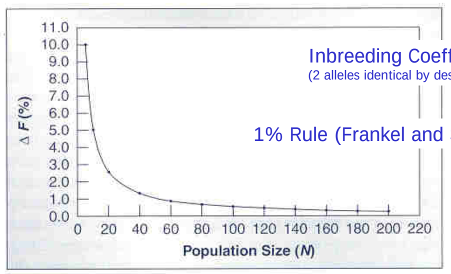
Small Populations
- reduced gene flow
- inbreeding depression
- drift
- stochasticity
- effective population size (N_e)

Declining Populations

Effective Population Size

- $N_e = 4N_mN_f / N_m+N_f$
- Eg: a population of seals with 6 males and 150 females?
- $N_e = (4*6*150)/(6+150) = \sim 23$

Thanks to Chuck Price



Inbreeding Coefficient
(2 alleles identical by descent)

1% Rule (Frankel and Soule)

Figure 5.3
Percent change in the inbreeding coefficient (ΔF) at different population sizes. Note that the value of the inbreeding coefficient increases as population size declines.
After Frankel and Soulé (1981).

Van Dyke 2003

Quickly lose rare alleles in bottlenecks

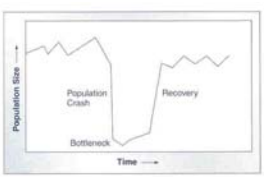


Figure 5.2
A graphical representation of population size before, during, and after a population bottleneck.

Cheetah
Major Histocompatibility Complex

Drift

When populations number less than a few hundred individuals random events become more important to genetic structure of population than natural selection

3,000-10,000 breeding adults

Cyprinodon macularius

Desert Pupfish

Photograph Courtesy of John Rinne

Desert pupfish declined due to the introduction and spread of exotic predatory and competitive fishes, water impoundment and diversion, water pollution, groundwater pumping, stream channelization, and habitat modification.

Healthy population of almost 10,000 fish inhabits this oasis. This last refuge of a unique fish is being actively managed.

Cyprinodon macularius

Desert Pupfish

Family Cyprinodontidae

-1-1/4 inches long
max. age of three years

-females are gray and drab
males are bluish, turning bright blue during spring breeding season.

-feed on insect larvae and other organic matter from pond bottom.

-prefer shallow pond depths, about 12 to 18 inches deep.

Quitobaquito pupfish (Endangered since 1986)

This tiny fish was once part of a widespread population, the range of which included the Colorado, Gila, San Pedro, Salt and Santa Cruz rivers and their tributaries in Arizona and California. The ancestors of the Quitobaquito and Sonoyta river pupfish are believed to have been cut off from their relatives in the Colorado River drainage about one million years ago.

The warm, slightly brackish water at Quitobaquito is ideal habitat for pupfish. Pupfish can tolerate salinity levels ranging from normal tap water to water three times saltier than the ocean. Therefore, they are well suited to desert environments where high evaporation rates create water with high salinity levels.

Although the water temperature at the spring is a constant 74°F, the water temperature in the pond fluctuates greatly during the year, from about 40°F or cooler in January to almost 100°F in August, especially in shallow areas... very tolerant of rapid temperature change and low oxygen content due to summer heat.

Extinction Vortex for a population

F Vortex: inbreeding depression, lethal equivalents (homozygous recessives)

A Vortex: genetic drift and loss of variation (can't adapt)

R Vortex: r = spontaneous rate of increase (coupled with environmental stochasticity)

D Vortex: discontinuity (isolation)

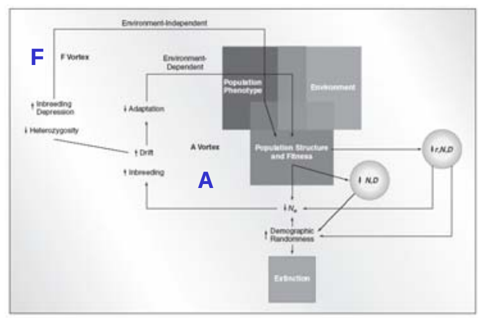


Figure 5.5
The F vortex and A vortex, two accelerating and degenerative cycles of population decline driven by an increasing level of inbreeding depression (F vortex) or a decreasing ability of the population to adapt to a changing environment (A vortex). Both are exacerbated in small populations. N is the population size, D is the population distribution, r is the population's instantaneous rate of increase, and N_e is the effective population size.
After Gilpin and Soulé (1986). VanDyke 2003

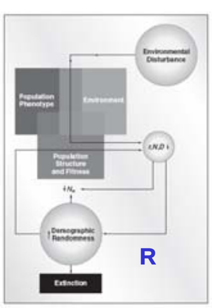


Figure 5.6
The R Vortex, an accelerating and degenerative cycle of population decline driven by increasing vulnerability to environmental disturbance at low population sizes. N is population size, D is population distribution, r is the population's instantaneous rate of increase, and N_e is the effective population size.
After Gilpin and Soulé (1986)

VanDyke 2003

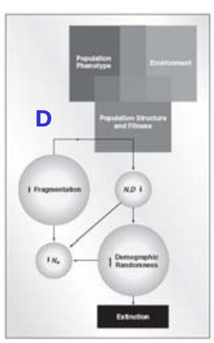


Figure 5.7
The D or discontinuity vortex, an accelerating and degenerative cycle of population decline driven by the fragmentation of the population into smaller and smaller subunits. N is population size, D is population distribution, and N_e is the effective population size. A lowering of N and an increase in demographic randomness can alter the spatial distribution of a population, introducing or increasing fragmentation. More fragmented distributions increase the likelihood of local extinctions.
After Gilpin and Soulé (1986).

Hardy Weinberg Equation

two alleles: p, q

$$(p + q)^2 = p^2 + 2pq + q^2$$

Under Hardy Weinberg Equilibrium
$H_e = 2pq$
H_o can be calculated

If p=0.6, q=0.4, then 2pq = 0.48 = H_e

Wright's Fixation Index

Fst = 0, or <0.01 indicate little divergence among pops.

Fst > 0.1 indicate much divergence among pops.

Hardy Weinberg Equilibrium, two alleles: p, q Expected heterozygosity = 2pq

Fst = (Ht-Hs)/Ht (H= heterozygosity)

Ht → Total Pool

Hs → Separate populations

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Equilibrium Heterozygosity ($\Delta H = 0$)

$$H^* = 2Nm$$

H = heterozygosity
N = population size
m = mutation rate

Therefore, smaller populations have lower equilibrium heterozygosity

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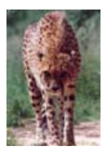
Minimum Viable Population (MVP)
(Frankel, Soule, Franklin, Shaffer)

50/500/+ Rule

→ Short term

→ Mid term

→ Long Term



PVA...

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Equilibrium Theory of Island Biogeography

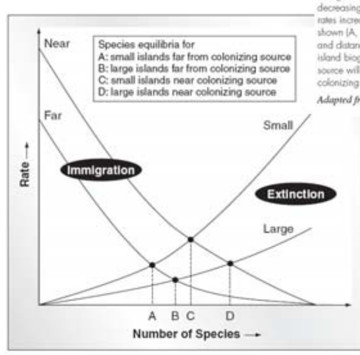

Figure 5.9
The equilibrium model of island biogeography predicts that numbers of species on an island represent an equilibrium between rates of immigration and extinction. Immigration rates increase with decreasing distance from an island's colonizing source. Extinction rates increase with decreasing area of the island. The four equilibria shown (A, B, C and D) depict different combinations of island size and distance from its colonizing source. The equilibrium theory of island biogeography predicts that large islands near a colonizing source will have more species than small islands far from a colonizing source.
Adapted from MacArthur and Wilson (1967).

VanDyke 2003

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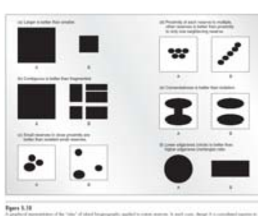
Equilibrium Theory of Island Biogeography



- •Habitat Fragmentation
- •Reserve Design
- •Predictions vs. Observations
- •Missing Factors

Rescue Effect?

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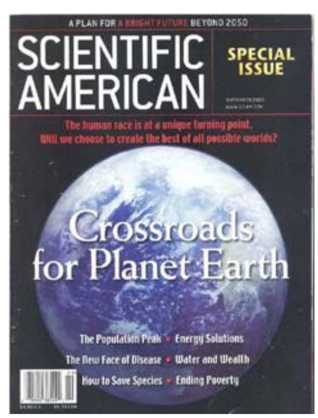

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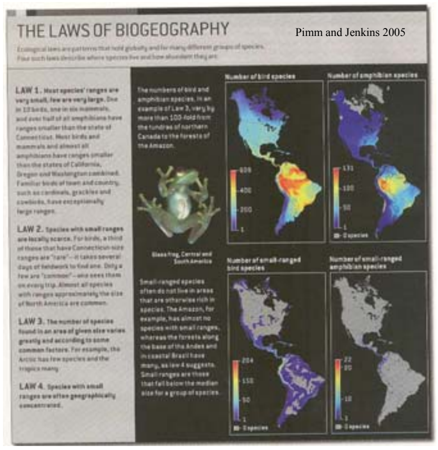

THE LAWS OF BIOGEOGRAPHY

Pimm and Jenkins 2005

Ecological laws are patterns that hold globally and for many different groups of species. Four such laws describe where species live and how abundant they are.

LAW 1. **Most species' ranges are very small, few are very large.** One in 10 birds, one in six mammals, and over half of all amphibians have ranges smaller than the state of Connecticut. Most birds and mammals and almost all amphibians have ranges smaller than the states of California, Oregon and Washington combined. Familiar birds of town and country, such as cardinals, grackles and cowbirds, have exceptionally large ranges.

LAW 2. **Species with small ranges are locally scarce.** For birds, a third of those that have Connecticut-size ranges are "rare" — it takes several days of fieldwork to find one. Only a few are "common" — one sees them on every trip. Almost all species with ranges approximately the size of North America are common.

LAW 3. **The number of species found in an area of given size varies greatly and according to some common factors.** For example, the Arctic has few species and the tropics many.

LAW 4. **Species with small ranges are often geographically concentrated.**

The numbers of bird and amphibian species, in an example of Law 3, vary by more than 100-fold from the tundras of northern Canada to the forests of the Amazon.

Glass frog, Central and South America

Small-ranged species often do not live in areas that are otherwise rich in species. The Amazon, for example, has almost no species with small ranges, whereas the forests along the base of the Andes and in coastal Brazil have many, as law 4 suggests. Small ranges are those that fall below the median size for a group of species.

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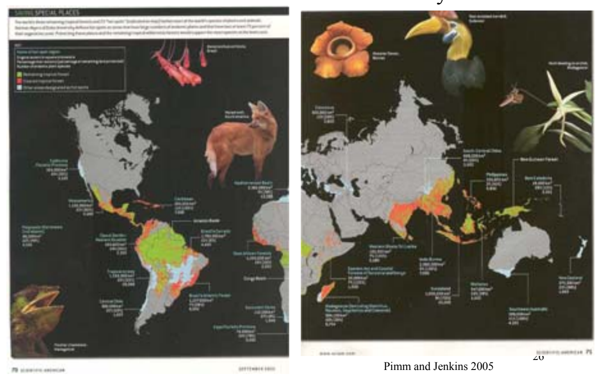
Where is biodiversity?

One tree in Peru with same ant diversity as Britain



Pimm and Jenkins 2005

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Metapopulation:

"Spatially disjunct groups of individuals with some demographic or genetic connection"

"largely independent yet interconnected by migration"

1. All local populations must be prone to extinction
2. Persistence of entire population requires recolonization of individual sites.

See p.193 in VanDyke text

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