Lecture 16, 12 Oct 2006
CH5 Paradigms, CH6 Genetics

Conservation Biology
ECOL 406R/506R
University of Arizona
Fall 2006

Kevin Bonine
Kathy Gerst

## Theoretical Paradigms


Jon G-M

## Genetics

Lab this week:
none until sewage treatment plant on 20 October
27-29 October = ORPI, Pinacate, CEDO (Mexico)
($, food, see website for lab readings)

---

## Housekeeping, 12 October 2006

506 Topic and References (12 Oct → 19 Oct)

Upcoming Readings
today: Text Ch.5, Biogeography excerpt, Ch.6

Tues 17 Oct: Text Ch. 7 (Kathy Gerst, invasive species)
Thurs 19 Oct: Culver 2000, Panther PVA; Text Ch. 6 and 7

Short oral presentations
12 Oct Robert Dietz
17 Oct Sarah Karasz and Allison Peterson
19 Oct Rachel Smith and Shea Cogswell
24 Oct Cori Dolan and Robert Johnson

---

The Arid Lands Resource Sciences
Graduate Interdisciplinary Program
invites you to the
dissertation defense of
doctoral candidate

Maeveen Behan

who will present her dissertation entitled

"Science and Lore in Animal Law"

on Monday, October 23rd
at 9:00 o'clock in the morning
in room 113 of the
Office of Arid Land Studies
located at
1955 East Sixth Street

All are encouraged to attend
Visitor parking available along the back (north) fence

---

## Global Climate Change Lecture Series

All lectures will take place at UA Centennial Hall.

All lectures begin at 7pm and are free to the public. Call 520.621.4090 for more information.

http://cos.arizona.edu/climate/

Tuesday, October 17
Global Climate Change: The Evidence
Malcolm Hughes, Professor of Dendrochronology

Tuesday, October 24
Global Climate Change: What's Ahead
Jonathan Overpeck, Director of the Institute for the Study of Planet Earth and Professor of Geosciences

Tuesday, October 31
Global Climate Change: The Role of Living Things
Travis Huxman, Assistant Professor of Ecology and Evolutionary Biology

Tuesday, November 7
Global Climate Change: Ocean Impacts and Feedbacks
Julia Cole, Associate Professor of Geosciences

Tuesday, November 14
Global Climate Change: Disease and Society
Andrew Comrie, Dean of the Graduate College and Professor of Geography and Regional Development

Tuesday, November 21
Global Climate Change: Could Geoengineering Reverse It?
Roger Angel, Regents' Professor of Astronomy

Tuesday, November 28
Global Climate Change: Designing Policy Responses
Paul Portney, Dean of the Eller College of Management and Professor of Economics

---

## Robert Dietz
## will speak for 10 minutes on Komodo Dragons

---

1. Given limited resources, would you concentrate conservation efforts on one species with high genetic diversity and perhaps several subspecies, OR, would you focus on several different species, each of them with low genetic diversity? Why?

2. Do genetically modified organisms (GMOs) constitute or lead to a conservatio

## Question 4 (due 17 October)

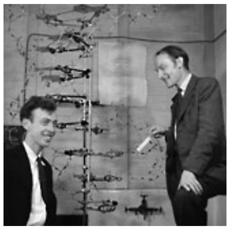
3. You have just been hired as a conservation consultant. Based on what you know from the SDCP and other research, what do you believe are the most important components of an effective policy? Why are these components so important to good conservation planning?

4. If islands are such “endemic hotspots,” should they be considered a conservation priority even though they comprise a small percentage of the world’s land mass? (similar scenario for coral reefs in marine systems)

5. How do advances in technology and increased understanding of molecular biology/genetics both bolster and detract from the goal of Conservation Biology and the ESA?

Chapter 5 (Paradigms…)

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



Chap 6 – Genetics of Conservation Biology

Equilibrium Theory of
Island Biogeography

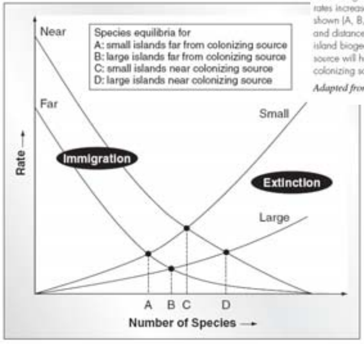


**Figure 5.9**
The equilibrium model of island biogeography predicts that numbers of species on an island represent an equilibrium between rates of immigration and extinction. Immigration rates increase with decreasing distance from an island's colonizing source. Extinction rates increase with decreasing 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

Equilibrium Theory of
Island Biogeography

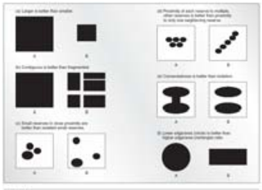


Figure 5.10

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

Rescue Effect?

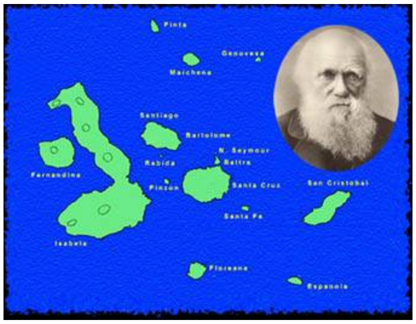
Island Biogeography
Quammen Excerpt from *Song of the Dodo* (p.52-55)

Lyell
Wallace
Darwin

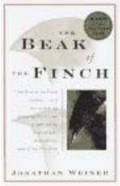
Frogs vs. Birds

Oceanic vs. Continental

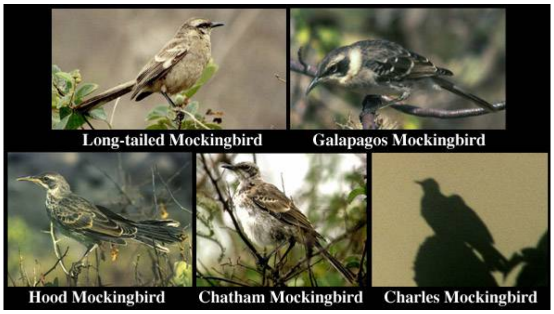
Size, Age, Distance



Daphne Major



http://www.rit.edu/~rhrsbi/GalapagosPages/DarwinFinch.html



http://www.rit.edu/~rhrsbi/GalapagosPages/mockingbird.html

Galapagos

Humboldt Current

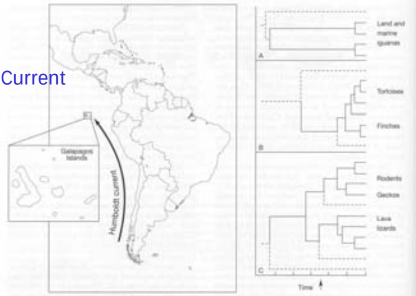


*Figure 5–11* **Phylogenetic relationships and patterns of colonization of vertebrates in the Galapagos Islands.** *Left,* The location of the Galapagos Islands and the direction of the Humboldt Current, which presumably helped transport colonizers to the islands. *Right,* Three major patterns of relationships of Galapagos vertebrates. The time scale is arbitrary. The arrow on the horizontal axis indicates the time of origin of the present archipelago and/or the initial introduction of each group. Solid lines indicate the radiation of the endemic Galapagos taxa; dashed lines indicate the relationship of these taxa to their closest living mainland sister group. (A) Pattern of relationships for the land and marine iguanas (*Conolophus* and *Amblyrhynchus*), which show minimal differentiation within species, but share a remote common ancestor considerably earlier than the origin of the islands. (B) The giant tortoises (*Geochelone*) (and Darwin's finches) are endemic radiations within the archipelago stemming from a single colonization event. In the case of the tortoises, the mainland ancestral group appears to be extinct. (C) The gecko (*Phyllodactylus*), lava lizard (*Microlophus*), and rodent radiations appear to have resulted from multiple introductions from separate mainland stocks already differentiated to some degree. *(Source: Patton 1984.)*

Pough et al. 2004

- Plate tectonics
- Climate (glaciation, drought)
- Sea level

*Table 5–5* The amount of time during two Pleistocene intervals that sea levels in southeast Asia were at or below present levels (BPL; given in meters). The approximate number of years in each time period, the approximate percentage of years in each time period, and the estimated number of times within each period that sea level fell below the level shown in column 1 are given.

| | Past 150,000 years | | | Past 250,000 years | | |
|---|---|---|---|---|---|---|
| Sea Level BPL (m) | Years | % of time | Events | Years | % of time | Events |
| 120 | 3,000 | 2 | 1 | 15,000 | 6 | 2 |
| 100 | 7,000 | 5 | 1 | 29,000 | 12 | 2 |
| 75 | 14,000 | 9 | 1 | 42,000 | 17 | 2 |
| 50 | 40,000 | 27 | 5 | 99,000 | 40 | 5 |
| 40 | 65,000 | 43 | 7 | 136,000 | 54 | 6 |
| 30 | 93,000 | 62 | 5 | 167,000 | 67 | 6 |
| 20 | 107,000 | 71 | 4 | 201,000 | 80 | 6 |
| 10 | 134,000 | 89 | 3 | 227,000 | 91 | 3 |

*Source:* after Voris 2000, Table 1.

Pough et al. 2004

## Biogeographic Realms

Holarctic

Gondwana

FIGURE 13.15 Biogeographic realms of the world.

Pangaea

Zug et al. 2001

Alfred Wegener, winter 1912-1913

Crustal Plates moving 1-12 cm / year

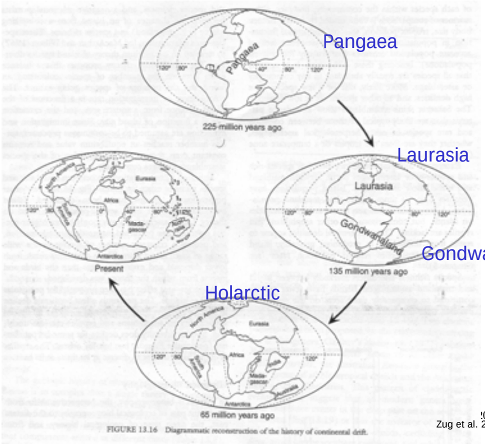
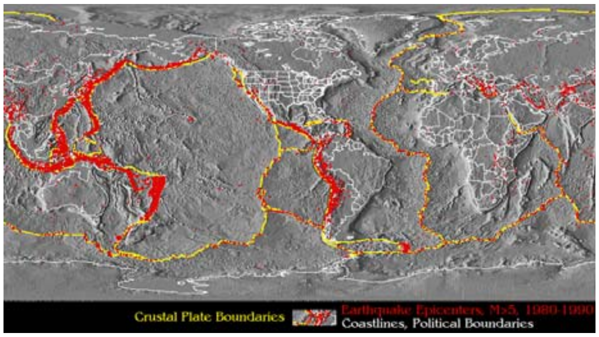
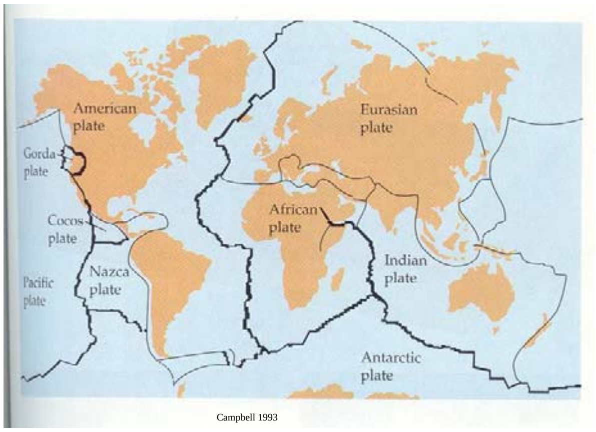


FIGURE 13.16 Diagrammatic reconstruction of the history of continental drift.

Zug et al. 2001

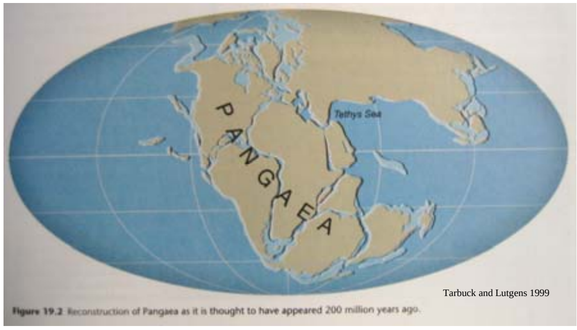
Plate Tectonics





Campbell 1993

Pangea 200 million years ago



Tarbuck and Lutgens 1999

**Figure 19.2** Reconstruction of Pangaea as it is thought to have appeared 200 million years ago.

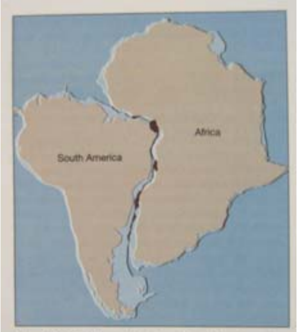
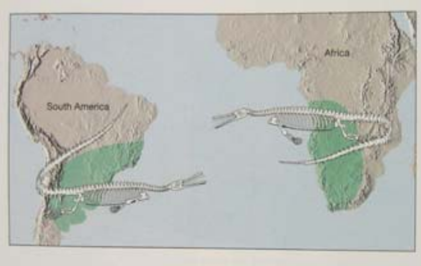


**Figure 19.3** This shows the best fit of South America and Africa along the continental slope at a depth of 500 fathoms (about 900 meters). The areas where continental blocks overlap appear in brown. (After A. G. Smith, "Continental Drift." In *Understanding the Earth*, edited by I. G. Gass. Courtesy of Artemis Press)

Tarbuck and Lutgens 1999



Tarbuck and Lutgens 1999

**Figure 19.4** Fossils of *Mesosaurus* have been found on both sides of the South Atlantic and nowhere else in the world. Fossil remains of this and other organisms on the continents of Africa and South America appear to link these landmasses during the late Paleozoic and early Mesozoic eras.

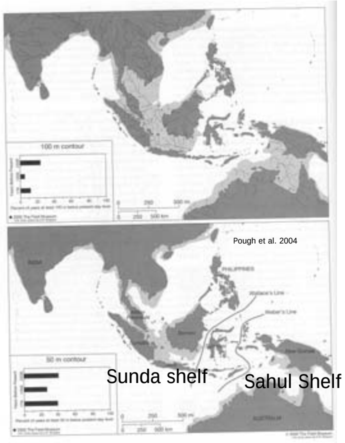
Dispersal

**Figure 19.5** These sketches by John Holden illustrate various explanations for the occurrence of similar species on landmasses that are presently separated by vast oceans. (Reprinted with permission of John Holden)

Tarbuck and Lutgens 1999

Vicariance

Alfred Russel Wallace
(1823 - 1913)



Pough et al. 2004

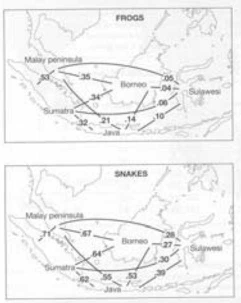
Wallace's Line
→
Weber's Line

Sulawesi

Sunda shelf

Sahul Shelf

Dispersal Ability



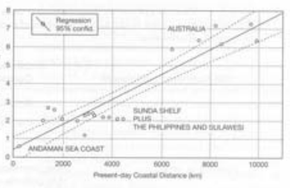
Pough et al. 2004

*Figure 5–13* **Patterns of faunal resemblance among areas of the Sunda Shelf in their frog (top) and snake faunas (bottom).** The numbers reflect the number of shared species between areas, calculated as indexes of faunal similarity, where Similarity = (2 × number of species in common)/[(number of species in area A) + (number in area B)]. Note that snakes share a much greater proportion of species among these areas than do frogs. This very likely results from differing dispersal capabilities as well as differences in the potential for population isolation and speciation. *(Source: Inger and Voris 2001.)*

Dispersal Ability (Isolation by Distance)

*Figure 5–15* **Correlation between genetic divergence and geographic coastline distance separating populations of *Cerberus rynchops* (linear regression with 95 percent confidence limits).** *(Source: Karns et al. 2000.)*

Pough et al. 2004



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

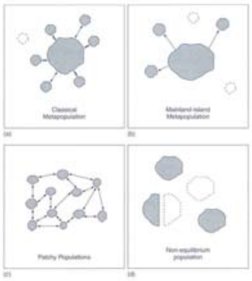


**Figure 5.16**
Types of metapopulation models. In a classical metapopulation, (a) some colonies may not exhibit high rates of movement for long periods of time. Also, colonization may unite several patches within a larger patch as a single entity that contributes to other sinks. Colonies farther from the source are more prone to extinction. The mainland-island metapopulation (b) depicts local extinctions occurring mostly among a subset of populations. The mainland/source, resistant to extinction, functions as the major provider of colonists. The island and sink metapopulations have little effect upon regional persistence. In patchy populations (c), because of the high levels of emigration and immigration, the patches function as a single unit. It is rare that discrete local populations become extinct. The absence or insufficiency of recolonization to balance extinction distinguishes nonequilibrium populations (d). Extinction of metapopulations occurs as part of an overall regional decline (i.e., a product of the reduction, fragmentation, or deterioration of a habitat).

*After Harrison (1991).*

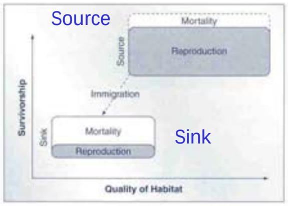
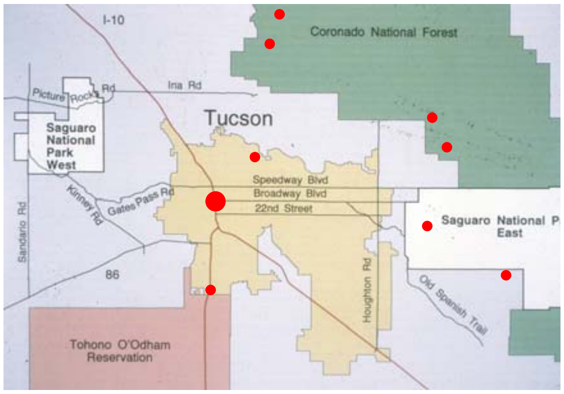


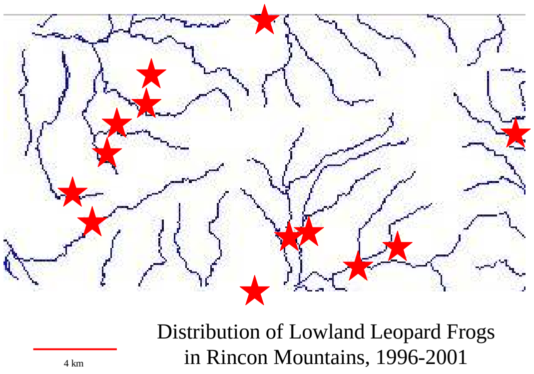
**Figure 5.17**
A visual representation of the source-sink model of habitat distribution. In source habitats, reproduction produces a population surplus (i.e., mortality does not decrease the number of individuals because of overcompensation through reproduction). Surplus individuals move to sink habitats where mortality exceeds survivorship. Sink habitats cannot be maintained by reproduction, but depend on immigration to maintain a population.

Metapopulation:

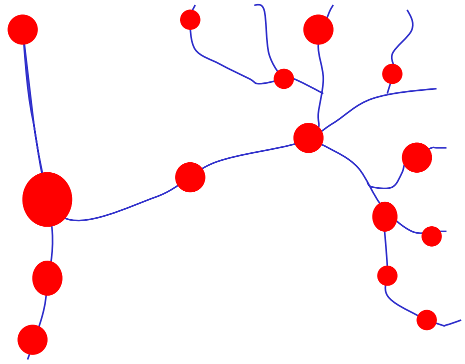
Hydrothermal Vents

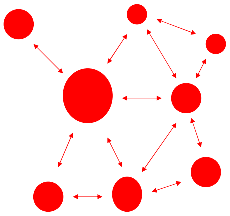
Lowland Leopard Frogs
(thanks to Don Swann)



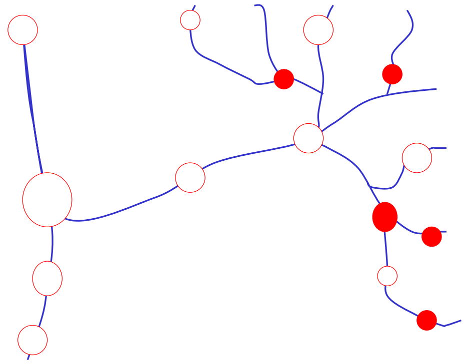


Distribution of Lowland Leopard Frogs
in Rincon Mountains, 1996-2001





Metapopulation Dynamics



Chytrid Fungus

## Juggling Balls, Oranges, and Mites:

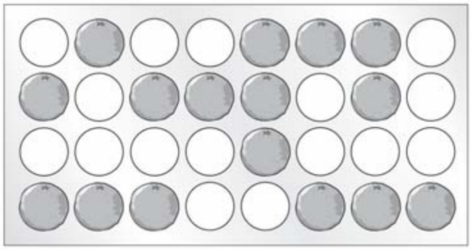


**Figure 5.11**
A diagrammatic representation of Huffaker's experiment on the persistence of a predator-prey system of two species of mite. Dark circles represent oranges that mites could colonize and white circles represent rubber balls of "nonhabitat" that they could not colonize.

*After Huffaker (1958) and Huffaker, Shea, and Herman (1963).*

---

## Habitat Heterogeneity

Conserve Bigger Area?

Conserve More Diverse Habitats?

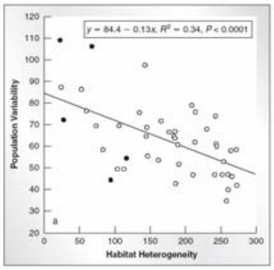


**Figure 5.23**
Populations of bush cricket (*Metrioptera bicolor*) subunits exemplify that population size is less variable as heterogeneity increases. Dark circles indicate patches where local extinctions occurred. White circles indicate patches with extant populations. Population variability was measured by the coefficient of variance (cv) of local population size, and habitat heterogeneity was measured using digitized infrared aerial photographs. Each patch was assigned values according to how much the patch deviated from the standard level of gray in the photographs (SD-hue).

*After Kindvall (1996).*

---

## Disturbances

-Endogenous
-Exogenous

An SUV is seen covered by sand as residents walk to their homes to inspect the damage by hurricane Ivan Wednesday, Sept. 22, 2004 in Pensacola Beach, Fla. Beach residents were allowed to see their homes for the first time since the hurricane. (AP Photo/Alan Diaz)

---

## Habitat Heterogeneity and Disturbance

Climax Community vs. Shifting Mosaic

---

- Tree Fall in Forest
- Beaver Dam on Stream