Lecture 16, 11 Oct 2007
Paradigms
Populations
Conservation Biology
ECOL 406R/506R
University of Arizona
Fall 2007
Kevin Bonine
Cathy Hulshof

Upcoming Readings
today: Text Ch. 5, Song of Dodo excerpt
Tues 16 Oct: Text 188-193
Thurs 18 Oct: Ch 7, Ch 8

Thanks to Scott Bonar, Ed Moll, Taylor Edwards
Q4 due 13 November

Debate 23 Oct 2007:
Should the Tumacacori Highlands be Wilderness?
Three groups – one will debate, another will evaluate, third will observe, then we rotate.

Conservation Biology Lab 406L/506L
Friday 19 Oct 1230 -> 1530
Meet 1230h S or W side BSE (4th and Highland)
Hat, water, sunscreen, close-toed shoes
Readings on Course Website re:
Sewage Treatment Plant, Sweetwater Wetland

Exam 1
Phenology?
Mean 80.1
Median 83.5
Count 34
Max 95.5
Min 43
SD 11.9
w/o bonus

Paradigms In Conservation
(Chapter 5)
1- Genetic Diversity (MVP, PVA)
2- Island Biogeography
3- Metapopulations
4- Habitat Heterogeneity
5- Disturbance

Genetics in Detail (Chap 6)
Populations in Detail (Chap 7)

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

Vs. Declining Populations
Effective Population Size

- \( N_e = \frac{4N_mN_f}{N_m+N_f} \)

- Eg: a population of seals with 6 males and 150 females?

- \( N_e = \frac{(4\times 6\times 150)}{(6+150)} = \sim 23 \)

Thanks to Chuck Price

Inbreeding Coefficient, \( F \)

(2 alleles identical by descent)

1\% Rule (Frankel and Soule)

<table>
<thead>
<tr>
<th>Population Size ( N )</th>
<th>( \Delta F(N) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>0.00</td>
</tr>
<tr>
<td>50</td>
<td>0.02</td>
</tr>
<tr>
<td>100</td>
<td>0.05</td>
</tr>
<tr>
<td>200</td>
<td>0.10</td>
</tr>
<tr>
<td>400</td>
<td>0.20</td>
</tr>
<tr>
<td>800</td>
<td>0.40</td>
</tr>
<tr>
<td>1,600</td>
<td>0.80</td>
</tr>
<tr>
<td>3,200</td>
<td>1.60</td>
</tr>
<tr>
<td>6,400</td>
<td>3.20</td>
</tr>
<tr>
<td>12,800</td>
<td>6.40</td>
</tr>
<tr>
<td>25,600</td>
<td>12.8</td>
</tr>
</tbody>
</table>

Figure 5.3

After Frankel and Soule (1981).

Quickly lose rare alleles in bottlenecks

Genetic 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

Population Extinction Vortex
(problems with small populations)

- 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)

Cyprinodon macularius

Desert Pupfish

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 populations of desert pupfish inhabit the oasis. This last refuge of a unique fish is being actively managed.

Photograph Courtesy of John Carne

Cheetah

Major Histocompatibility Complex

Van Dyke 2003
Hardy Weinberg and Heterozygosity

two alleles: p, q

\[(p + q)^2 = p^2 + 2pq + q^2\]

Under Hardy Weinberg Equilibrium:

\[H_o = 2pq\]

If \(p=0.6\), \(q=0.4\), then \(2pq = 0.48\) = \(H_o\)

Inbreeding, if \(H_o < H_e\)

Outbreeding, if \(H_o > H_e\)

Equilibrium Heterozygosity (\(\Delta H = 0\))

\[H^* = 2Nm\]

\(H = \text{heterozygosity}\)

\(N = \text{population size}\)

\(m = \text{mutation rate}\)

Therefore, smaller populations have lower equilibrium heterozygosity

Assumption: reduced genetic variation in a population correlated with reduced ability to adapt to changing environmental conditions.

Wright’s Fixation Index

\[Fst = 0, \text{ or } <0.01 \text{ indicate little divergence among pops.}\]

\[Fst > 0.1 \text{ indicate much divergence among pops.}\]

Minimum Viable Population (MVP)

(Frankel, Soule, Franklin, Shaffer)

50/500+/ Rule

Short term

Mid term

Long Term

PVA...
2. Island Biogeography

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

Lyell
Wallace
Darwin
Frogs vs. Birds
dispersal

MacArthur
Wilson
Oceanic vs. Continental
succession

Size, Age, Distance
~equilibrium

Islands, especially Continental, affected by:
- Plate tectonics
- Climate (glaciation, drought)
- Sea level

<table>
<thead>
<tr>
<th>Connectivity</th>
<th>Post: 150,000 years</th>
<th>Post 200,000 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sea Level SBP (m)</td>
<td>Years</td>
<td>% of time</td>
</tr>
</tbody>
</table>
| 10 | 3,000 | 5 | 25,000 | 1 | 20,000 | 6 | 2
| 100 | 7,000 | 5 | 25,000 | 1 | 20,000 | 12 | 2
| 15 | 14,000 | 9 | 42,000 | 1 | 20,000 | 17 | 2
| 90 | 40,000 | 27 | 90,000 | 9 | 40,000 | 42 | 5
| 40 | 66,000 | 49 | 136,000 | 7 | 66,000 | 54 | 6
| 30 | 80,000 | 62 | 100,000 | 5 | 80,000 | 67 | 6
| 20 | 120,000 | 71 | 200,000 | 4 | 120,000 | 80 | 6
| 10 | 134,000 | 89 | 220,000 | 3 | 134,000 | 91 | 3

(From: after Vors 2000, Table 1)

Equilibrium Theory of Island Biogeography

- Habitat Fragmentation
- Reserve Design
- Predictions vs. Observations
- Missing Factors
  - Rescue Effect
  - Habitat Suitability
  - Sink vs. Source
  - Habitat Heterogeneity
  - Species Interactions
Plate Tectonics - not fully accepted until 1960s

Wallace's Line

Weber's Line

Sulawesi

Dispersal Ability
3. 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

Metapopulation:

Hydrothermal Vents

Lowland Leopard Frogs (thanks to Don Swann)
Distribution of Lowland Leopard Frogs in Rincon Mountains, 1996-2001

Metapopulation Dynamics
4. Habitat Heterogeneity

Conserve Bigger Area?

Conserve More Diverse Habitats?

5. Disturbances

- Endogenous
- Exogenous

Habitat Heterogeneity and Disturbance

Climax Community vs. Shifting Mosaic

- Tree Fall in Forest
- Fire
- Beaver Dam on Stream
Intermediate Disturbance Hypothesis

"succession reset"  "supercompetitors"