Wednesday 08 February 2006, 12th class meeting  
(Miller Chapters 3 & 4; Quammen)

Environmental Biology (ECOL 206)  
U. Arizona, spring 2006  
Kevin Bonine, Ph.D.  
Alice Boyle, Kristen Potter, Graduate TAs

1. Evolution  
2. Quammen 1985  
3. 206 Lab Website for handouts and assignments  
 (bring small notebook to lab)  
4. Thank Chuck Price  
5. Taylor Edwards Friday  
6. Exam Wed 15 Feb

Guy McPherson

"Threats to Biological Diversity in the Sky Islands: Can an Informed Citizenry Overcome Society?"

Sky Island Alliance and the Environmental Law Society are hosting a speaker series that will run January-May 2006 with one speaker event each month. Our second event will be held on:

Wednesday, February 15, 2006
at the University of Arizona Rogers College of Law  
1201 E. Speedway Blvd. Room 140
The presentation will begin at 6 p.m. with an opportunity to ask questions and interact with our speaker afterward. Free. Call Sky Island Alliance 624-7080 x209 for more information.

Abstract:
Development of a just, sustainable human enterprise requires us to acknowledge and account for the explicit links between environmental protection, social justice, and the human economy. This will require contributions from virtually every segment of society, and, while striving for global ideals, we must start with local actions. I describe historical and contemporary "drivers" behind relatively coarse-scale ecosystems in the Sky Islands of the American Southwest. Cursory inspection of factors such as fire, livestock grazing, urbanization, biological invasions, and regional climate change indicate the important role played by the current generation of decision-makers in creating a just, sustainable future. I provide a general template and some specific examples that may facilitate the transition to sustainability.

Biographical sketch:
Guy R. McPherson is a professor in the University of Arizona School of Natural Resources, and he holds an adjunct appointment in the Department of Ecology & Evolutionary Biology. He is an award-winning researcher, teacher, and mentor.


We hope to see you there!

Our March speaker event will be on March 9th with speaker Bruce Babbitt.
Galapagos (Alan Alda) 18 min video clip

Primary Succession.
Similarities to Hawaii?
total # species, # endemics?

How did species get to the Galapagos
(beginning ~10 million years ago)?

Why no fear of humans?

(Adaptive Radiation to fill available niches)

Ground Finches

Charles Darwin visited 1830s.

Theory of Evolution by Natural Selection

Amblyrhynchus cristatus

Natural Selection:

Ricklefs 2001, Figure 16.14

Favors Average Traits
Favors One Extreme
Favors Both extremes

Stabilizing selection
Directional selection
Disruptive selection

Beak Size (for example)
Darwin's Finches

Evolution by Natural Selection

Figure 20.12
Natural selection in action: beak evolution in one of Darwin's finches. The medium ground finch, one of the birds Darwin found on the Galápagos, uses its strong beak to crush seeds (see inset). Given a choice of small seeds or large seeds, the birds eat mostly small ones, which are easier to crack. During dry years, small seeds are produced in such abundance that ground finches consume relatively few large seeds. This changes during dry years, when both small and large seeds are in short supply and the birds resort to eating a larger than usual proportion of large seeds. The change in diet is correlated with a change in the average depth (top to bottom tension) of the birds' beaks. Field studies comparing offspring to parents confirm that this trait is inherited rather than acquired (by exercising the beak on large seeds, for example). The most likely explanation is that those birds that happen to have stronger beaks have a feeding advantage during droughts and pass the genes for this trait on to their offspring. Campbell 1993

Figure 19.1 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
Darwin to the Galapagos

Genovesa

Fernandina
And
Isabela
Amblyrhynchus cristatus
Galapagos Marine Iguana

Martin Wikelski, Princeton
Galapagos Marine Iguana (Iguanidae)

Only lizard to feed at sea
-algae, seaweed

Up to 10 or 12 m deep
Up to a hour-long dives for large males
(Darwin shipmate)

Highly social
8,000 indivs/ km of coast

16 islands
Cold upwelling water nourishes algae

Fernandina/Isabela
males to 10+ kg
females to almost 3 kg

Genovesa
males only to 1 kg
females to < 1kg

Why?
Water temperature and current strength
Galapagos Marine Iguana (Iguanidae)

El Nino → lack of food (Why?)

Starvation b/c high cost of salt excretion

Animals may lose 15% body length
- bone absorption

Only adult vertebrate known to regularly shrink
(astronauts)

Largest animals die
- sexual selection
- natural selection
Nothing in biology makes sense except in the light of evolution.

Theodosius Dobzhansky
Modern Synthesis (Evolutionary Synthesis), 1930s

Mendel
  (genetics, 1865)
  +

Darwin
  (natural selection, 1859)
  +

Paleontology
  (speciation, extinction, plate tectonics [Lyell Geology])
  +
  etc.

- Ernst Mayr (1942 Systematics and the Origin of Species)
- Theodosius Dobzhansky
- George Gaylord Simpson
- G. Ledyard Stebbins
Define Evolution...

Change in gene frequencies across generations (in a population).
Figure 5-5: Fossils and radiometric dating indicate that five major mass extinctions (indicated by arrows) have taken place over the past 500 million years. Major extinctions leave large numbers of organisms extinct (reduced) and new species evolve. As a result, mass extinctions have been followed by periods of recovery (represented by the wedge shapes) called adaptive radiations. During these periods, which lasted over 10 million years or more, new species evolved to fill now-extinct ecological niches (shades). Many experts believe that we are now in the midst of a sixth mass extinction, caused primarily by human activities.

Adaptive Radiation

Figure 5-10: Adaptive radiation of mammals began in the first 10–12 million years of the Cenozoic era (which began about 65 million years ago) and continues today. This evolution of a large number of new species is thought to have resulted when huge numbers of new and vacated ecological niches became available after the mass extinction of dinosaurs near the end of the Mesozoic era. (Used by permission from Ceclo Starr and Ralph Taggert, Ecology: The Unity and Diversity of Life, 8th ed., Belmont, Calif.: Wadsworth, 1998)
**r = intrinsic rate of increase**

Rate that population could grow with unlimited resources

"r-selected" organisms:
1. Reproduce early and often
2. Short generation times
3. Many offspring

**K = carrying capacity**

1. Limited by
   - resources
   - competition
   - predators

Therefore have intraspecific competition and...

**Evolution by Natural Selection**

1. Trait must be **variable**
2. Trait must be **heritable**
3. Trait must **differentially affect fitness**

**Adaptation**

1. Trait must be heritable and differentially affect fitness
2. Adaptation implies a **comparison**
3. Adaptation depends on **environment**

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**Amblyrhynchus cristatus**

Survival and Reproduction
Adaptation depends on Environment

Ear lobes

Mid-digital hair

Tongue rolling

Mini-thumbs?

Other more important traits/characteristics...
Sickle-cell Anemia:

Change of one nucleotide in human hemoglobin gene:
- One copy may be resistant to malaria
- Two copies leads to anemia (inability to transport sufficient O₂)

Origin of all variation is genetic mutations

In the context of biological evolution:
(each of these does what over time?)

Genes... Mutate (neutral/harmless, detrimental, beneficial)
Individuals... are Selected
Populations... Evolve
Population Size
and
Genetic Variability

Species = ?

**Biological Species Concept (Mayr)**
“a group of interbreeding populations that are reproductively isolated from other such groups”

- 2-morphological/taxonomical species concept (plants)
- 3-evolutionary species concept
- 4-genetic species concept
- 5-paleontological species concept
- 6-cladistic species concept
Ernst Mayr is one of the greatest influences on evolutionary biology since Darwin. Mayr was one of the architects of the evolutionary synthesis of the 1930s and 1940s, which unified biology by integrating Darwin's theory of natural selection with new discoveries in genetics, palaeontology, and taxonomy. Mayr based his views on evolution mainly on relationships among bird species that he studied on Pacific islands. Now 89 years old, Mayr, Professor Emeritus at Harvard, is still going strong and generating exciting new ideas. His latest book, One Long Argument (Harvard University Press, 1991), analyses Darwin's theories. I interviewed Professor Mayr at his summer cottage in New Hampshire.

Ernst Mayr (1904-2005)
Published papers for > 80 years

You've also written that we humans have extraordinary responsibility because of our uniqueness as a species. Yes, humans are basically responsible for all the bad things that at the present time happen to our planet, and we are the only ones who can see all these things and do something about them. If we would stop the human population explosion, we would have already won two-thirds of the battle. That we live here just as exploiters of this planet is an ethic that does not appeal to me. Having become the dominant species on our planet, we have the responsibility to preserve the well-being of this planet. I feel that it should be a part of our ethical system that we should preserve and maintain and protect this planet that gave origin to us.

Ernst Mayr interviewed in Campbell 1993
Biological Species Concept
1. Testable and operational
2. Definition compatible with established legal concepts
3. Focus on level of biodiversity that agrees with tradition of conservation

Conserve Species as
**TYPES**
or as
**EVOLUTIONARY UNITS**

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**David Quammen 1985**
Is Sex Necessary?
**Natural Acts**

- Parthenogenesis ("virgin birth")
- Asexual vs. Sexual Reproduction
- Recombination

**Aphids** are excellent opportunists (v. equilibrium ‘K’ species)
- Asexual (rapid, exploitation)
- Then Sexual (shuffle the genes once/year)

Maintain
- variability
- diversity
- adaptability

1 aphid, 6 generations, → 318,000,000
Mendelian Genetics

Figure 13.1
Gregor Mendel (1822–1884). Based on his experiments with garden peas, Mendel built a model of inheritance that became the foundation of modern genetics. His published records of these experiments provide a window into a great scientific mind. This chapter examines Mendel’s experiments and conclusions and applies Mendelian concepts to human heredity.

Campbell 1993

Figure 13.2
A genetic cross. To hybridize between pea varieties, Mendel used an artist’s brush to transfer pollen. In this case, the character of interest is flower color, and the two varieties are purple versus white flowers. Seeds develop within the female organ, or carpel, which develops into the fruit (pod). Germination of the seeds produces the first generation hybrids, which all have purple flowers. The result is the same for the reciprocal cross, the transfer of pollen from purple flowers to white flowers.

Campbell 1993

Chapter 20: Descent with Modification: A Darwinian View of Life

Figure 20.5
Descent in historical context.

Campbell 1993

Campbell 1993

Campbell 1993
Mendelian Genetics

One gene
Two alleles

Dominant (purple)
Recessive (white)

Figure 13.3
Mendel tracked heritable characters for three generations. When F1 hybrids were allowed to self-pollinate, or when they were cross-pollinated with other F1 hybrids, a 3:1 ratio of the two varieties occurred in the F2 generation. An "x" sign symbolizes a genetic cross, or mating. (Campbell 1993)

Figure 13.6
A testcross. A testcross is designed to reveal the genotype of an organism that exhibits a dominant trait, such as purple flowers in pea plants. Such an organism could be either homozygous or heterozygous for the dominant allele. The most efficient way to resolve the genotype is to cross the organism with an individual expressing the recessive trait. Since we know the genotype of the white-flowered parent (it must be homozygous for this trait to be expressed), we can deduce the genotype of the purple-flowered parent by observing the phenotypes of the offspring.

Figure 13.19
Incomplete dominance in snapdragons color. When red snapdragons are crossed with white ones, the F1 hybrids have pink flowers. Segregation of alleles into the gametes of the F1 plants results in an F2 generation with a 1:2:1 ratio for both genotype and phenotype.
The Genetic Code

1-Transcription
2-Translation

Proteins of amino acids
Ricklefs 2001, Figure 16.15

Result of **Disruptive Selection** (Favors Both extremes)

Ridley 1996

**Drosophila Bristle Count**

**Disruptive Selection** (Favors Both extremes)
Selection for Human Birth Weight

Figure 6.24 Stabilizing selection on birthweight in humans. The horizontal axis represents birthweight. The left vertical axis and the bar chart show the distribution of birthweights in a sample of 15,730 babies. The average birthweight is about 7 pounds. The right vertical axis and the data points with best-fit curves show mortality rate as a function of birthweight (in a logarithmic scale). The mortality rate is much higher among very small and very large babies than among babies of average size. (Note that in the figure, fit curves are plotted as probability of mortality, whereas in Figure 6.23, fit curves are plotted as probability of surviving.) The optimum birthweight is that with the lowest mortality rate. It is very close to the population average. Manual selection on birthweight in this population tends to hold the population average at a constant value (from Cavalli-Sforza and Bodmer 1971 and references therein.)
Speciation often result of:
1. Geographic Isolation
2. Reproductive Isolation

Stalk Eyed Flies

Sexual Selection
Evolution by Natural Selection

vs. Lamarck

Galapagos Finches

*Brassica oleracea*

Figure 37–8. A number of common vegetables are members of the genus *Brassica*, including cauliflower, broccoli, cabbage, brussels sprouts, and kale. Artificial selection is responsible for the variation shown within this species.

Solomon et al. 1993
Alfred Wegener, winter 1912-1913

Crustal Plates moving 1-12 cm / year

Plate Tectonics
Pangea 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 J. C. Cass. Courtesy of Artemis Press)

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.
Convergent Evolution

Giant Armadillo
North America

Giant Pangolin
Africa

Giant Anteater
South America

Spiny Anteater
Australia

Convergence
Convergent Evolution

In many instances, animals which live in similar habitats resemble each other in outward appearance. These similar looking animals may, however, have quite different evolutionary origins.

Swifts, swallows and martins all hunt for insects while they fly. They have streamlined bodies with long wings.

Hummingbirds and sunbirds feed on nectar from flowers. They have long bills to reach the nectar at the base of flowers.

Based on appearance only we would conclude that sunbirds are related to hummingbirds and that swifts are related to swallows and martins. In reality, genetic techniques have shown that swifts are related to hummingbirds, while sunbirds are related to swallows and martins.