What factors correlated with high diversity?

- Energy
- Precipitation
- Temperature
- Area
- Habitat heterogeneity (e.g., foliage height and birds)
- Stable environment
- Moderate (intermediate) disturbance level (shifting mosaic, no climax)

Distribution and Abundance

Other Miller 2003

Figure 4-12 Key physical and chemical or abiotic factors affecting terrestrial ecosystems (left) and aquatic life zones (right)
Range of tolerance of abiotic factor(s)

Terrestrial Biomes
(Forest, Desert, Grassland, Tundra, etc.)
Biotic (~Vegetative) Communities

Climate
1. Temperature
2. Precipitation
3. Soil type

- Latitude
- Altitude
1. Competition

*Anolis*

Figure 2.4 Biomes and climate distributions of the major biomes are plotted on axes of mean annual precipitation. Within the region bounded by the dashed line, factors such as seasonality of drought, fire, and grazing strongly affect which type of vegetation is present (Modified from Whittaker 1970.)

Ecomorphs on Caribbean Islands
*Pisaster* (predatory sea star)
Paine
15 vs. 8 spp.
(mussels)

2. Predation
3. Parasitism

4. Mutualism

See 4-2 in Miller 2003
5. Commensalism

Florida

Ecuador

Bromeliads

Stalk-Eyed Flies

Sexual Selection
Figure 4.4
A general species-area relationship among some Caribbean islands. Note that species richness on islands increases with increasing area.
Based on data from Darling et al. (1985-86).

Species-Area Relationship
Species-Area Relationship

3 step loss of biodiversity
(Rosenzweig)

1. Endemics
2. Sink populations
3. Stochasticity

Therefore end up with lower steady state species richness and loss of biodiversity

Endemism and Islands (Tuatura, Silversword)
Island Biogeography

\[ S = cA^Z \]

\( S = \) species richness
\( c = \) taxon-specific constant
\( A = \) area
\( Z = \) extinction coefficient for taxon
Figure 4.6
When the size of a natural area is decreased, the first species lost are endemics. Next, sink species (those that are not reproducing fast enough to replace themselves) go extinct locally. Finally, failure to replace accidental losses fast enough brings the province to a still lower steady state of biodiversity.

After Rosenzweig (1999).

Figure 4.7
The "cookie-cutter" model of the effects of habitat loss on endemic species. If the cookie cutter strikes at subarea A, seven species lose habitat but none is exterminated. In contrast, if the cookie cutter strikes subarea B, an area containing species with more restricted ranges, seven species lose habitat, and four species are exterminated. Thus, random habitat loss produces a disproportionately high rate of extinction in endemic species.

Species Focus ---> Biodiversity and Process Focus (ESA)

What being lost vs. why...

Species = ?

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

2-morphological/typological species concept (plants)
3-evolutionary species concept
4-genetic species concept
5-paleontological species concept
6-cladistic species concept
Conserve Species as
TYPES
or as
EVOLUTONARY UNITS

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, palentology, 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), analyzes 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

Galapagos Finches

Brassica oleracea

Figure 22.3 Ernst Mayr in New Galilee, 1897. During his expedition, the naturalist (on the right, photographed with his guide) was struck by the almost exact match in form he and the native Finches divided the birds of the Galapagos Islands into separate species. It was one of many experiences that led to Mayr's biological species concept, which emphasizes interbreeding within species and reproductive isolation between species.

Figure 23.8 A number of common vegetables are members of the same species, Brassica oleracea, including cauliflower, broccoli, cabbage, brussels sprouts, and kale. Artificial selection is responsible for the variation shown within this species.

Salomon et al. 1993
Aspidoscelis (Cnemidophorus)
Species vs. Parthenospecies...

1. Indicator Species
   - migratory birds
   - amphibians

2. Keystone Species
   - top predators
   - key pollinators

3. Umbrella Species

Native Species
vs.
Nonnative, exotic, alien
Measuring Biodiversity
- alpha       - beta       - gamma

**Alpha**
species within a community

- all populations occupying a given area at a given time
- often broken into taxonomic groups or functional roles

1) Species **Richness** ( # of species)
2) Species **Evenness** (how many of each type?)

**Shannon Diversity Index** (richness and evenness)
\[ H' = -\sum_{i} p_i \ln (p_i), \quad (i = 1, 2, 3 \ldots S) \]

\[ p_i = \text{proportion of total community abundance represented by ith species} \]

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<th>SITE B</th>
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**Shannon Index in Tallgrass Prairie**
( indiv spp abundance relative to total abundance)

What if removed three species from B?
### Process and Pattern

#### 1 Functional Types

Increase either to increase biodiversity

Which to preserve?

#### 2 Functional Analogs

Niche: Ecological role of a species in a community

---

### Table 4.3

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Beta area or regional diversity (beta richness) diversity of species **among communities** across landscape gradient
- slope, moisture, temperature, precipitation, disturbance, etc.

**Whittaker’s Measure** = $\frac{S}{\alpha} - 1$

where $S$ = # spp in all sites, $\alpha$ = avg. # spp/site

a) if no community structure across gradient $= 0$
   - broad ecological tolerances, niche breadth

b) $100/10 - 1 = 9$ high beta diversity

**Beta Diversity**

1) quantitative measure of diversity of communities that experience **changing environmental gradients**

2) are species **sensitive**, or not, to changing environments?
   are there associations of species that are **interdependent** (plants, pollinators, parasites, parasitoids)?

3) how are species gained or lost across a **TIME** gradient?

**Succession, community composition, effects of disturbance**
Alpha and Beta Diversity Hotspots

Figure A. Hot spots of rarity and species richness in the lower 48 United States. Read as a topographic map with concentric circles showing higher values of the rarity-weighted species richness index (RWRI). Hotspots are found in CA, the Death Valley region of Nevada, the Appalachian Mountains, and the Florida panhandle and Everglades. Many other regions of higher diversity are found in other parts of the U.S., and the Hawaiian islands (not shown) have the greatest concentration of range-restricted species by far. To achieve a high RWRI both α- and β-diversity must be high. (Modified from Stein et al. 2005)

Groom et al. 2006

Figure 4.2

The number of species on a given site in one kind of habitat is a measure of α diversity/species richness. The average number of species per habitat is a measure of β diversity. The rate of species change over landscape scales distances in the same habitat is a measure of γ diversity (geographic replacement of species).
Measuring Biodiversity
- alpha       - beta       - gamma

**Gamma**

rate of change of species composition with distance
(geography, rate of gain and loss of species)

**alpha rarity** with increased number of species
(fewer of each type)

**beta rarity** with habitat specialists

**gamma rarity** if restricted to particular geographic areas

---

Missing?

Species role in ecosystem?
Rarity
Phylogenetic Representation
Ecological Redundancy

**Edges vs. Interior (e.g., fragmentation)**
(spp richness increases, but are broad generalists, not interior habitat specialists)

**All species are not equivalent** (normative valuation?)
Endemism...
THE LAWS OF BIOGEOGRAPHY

Pimm and Jenkins 2005

LAW 1. Most species' ranges are very narrowly defined, e.g., less than 100 km², and at the lower end, only a few species have ranges less than 1 km². The units of measurement range from the size of a lake to the size of a continent, and the number of species in each falls between these extremes.

LAW 2. Species with small ranges are typically rare. For example, a third of the species of the family Ctenomys have ranges less than 1 km². The small range size is associated with the lack of environmental variation in these species, which reduces the chances of finding suitable habitats.

LAW 3. The number of species in a given area is greater than the number of species in the surrounding area. This is due to the fact that species with small ranges tend to be more abundant in areas with high environmental diversity.

LAW 4. Species with small ranges are often geographically constrained.

The number of bird species and amphibian species in an area is positively correlated with the number of bird species and amphibian species in the surrounding area.
Figure 4.9
Eight categories of species abundance in British plants based on geographic range, habitat specificity, and local population size. Note that only one category (broad habitat specificity, wide geographic distribution, and large local population) can truly be considered "common." Species in the other seven categories are rare in one or more dimensions.
Adapted from Balick and Wiens (1989), VanDyke 2003
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 population of almost 10,000 fish inhabits this oasis. This last refuge of a unique fish is being actively managed.

Cyprinodon macularius 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.
Pricing Biodiversity

\[ R_I = (D_i + U_i)(\Delta P_i/C_i) \]

- \( D \) = distinctiveness
- \( U \) = utility
- \( \Delta P \) = enhanced probability of survival
- \( C \) = cost of strategy

Direct limited funds...
Ecological Contribution?

See Fig 2-1 (Pough et al., 2001)
Rhynchocephalia
- evolved before dinosaurs
- world-wide distribution in Mesozoic
- most extinct at end Cretaceous (65mya)

Sphenodontidae
- 1 extant genus (*Sphenodon*)
- 2 extant species
- restricted to small islands of New Zealand
- long lived

Pricing Biodiversity

\[ R_i = (D_i + U_i)(\Delta P_i/C_i) \]

D = distinctiveness
U = utility
\( \Delta P \) = enhanced probability of survival
C = cost of strategy

Direct limited funds...
Ecological Contribution?
Discussion:

Biodiversity vs. Wilderness

“no essential contradiction between social interests and biodiversity conservation”

p.109, VanDyke (Sarkar, 1999)

END