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Lecture 09, 21 Sept 2004
Van Dyke Ch4 n 5

Conservation Biology
ECOL 406R/506R
University of Arizona
Fall 2004

Kevin Bonine
Kathy Gerst

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Conservation Biology 406R/506R


1. Biodiversity
   -Van Dyke Ch 4

2. Paradigms and Theories
   -Van Dyke Ch 5

3. Lab Friday at computer lab (ECE 206)

4. Role Playing Write-Up due today

5. Exam Tuesday next week
   Old Exam on website, Review sheet?

21b

Costanza et al. 1997

The value of the world's ecosystem services and natural capital

Robert Costanza*†, Ralph d'Arge‡, Rudolf de Groot§, Stephen Farber‖, Monica Grasso†, Bruce Hannon¶, Karin Limburg#☆, Shahid Naeem, Robert V. O'Neill††, Jose Paruelo‡‡, Robert G. Raskin§§, Paul Sutton‖‖ & Marjan van den Belt¶¶**

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¶¶ Ecological Economics Research and Applications Inc., PO Box 1589, Solomons, Maryland 20688, USA

The services of ecological systems and the natural capital stocks that produce them are critical to the functioning of the Earth's life-support system. They contribute to human welfare, both directly and indirectly, and therefore represent part of the total economic value of the planet. We have estimated the current economic value of 17 ecosystem services for 16 biomes, based on published studies and a few original calculations. For the entire biosphere, the value (most of which is outside the market) is estimated to be in the range of US$16–54 trillion ($10^{12}$) per year, with an average of US$33 trillion per year. Because of the nature of the uncertainties, this must be considered a minimum estimate. Global gross national product total is around US$18 trillion per year.

21c

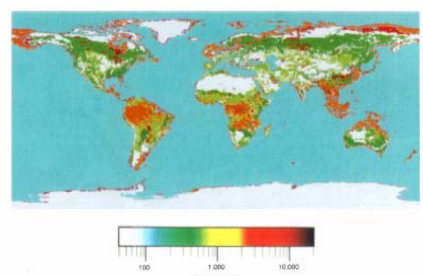

Figure 2 Global map of the value of ecosystem services. See Supplementary Information and Table 2 for details.

Costanza et al. 1997

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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

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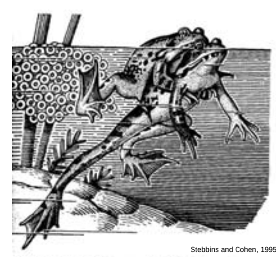
- Organism
  ↕
- Population
  ↕
- Species
  for sexual species under natural conditions:
  group of individuals which actually (or potentially) interbreed, producing live, fertile offspring



Stebbins and Cohen, 1995

Red-legged Frogs (*Rana aurora*) (w N Am) in pectoral amplexus.

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Galapagos Finches

Brassica oleracea

Figure 17–8 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. (Raymond Tschoepe)

Solomon et al. 1993

24b

Aspidoscelis (*Cnemidophorus*)
Species vs. Parthenospecies...

24c

Dessaur et al. 2000
Hybridization in Whiptail Lizards

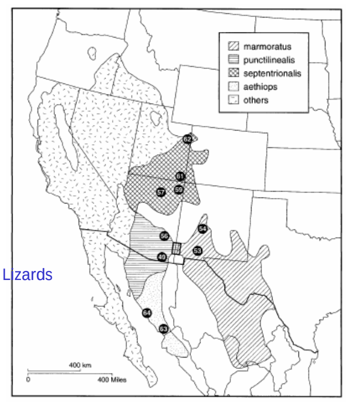

Fig. 1. Geographic range of the western whiptail lizard, *Cnemidophorus tigris* sensu lato, in the continental southwestern United States and northern Mexico. Rectangle (SE Arizona and SW New Mexico) outlines the contact region (detailed in figs. 3–5) where *C. t. punctilinealis* interbreeds with *C. t. marmoratus*. Numbers designate collecting sites (appendix 2) for specimens additional to those obtained within the contact region (fig. 3; appendix 1).

24d

Dessaur et al. 2000
Hybridization in
Whiptail Lizards

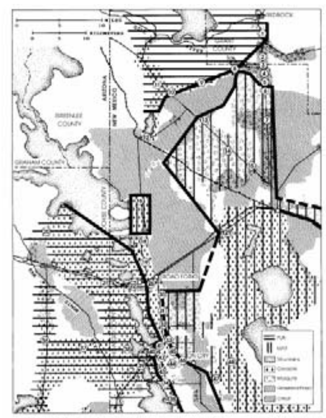

Fig. 49. The contact region. Horizontal lines represent range of pure *punctilinealis* (coloration indices of 0–0.2; table 24), and vertical lines pure *marmoratus* (coloration indices of 0.8–1.0). Sites in between (2–5, 13, 19, 26, and 41–44) represent primarily hybrids (coloration indices of 0.13–0.79).

24e

Dessaur et al. 2000
Hybridization in
Whiptail Lizards

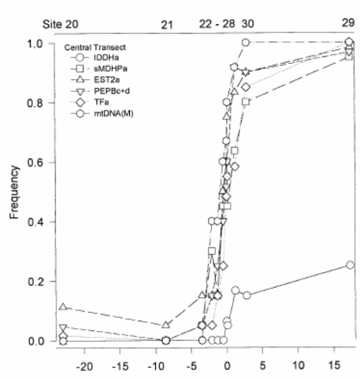

Fig. 31. Average frequencies of the *marmoratus* alleles at each of the four diagnostic loci and of the *marmoratus* mtDNA haplotype at sites along the central transect (fig. 5). The frequency change in the IDDH a-allele, which occurs only in *marmoratus*, is also shown. The central hybrid zone was about 3.2 km wide, with the midpoint of gene exchange at site 26 (compare with fig. 40).

24f

A. Cullum 1997,
Am.Nat.

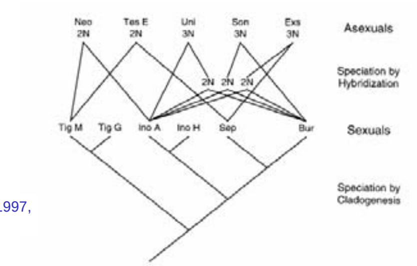

FIG. 1.—*Cnemidophorus* phylogeny. This hypothesized phylogeny of *Cnemidophorus* species examined in this study is intended only to show relationships among species, not the time of particular speciation events. The sexual group shows the typical bifurcating pattern of speciation via cladogenesis. The appearance of the asexual species exhibits the reticulate pattern of a hybridization event. Ploidy of asexual species is shown below their abbreviation. In triploid asexuals, intermediate diploid hybrids were believed to be involved in the two hybridization steps. Note that both sexual and asexual species have persisted independently since the hybridization events. Species abbreviations: *Neo*, *C. neomexicanus*; *Tes*, *C. tesselatus* clone "E"; *Uni*, *C. uniparens*; *Son*, *C. sonorae*; *Exs*, *C. exsanguis*; *Tig M*, *C. tigris marmoratus*; *Tig G*, *C. tigris gracilis*; *Ino A*, *C. inornatus arizonae*; *Ino H*, *C. inornatus heptagrammus*; *Sep*, *C. septemvittatus*; *Gul*, *C. gularis*; and *Bur*, *C. burti stictogrammus*. Sexual species phylogeny based on Dessauer et al. (1989a), Dessauer and Cole (1989), and Moritz et al. (1989). Asexual species phylogeny based on Good and Wright (1984) and Dessauer and Cole (1989).

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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

EVOLUTONARY UNITS

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Measuring Biodiversity

- alpha - beta - gamma

Alpha

species within a community

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)

$H' = -\sum_i p_i \ln(p_i)$, ($i$ = 1, 2, 3 ... S)

p_i = proportion of total community abundance represented by ith species

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Table 4.3 Abundance (individuals/10 ha) and diversity (Shannon index, $H' = -\Sigma(p_i \ln p_i)$) of avian species from two tallgrass prairie sites at DeSoto National Wildlife Refuge, Iowa. Note that site A, with fewer species (8) and two highly abundant species (common yellowthroat and field sparrow), has a lower value of diversity than site B, which has more species (11) that are more equally abundant. Van Dyke 2003

SPECIES	SITE A	SITE B
Common yellowthroat	8.24	1.21
Field sparrow	2.94	2.84
Dickcissel	1.18	2.23
Red-winged blackbird	0.29	0.81
Brown-headed cowbird	2.06	1.82
American goldfinch	1.47	1.02
Ringneck pheasant	0.59	1.63
Mourning dove	1.18	0.61
Eastern kingbird	—	1.60
Grasshopper sparrow	—	4.48
Northern bobwhite	—	2.64
Shannon diversity (H')	1.64	2.25

Shannon Index in Tallgrass Prairie

(indiv spp abundance relative to total abundance)

What if removed three species from B?

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1.64					2.25			
a	prop	ln	propxln		b	prop	ln	propxln
8.24	0.459053	-0.77859	-0.35741		1.21	0.057922	-2.84865	-0.165
2.94	0.163788	-1.80918	-0.29632		2.84	0.13595	-1.99547	-0.27128
1.18	0.065738	-2.72208	-0.17894		2.23	0.10675	-2.23727	-0.23883
0.29	0.016156	-4.12546	-0.06665		0.81	0.038775	-3.24999	-0.12602
2.06	0.114763	-2.16488	-0.24845		1.82	0.087123	-2.44043	-0.21262
1.47	0.081894	-2.50233	-0.20493		1.02	0.048827	-3.01947	-0.14743
0.59	0.032869	-3.41522	-0.11226		1.63	0.078028	-2.55069	-0.19902
1.18	0.065738	-2.72208	-0.17894		0.61	0.029201	-3.53357	-0.10318
					1.6	0.076592	-2.56927	-0.19678
					4.48	0.214457	-1.53965	-0.33019
					2.64	0.126376	-2.06849	-0.26141
17.95	1		**-1.64391**		20.89	1		**-2.25177**
drop top 3					drop bottom 3			
b	prop	ln	propxln		b	prop	ln	propxln
					1.21	0.099425	-2.30835	-0.22951
					2.84	0.233361	-1.45517	-0.33958
					2.23	0.183237	-1.69697	-0.31095
0.81	0.055441	-2.89243	-0.16036		0.81	0.066557	-2.70969	-0.18035
1.82	0.124572	-2.08287	-0.25947		1.82	0.149548	-1.90014	-0.28416
1.02	0.069815	-2.6619	-0.18584		1.02	0.083813	-2.47917	-0.20779
1.63	0.111567	-2.19313	-0.24468		1.63	0.133936	-2.01039	-0.26926
0.61	0.041752	-3.176	-0.13261		0.61	0.050123	-2.99327	-0.15003
1.6	0.109514	-2.2117	-0.24221					
4.48	0.306639	-1.18208	-0.36247					
2.64	0.180698	-1.71093	-0.30916					
14.61	1		**-1.8968**		12.17	1		**-1.97163**

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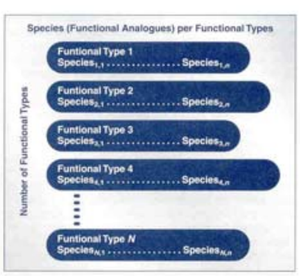

Figure 4.3
Total species diversity can be measured as the product of the number of functional types and the number of species per functional type. Two populations may have the same species diversity and still differ. For example, one may have many functional types and few functional analogues, and the other may have many analogues but few functional types. The relative number of functionally analogous species within each functional type is indicated by the width of the oval. Van Dyke 2003

Process and Pattern

1 Functional Types

2 Functional Analogs

Increase either to increase biodiversity

Which to preserve?

Niche:

Ecological role of a species in a community

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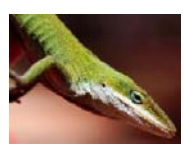
1. Competition



Anolis

Ecomorphs on Caribbean Islands

31

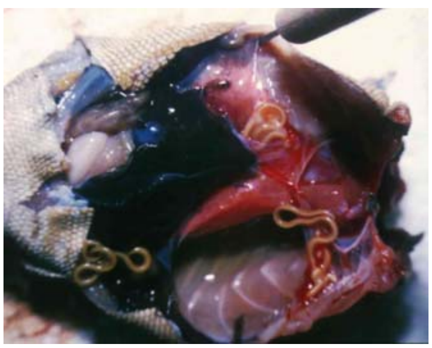
Pisaster (predatory sea star)
Paine
15 vs. 8 spp.
(mussels)

32

2. Predation

33

3. Parasitism



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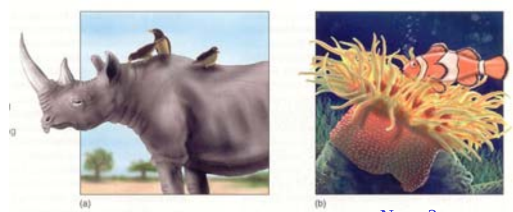
4. Mutualism

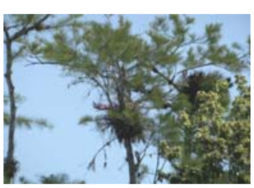


Nemo?

See 4-2 in Miller 2003

35

5. Commensalism



Florida

Ecuador

Bromeliads

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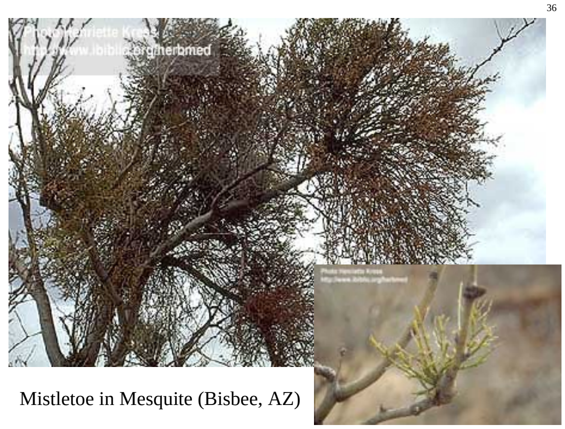

Mistletoe in Mesquite (Bisbee, AZ)

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Indicator Species
-migratory birds
-amphibians

Keystone Species
-top predators
-key pollinators

Rana pipiens
Northern Leopard Frog

Native Species
vs.
Nonnative, exotic, alien

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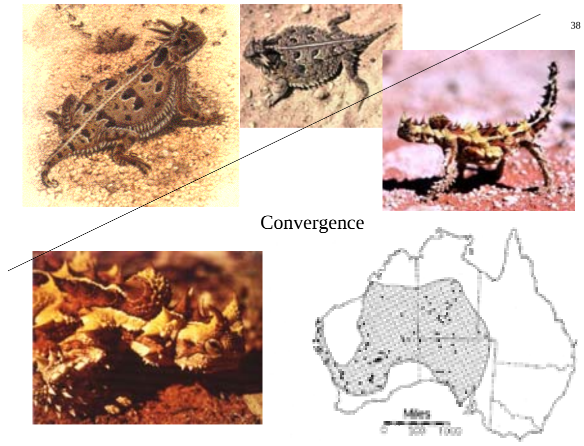

Convergence

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Distribution and Abundance

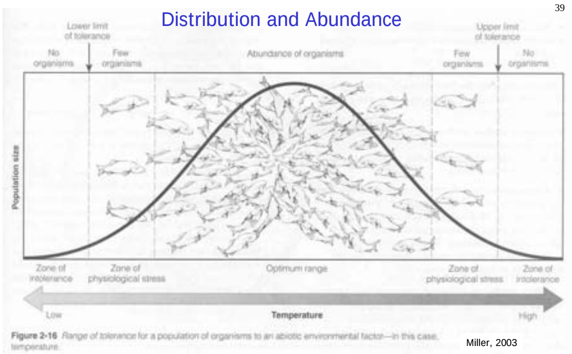

Figure 2-16 Range of tolerance for a population of organisms to an abiotic environmental factor—in this case, temperature.

Miller, 2003

Range of tolerance of abiotic factor(s)

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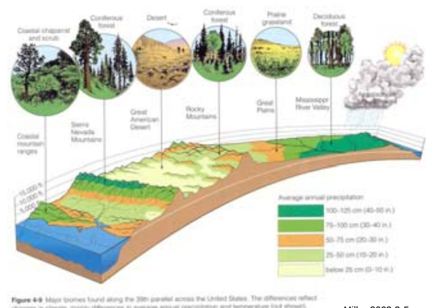
Terrestrial Biomes

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

Climate
1. Temperature
2. Precipitation
(3. Soil type)

- Latitude
- Altitude



Miller 2003 3-5

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Measuring Biodiversity
- alpha - beta - gamma

Beta
area or regional diversity (beta richness)
diversity of species among communities across landscape

gradient
- slope, moisture, temperature, precipitation, disturbance, etc.

Whittaker's Measure = 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

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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

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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

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Other Correlates of Diversity

-Intermediate Disturbance
(shifting mosaic, no climax)

-Habitat Heterogeneity
(e.g., foliage height and birds)

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Measuring Biodiversity
- alpha - beta - gamma

Missing?

Species role in ecosystem?
Rarity
Phylogenetic Representation

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

All species are not equivalent (normative valuation?)

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Pricing Biodiversity

$R_i = (D_i + U_i)(\text{delta}P_i/C_i)$

D = distinctiveness
U = utility
delta P = enhanced probability of survival
C = cost of strategy

Direct limited funds...
Ecological Contribution?

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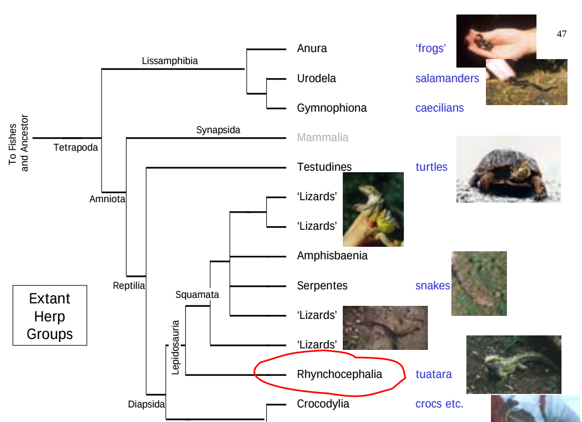

See Fig 2-1 (Pough et al., 2001)

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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

$R_I = (D_i + U_i)(deltaP_i/C_i)$

D = distinctiveness
U = utility
delta P = enhanced probability of survival
C = cost of strategy

El Endo

Direct limited funds…
Ecological Contribution?