Lecture 08, 13 Sept 2007
Biodiversity
Legislation

Conservation Biology
ECOL 406R/506R
University of Arizona
Fall 2007

Kevin Bonine
Cathy Hulshof

Upcoming Readings
today: Text Ch. 4, and pp. 207-213
Text Ch. 2; ESA & NEPA links
Tues 18 Sept: SDCP and ESA links
Thurs 13 Sept: see debate-related readings on website

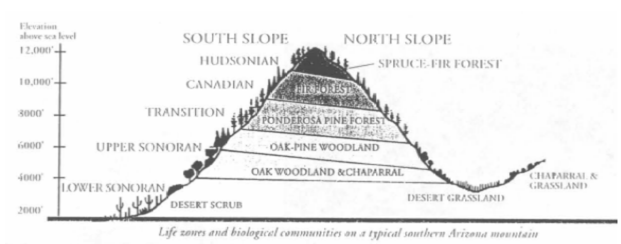
Q2 due 13 Sept if you choose

1

Conservation Biology Lab 406L/506L

Next Lab SATURDAY 15 September
0700h S or W side BSE (4th and Highland)
Hat, water, sunscreen, close-toed shoes
Lunch, snacks, weather gear, ($?)

Readings on Course Website – print:
Handouts 1 and 2,
last 3 pages of:
"Miscellaneous Mt. Lemmon-related information "



2

Debate 20 Sept 2007:
Should the flat-tailed horned lizard (*Phrynosoma mcallii*) be ESA listed?

Three groups – one will debate, another will evaluate, third will observe, then we rotate.

406	506
Debate 1 (20 Sept.)	Debate 1 (20 Sept.)
Group A debate	506 A assist
Group B evaluate	506 B assist
Group C observe	506 C observe
Debate 2 (23 Oct.)	Debate 2 (23 Oct.)
Group A observe	506 A observe
Group B debate	506 B assist
Group C evaluate	506 C assist
Debate 3 (15 Nov.)	Debate 3 (15 Nov.)
Group A evaluate	506 A assist
Group B observe	506 B observe
Group C debate	506 C assist

3

Interested in short-term experiences like summer opportunities or post-baccalaureate internships?
Want to get the inside scoop on some of the best ones out there?

Come listen to our eight guest speakers, enjoy a free delicious dinner,
and learn about some interesting things others have done!

Fall 2007 Science and Engineering Career Series:
Internships and Summer Opportunities

Monday, September 17
4:00PM - 5:30PM
Life Sciences South 240

Guest Speakers:

- **Jessica Lesson, Sanofi-Aventis Intern** (Current UA Student, MCB)
- **Erin Palmer, UBRP and BRAVO Participant** (Current UA Student, Biochemistry)
- **Omar Contreras, National Institutes of Health Intern and UA Public Health Student** (UA Alumus in MCB)
- **Alok Patel, Program Coordinator, Imaginations - Thailand** (UA Alumnus in MCB)
- **Leah Baker, Presidential Management Fellow and Former Peace Corps Member** (UA Alumna in Biology)
- **Lora Grainger, Former Collaboration for the Advancement of Teaching Technology and Science (CATTS) Fellow** (current PhD Candidate in Immunology at UA)
- **Dr. Sean Dessureault, Faculty Advisor for Engineers Without Borders** (UA Faculty in Engineering)
- **Margo Ellis, International Research Experience for Undergrads and Former Motorola Intern** (Current PhD Candidate in Materials Science and Engineering at UA)

This event is free and open to all interested, but space is limited!
Please RSVP to Jennifer Cubeta at cubeta@email.arizona.edu if you plan to attend

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Upcoming EEB Monday Seminar
Please note special time and location

Date: September 17, 2007
Time: 3:00 pm
Location: Marley Auditorium, Room 230

<u>Dr. Scott Saleska</u>
Dept. of Ecology & Evolutionary Biology
University of Arizona
http://www.eebweb.arizona.edu/faculty/saleska

The once (and future?) forest: vegetation carbon balance, ecosystem-scale phenology, and climate change in the Amazon basin

Understanding the factors that control large-scale ecosystem metabolism is a fundamental challenge of ecosystem ecology and biogeochemistry. Such understanding may also be important for addressing the practical question of whether ecosystem response to global climate change will substantially dampen or amplify anthropogenic global warming. The scientific challenge and the practical question are both especially acute in the tropics, where extensive forests have the potential to be large sinks for atmospheric CO2, but where their existence may also be threatened by climate change-induced drought. In this talk, I focus on how our recent work on two problems in ecosystem metabolism in the tropical forests of the Amazon basin -- the balance between photosynthesis and respiration (carbon balance), and the phenology of photosynthetic metabolism -- give insight into how these forests may respond to future climate change.

This is a joint seminar presentation with the Department of Soil, Water and Environmental Science. Refreshments will be provided outside the auditorium at 2:40 pm.

5

Sustainability Town Hall
with Congressman Harry Mitchell
Friday, September 21st, 2 to 3:30 pm
Social with Refreshments: 3:30 to 4 pm
Arizona State University, Tempe Campus: Old Main, Carson Ballroom

This Town Hall will feature panelists from the Global Institute of Sustainability and the community discussing how universities, municipalities, businesses, and ordinary people can walk a common path toward sustainability.

Moderator, John d'anna
Senior Editor, Valley and State, The Arizona Republic

Infusing Sustainability throughout the University
Jonathan Fink, Director, Global Institute of Sustainability

Studying Sustainability
Charles Redman, Director, School of Sustainability

Sustainability as an Economic Engine
Jay Golden, Co-Director, National Center of Excellence, Global Institute of Sustainability

Green Building in the City
Anthony Floyd, Green Building Manager, City of Scottsdale

Reducing Your Carbon Footprint
Harvey Bryan, Professor, School of Architecture and Landscape Architecture, School of Sustainability 6

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)

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

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?

8

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**

9

~guilds

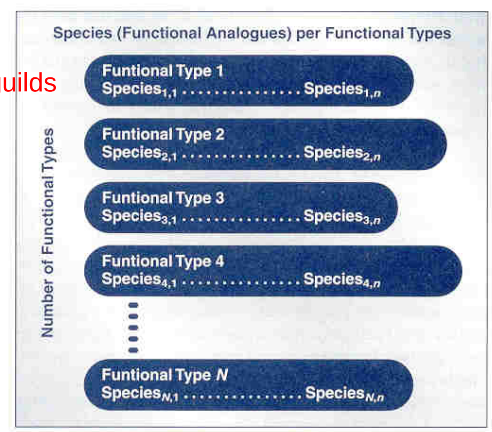

Figure 4.3
Total species diversity can be measured as the product of the number of functional types and the number of species per functional type. Two populations may have the same species diversity and still differ. For example, one may have many functional types and few functional analogues, and the 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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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

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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Alpha and Beta Diversity Hotspots

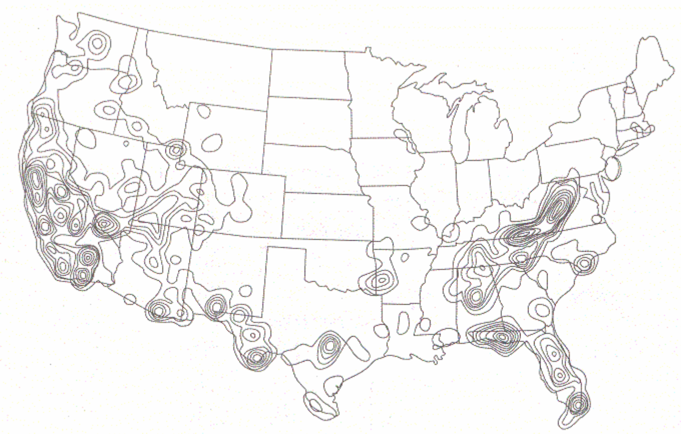

Figure A Hot spots of rarity and species richness in the lower 48 United States. Read as a topographic map with concentric circles showing higher values of the rarity-weighted species richness index (RWRI). Hotspots are found in CA, the Death Valley region of Nevada, the Appalachian Mountains, and the 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. 2000.)

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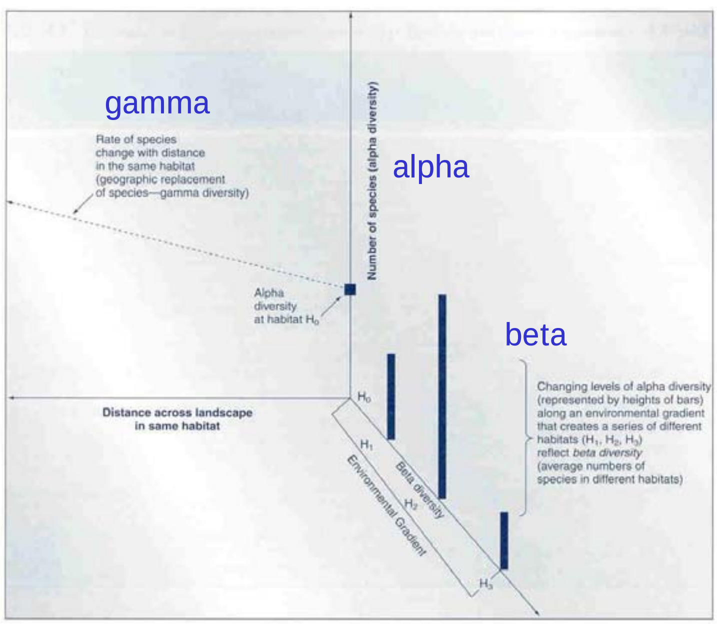
Groom et al. 2006



Van Dyke 2003

Figure 4.2
The number of species on a given site in one kind of habitat is a measure of alpha diversity (species richness). The average number of species per site along an environmental gradient (number of species per habitat) is a measure of beta diversity. The rate of species change over landscape scale distances in the same habitat is a measure of gamma diversity (geographic replacement of species).

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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)

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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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Measuring Biodiversity
- alpha - beta - gamma

Missing?

Species role in ecosystem?
Rarity *per se*
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?)

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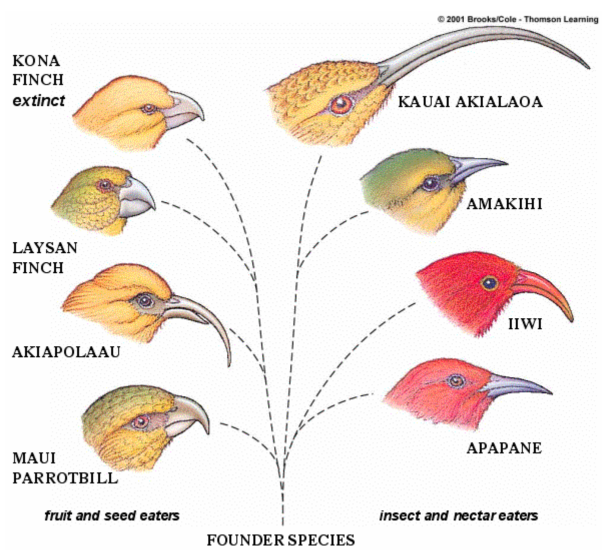
Endemism…

LIFE 8e, Figure 23.15

Hawaiian Honeycreepers:



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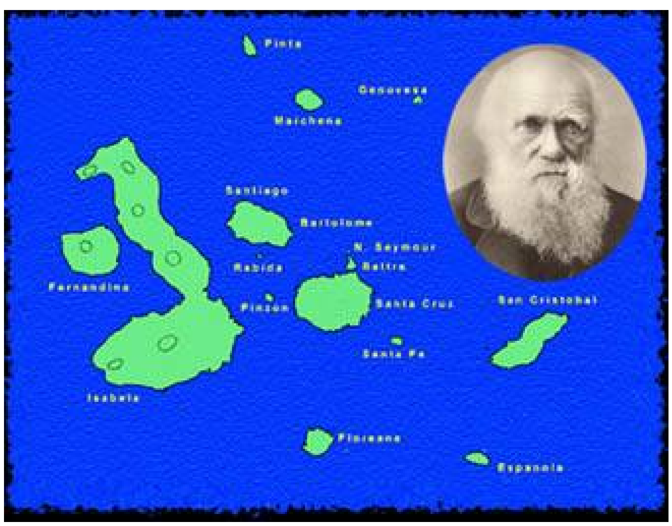
http://www.rit.edu/~rhrsbi/GalapagosPages/DarwinFinch.html

19



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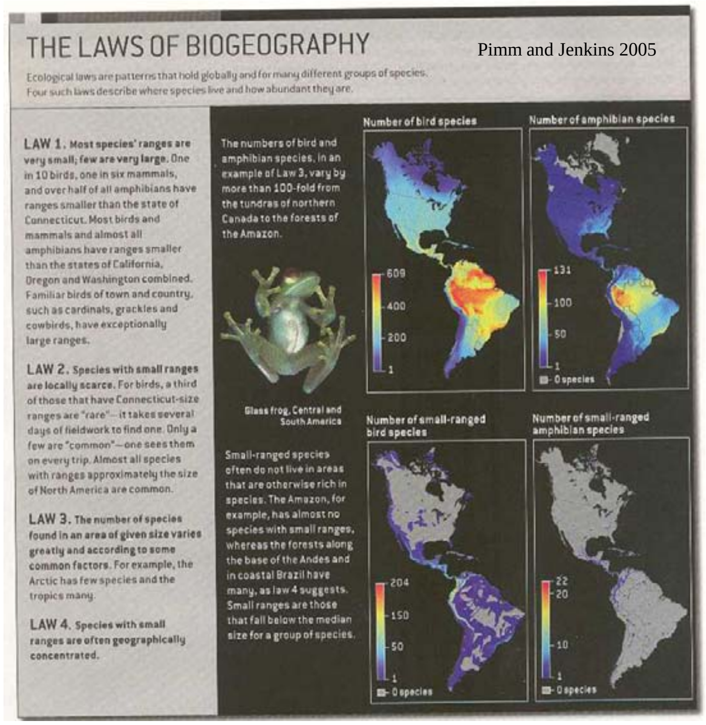

THE LAWS OF BIOGEOGRAPHY

Pimm and Jenkins 2005

Ecological laws are patterns that hold globally and for many different groups of species. Four such laws describe where species live and how abundant they are.

LAW 1. Most species' ranges are very small; few are very large. One in 10 birds, one in six mammals, and over half of all amphibians have ranges smaller than the state of Connecticut. Most birds and mammals and almost all amphibians have ranges smaller than the states of California, Oregon and Washington combined. Familiar birds of town and country, such as cardinals, grackles and cowbirds, have exceptionally large ranges.

LAW 2. Species with small ranges are locally scarce. For birds, a third of those that have Connecticut-size ranges are "rare"—it takes several days of fieldwork to find one. Only a few are "common"—one sees them on every trip. Almost all species with ranges approximately the size of North America are common.

LAW 3. The number of species found in an area of given size varies greatly and according to some common factors. For example, the Arctic has few species and the tropics many.

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

The numbers of bird and amphibian species, in an example of Law 3, vary by more than 100-fold from the tundras of northern Canada to the forests of the Amazon.

Glass frog, Central and South America

Small-ranged species often do not live in areas that are otherwise rich in species. The Amazon, for example, has almost no species with small ranges, whereas the forests along the base of the Andes and in coastal Brazil have many, as law 4 suggests. Small ranges are those that fall below the median size for a group of species.

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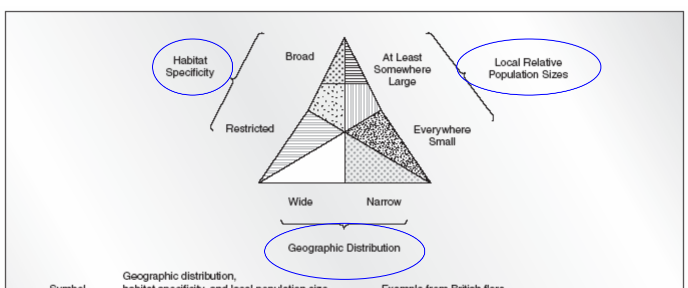

Symbol	Geographic distribution, habitat specificity, and local population size	Example from British flora
	Wide, broad, at least somewhere large	*Deschompsia cespitosa*, tufted hair-grass
	Wide, broad, everywhere small	*Hypochoeris maculata*, spotted gosmore
	Wide, restricted, at least somewhere large	*Ammophila arenaria*, marram grass
	Wide, restricted, everywhere small	*Draba muralis*, wall whitlow grass
	Narrow, broad, at least somewhere large	*Primula scotica*, Scottish bird's-eye primrose
	Narrow, restricted, at least somewhere large	*Agrostis setacea*, bristle-leaved bent
	Narrow, broad, everywhere small	(no example)
	Narrow, restricted, everywhere small	*Lloydia serotina*, alpine lily

Figure 4.9
Eight categories of species abundance in British plants based on geographic range, habitat use, and relative 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 Rabinowitz, Cairns, and Dillon (1986). VanDyke 2003

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Cyprinodon macularius

Desert Pupfish

Photograph Courtesy of John Rinne

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

Desert Pupfish

Family Cyprinodontidae


Photograph Courtesy of John Rinne

-1-1/4 inches long
max. age of three years

-females are gray and drab
males are bluish, turning bright blue during spring breeding season.

-feed on insect larvae and other organic matter from pond bottom.

-prefer shallow pond depths, about 12 to 18 inches deep.

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.

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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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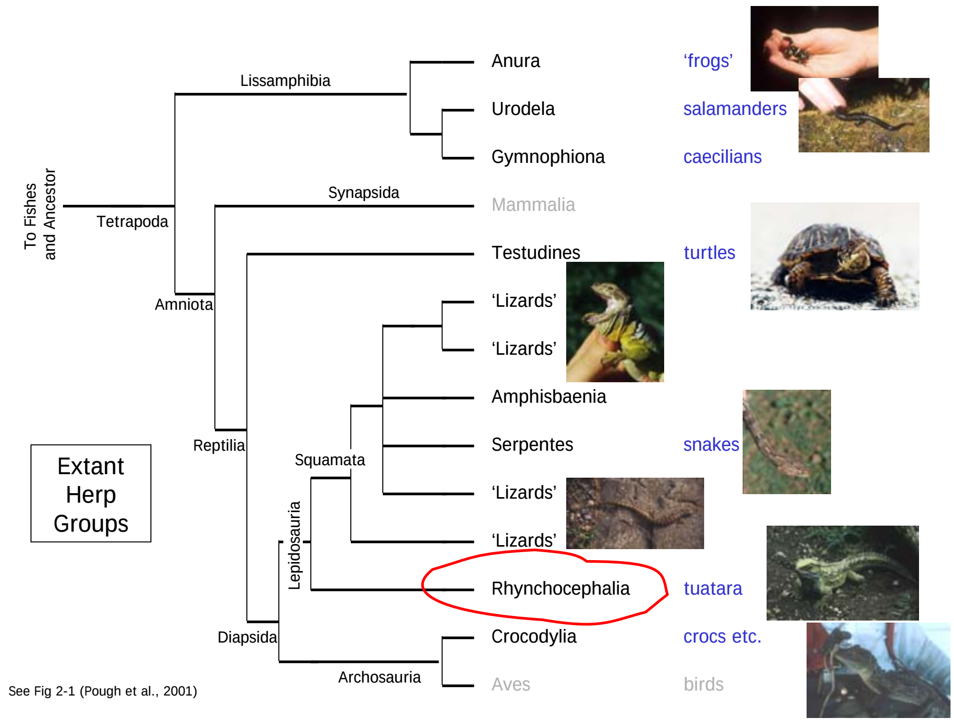

See Fig 2-1 (Pough et al., 2001)

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

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

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

Direct limited funds...
Ecological Contribution?

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Administrative Laws

Executive Orders

Treaties

State Laws

Federal Laws

Policies

Agreements

Conservation Legislation:

Van Dyke Ch.2 Laws and Regulations

Con Bio:
Regulatory Science?
Legally Empowered Discipline?

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Domestic

Laws arose 1970's following concern of 1950s+

Laws reflect current social values but also persist into the future...

Advocacy

ConBio: science and empirical data + law/policy?

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1872 Yellowstone NP
1891 Forest Reserve Act
1916 NPS

1964 Wilderness Act
1965 Land and Water Conservation Fund Act
-acquire lands, use resource revenues
1969/1970 NEPA (EIS)
-think about environment up front
1970 Clean Air Act
1972 Clean Water Act
1973 ESA (species focus)
endangered, threatened, critical habitat
recovery plan
1980 Superfund (1995 Brownfields)

33

Successful Laws:
-Inspirational and radical?
-Growth in influence?
-Science and Monitoring?

Does law create social values?

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Litigation

e.g., polluters liable, citizen involvement, NGOs,
public comment, transparency

EDF 1968
people have right to clean environment

1978 TVA vs. Hill (Snail darter)
God Squad (economic impact vs. habitat)

Endangered Species Committee

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Conservation Easements
remove development rights -->
value decreases so less in taxes

reversible?

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National Environmental Policy Act of 1969 (NEPA)

Requires that all Federal Agencies prepare detailed environmental impact statements for "every recommendation or report on proposals for legislation and other major Federal actions that significantly affect the quality of the human environment."

Federal Hook or Nexus? (land, funds, permits)

3

The Story of NEPA

(through the eyes of Dave Prival, Brooke Gebow, and Cori Dolan, March 2004)

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"…man and nature can exist in productive harmony…"

- National Environmental Policy Act (1969) [40]

Under NEPA, if a government agency is planning to do something that will significantly affect the quality of the environment, that agency has to write an…

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Environmental
Impact
Statement

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National Environmental Policy Act of 1969 (NEPA)

- Environmental Assessment (EA)
- FONSI
- Environmental Impact Statement (EIS)
- Categorical Exclusion (CatEx)

NEPA, NEPA, NEPA!!!!!