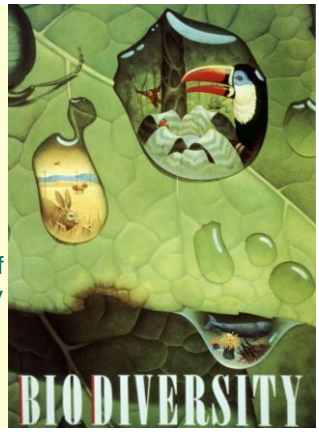
Biodiversity

The heart and soul of conservation ecology

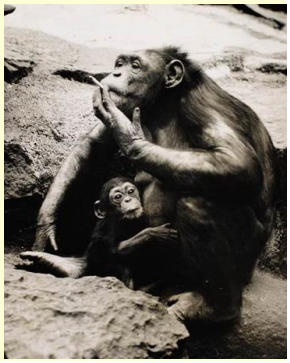


What's biodiversity in the first place?

- Biological diversity
  - The variety of life in all its forms, and at all levels of organization.
  - The variety and relative abundance of species.
  - The genetic, taxonomic, and ecosystem variety in living organisms of a given area, environment, ecosystem, or the whole planet.
  - The structural and functional variety of life forms at genetic, population, species, community, and ecosystem levels.

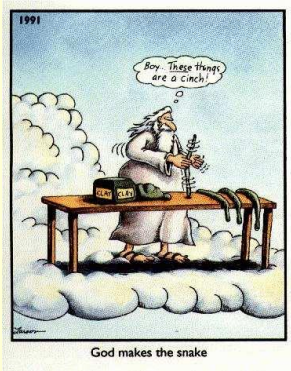
What about just protecting species?

- How do you define a species?
- Isn't this obvious?
- Implications for ESA?
- What about the public?



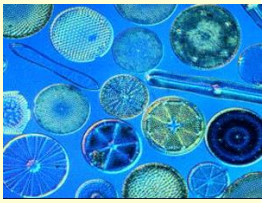
What's a species?

- Several different concepts
- **Typological**



What's a species?

- **Morphological**



What's a species?

- **Ecological**

THE NICHE-RELATIONSHIPS OF THE CALIFORNIA THRASHER.[1]

BY JOSEPH GRINNELL.

THE California Thrasher (*Toxostoma redivivum*) is one of the several distinct bird types which characterize the so-called "Californian Fauna." Its range is notably restricted, even more so than that of the Wren-Tit. Only at the south does the California Thrasher occur beyond the limits of the state of California, and in that direction only as far as the San Pedro Martir Mountains and San Quintin, not more than one hundred and sixty miles below the Mexican line in Lower California.

An explanation of this restricted distribution is probably to be found in the close adjustment of the bird in various physiological and psychological respects to a narrow range of environmental conditions. The nature of these critical conditions is to be learned through an examination of the bird's habitat. It is desirable to make such examination at as many points in the general range of the species as possible with the object of determining the elements common to all these points, and of these the ones not in evidence beyond the limits of the bird's range. The following statements in this regard are summarized from the writer's personal experience combined with all the pertinent information afforded in literature.

1917; The Auk

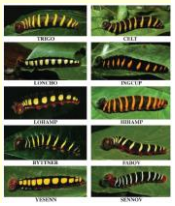
What's a species?

- **Biological**
  - Mayr (1969)

What's a species?

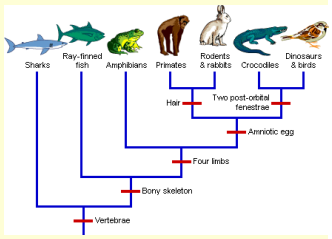
- **Genetic**

Ten species in one: DNA barcoding reveals cryptic species in the neotropical skipper butterfly *Astraptes fulgerator*



What's a species?

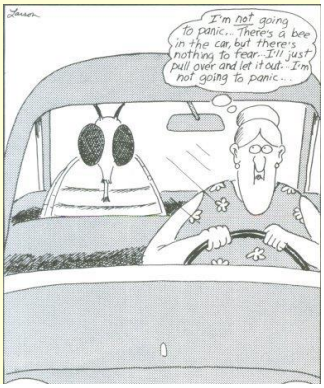
- **Phylogenetic/Cladistic**
  - Synapomorphies



http://evolution.berkeley.edu/evosite/evo101/IIHistory.shtml

Species definitions

- What's a conservation ecologist to do?



Special kinds of species

- **Keystone**
- Ecosystem engineers
- Indicator
- Umbrella
- Flagship
- Vulnerable
- Economic

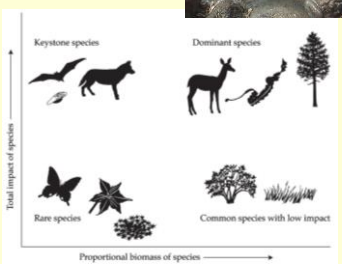


Fig. 3.5

Special kinds of species

- Keystone
- **Ecosystem engineers**
- Indicator
- Umbrella
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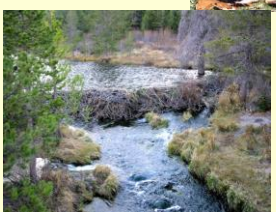
- Vulnerable
- Economic



Special kinds of species

- Keystone
- Ecosystem engineers
- **Indicator**
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Special kinds of species

- Keystone
- Ecosystem engineers
- Indicator
- **Umbrella**
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Special kinds of species

- Keystone
- Ecosystem engineers
- Indicator
- Umbrella
- **Flagship**
- Vulnerable
- Economic

Special kinds of species

- Keystone
- Ecosystem engineers
- Indicator
- Umbrella
- Flagship
- **Vulnerable**
- Economic

Photo: John Abbott

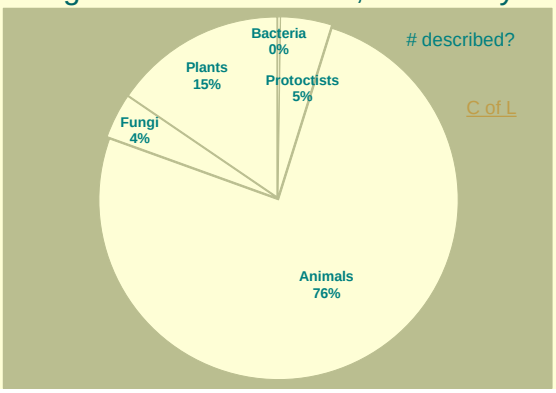
"Rarity precedes extinction" (Darwin 1859)

Special kinds of species

- Keystone
- Ecosystem engineers
- Indicator
- Umbrella
- Flagship
- Vulnerable
- **Economic**


Aren't we all special?

Regardless of the name, how many?



described?

C of L

And, is that all?

A realistic total #?

TABLE 2.1 *Number of Living Species in Major Phyla*[a]

Domain/ kingdom	Phylum	Number of described species	Number of estimated species	Percent described
Viruses	—	5,000	500,000	1
Bacteria	—	4,760	1,000,000	0.5
Archaea	—	259	Unknown	
Eukarya				
Protista[b]	—	80,000	500,000	16
Fungi	Eumycota	80,000	1,500,000	5
Plantae	Bryophyta	15,000	30,000	50
	Trachaeophyta	272,655	500,000	55
Animalia	Porifera	15,000	—	—
	Cnidaria	10,000	—	—
	Platyhelminthes	25,000	—	—
	Rotifera	1,800	—	—
	Bryozoa	5,000	—	—
	Nematoda	25,000	400,000	6
	Arthropoda	1,065,000	9,000,000[c]	12
	Annelida	15,000	—	—
	Mollusca	70,000	200,000	35
	Echinodermata	7,000	—	—
	Chordata	57,739	60,000	96

Source: Adapted from data in Margulis and Schwartz 2000; Lecointre et al. 2001; IUCN Red List 2004; Gaston and Spicer 2004; Maddison and Schultz 2004.

[a]Major phyla listed have >1000 described species.

[b]Protista lumps 5–7 distinct kingdoms within the domain Eukaryota.

One famous older extrapolation

Biodiversity and Conservation 2, 215–232 (1993)

How many species are there?

NIGEL E. STORK

Biodiversity Division, Entomology Department, The Natural History Museum, Cromwell Road, London SW7 5BD, UK

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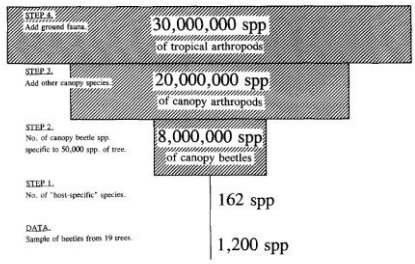
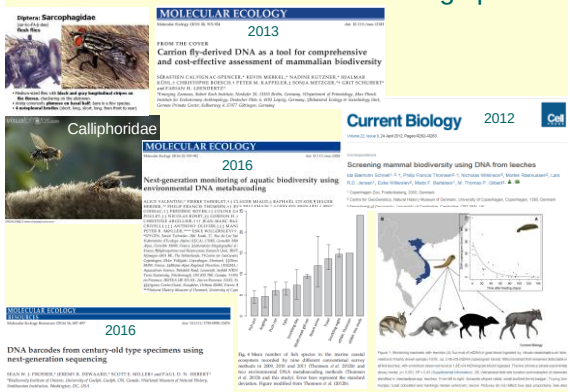


Fig. 1. Erwin's (1982) method of estimating global diversity of tropical insects. Note that on this scale the thickness of the lines for the DATA and STEP 1 levels should be 0.0016 mm and 0.012 mm thick.

Terry Erwin

Some recent advances in detecting species



Do we need them all?

- Some competing hypotheses (plus null)

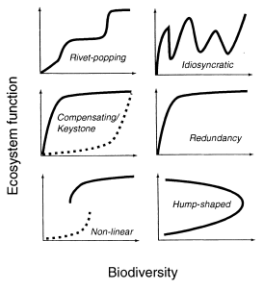


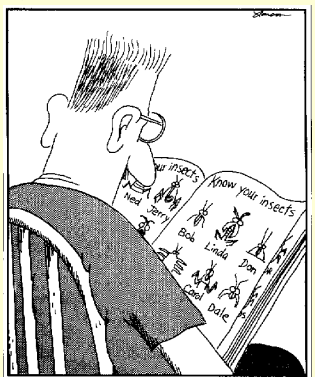
Figure 1. Examples of several proposed hypothetical associations between biotic diversity and ecosystem function. Function refers to biogeochemical processes of ecosystems. Authors for the hypotheses are as follows: rivet-popping, Ehrlich and Ehrlich (1981); non-linear, Carpenter (1996); redundancy, Walker (1992) and Lawton and Brown (1993); idiosyncratic, Naeem et al. (1995); humped-shaped, Rosenzweig and Abramsky (1994); and compensating/keystone, Sala et al. (1996).

Naeem (1998)

Describing biodiversity

- Alpha
- Beta
- Gamma

Introduced by R.H. Whittaker (1972, *Taxon*)



Alpha diversity (α)

EstimateS — Statistical Estimation of Species Richness and Shared Species from Samples

Home | About EstimateS | EstimateS Download | EstimateS User's Guide | Support | EstimateS & Biota | Links

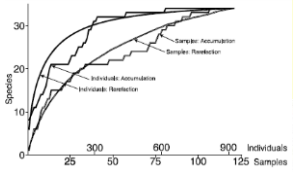


Figure 1 Sample- and individual-based rarefaction and accumulation curves. Accumulation curves (jagged curves) represent a single ordering of individuals (solid-line, jagged curve) or samples (open-line, jagged curve), as they are successively pooled. Rarefaction curves (smooth curves) represent the means of repeated re-sampling of all pooled individuals (solid-line, smooth curve) or all pooled samples (open-line, smooth curve). The smoothed rarefaction curves thus represent the statistical expectation for the corresponding accumulation curves. The sample-based curves lie below the individual-based curves because of the spatial aggregation of species. All four curves are based on the benchmark

Gotelli and Colwell (2001)

Beta diversity (β)

- Describes…
- Many methods used to quantify
  - Whittaker's Measure
    - S/α - 1
    - Where S = all species across sites; α = average # of species per site

Miami of Ohio agroecosystem plots & mesocosms

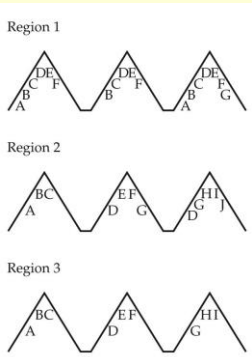
α and β Diversity example

Table 1. Characteristics of 30-m transects established on the rims of six Carolina bays at Lewis Ocean Bay Heritage Preserve. In each bay, two transects were established, one on a side rim and one on an end rim. Means are presented ± standard error, n = 6. Superscript letters indicate no significant ($P \geq 0.05$) differences between side and end transects.

Position	Richness (S)	Beta Turnover (β_T)	Axis Length (SD)	Elevation Change (m)
Side	18.7 ± 1.8^a	3.2 ± 0.3^a	4.0 ± 0.5^a	0.6 ± 0.2^a
End	21.8 ± 2.2^a	3.0 ± 0.3^a	4.3 ± 0.3^a	0.6 ± 0.1^a

Laliberte et al. (2007)

Gamma diversity (γ)



	Alpha (species per mountain)	Gamma (species per region)	Beta (gamma/alpha)
Region 1	6	7	1.2
Region 2	4	10	2.5
Region 3	3	9	3.0

Diversity indices

- Combination of _____ and _____
  - Examples: Shannon index, Simpson index
- Some issues
  - What do they really mean?
  - Describes an overall community, not ….

THE NONCONCEPT OF SPECIES DIVERSITY: A CRITIQUE AND ALTERNATIVE PARAMETERS[1]

STUART H. HURLBERT[2] (1971)

Division of Biological Control, Department of Entomology, University of California, Riverside

Abstract. The recent literature on species diversity contains many semantic, conceptual, and technical problems. It is suggested that, as a result of these problems, species diversity has become a meaningless concept, that the term be abandoned, and that ecologists take a more critical approach to species-number relations and rely less on information theoretic and other analogies. As multispecific collections of organisms possess numerous statistical proper-

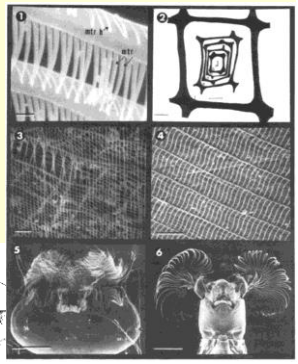
Some explanations of biodiversity

- Niches and competition
- Species area relationship
- Intermediate disturbance hypothesis
- Productivity

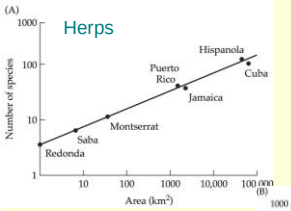
When the British biologist J. B. S. Haldane was asked by a group of theologians what one could conclude as to the nature of the Creator from a study of His creation, Haldane is said to have answered, "An inordinate fondness for beetles".

Niches and competition

- Gause's law of competitive exclusion
- Resource partitioning leads to…



Species-area relationship



- Mechanism?

Fig. 2.13

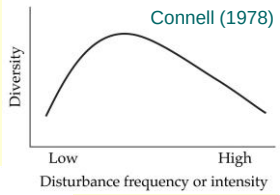
Species-area equation

- ?
- But, ecologists often do what to the equation?
- z often set to _____
- Implications for conservation?

Intermediate disturbance hypothesis

- Mechanism?

Townsend et al. (1997)



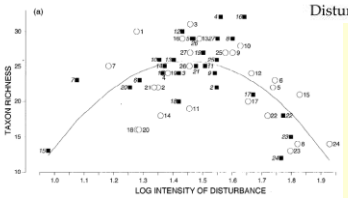


Fig. 2.18

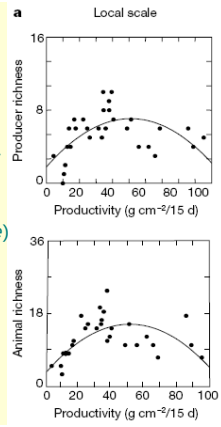
But, see Mackey & Currie (2001, *Ecology*)

Productivity

Mechanism?

Diversity in 30 freshwater ponds of Michigan

Chase & Leibold (2002, *Nature*)



But, see Adler et al. (2011, *Nature*)

Geographic trends: An old stand-by

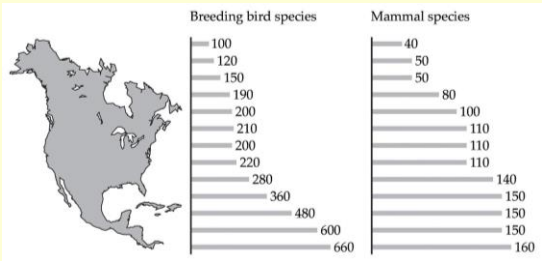


Fig. 2.12

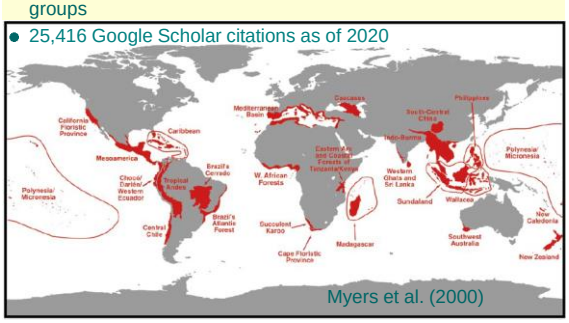
Hotspots of diversity

- Are some places more important to protect?

Taxa	# of Species	# Endemic	% Endemic
Plants	13,000	11,600	89.2
Mammals	155	144	92.9
Birds	310	181	58.4
Reptiles	384	367	95.6
Amphibs	230	229	99.6
Fishes	164	97	59.1

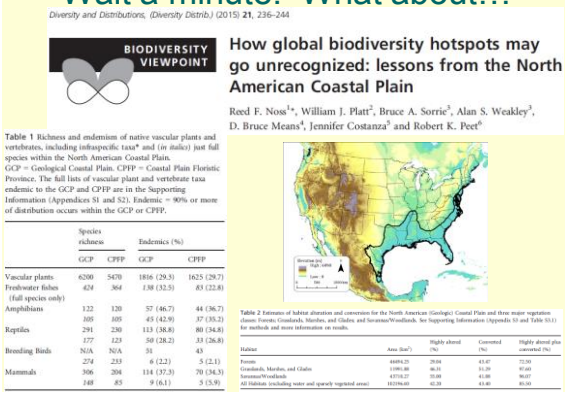
Biodiversity hotspots

- 25 hotspots; 1.4% of land cover of Earth
- Contains 44% vascular plants; 35% of 4 vertebrate groups
- 25,416 Google Scholar citations as of 2020



Myers et al. (2000)

Wait a minute. What about…



Diversity and Distributions, (Diversity Distrib.) (2015) **21**, 236–244

BIODIVERSITY VIEWPOINT

How global biodiversity hotspots may go unrecognized: lessons from the North American Coastal Plain

Reed F. Noss[1]*, William J. Platt[2], Bruce A. Sorrie[3], Alan S. Weakley[3], D. Bruce Means[4], Jennifer Costanza[5] and Robert K. Peet[6]

Table 1 Richness and endemism of native vascular plants and vertebrates, including infraspecific taxa* and (*in italics*) just full species within the North American Coastal Plain. GCP = Geological Coastal Plain. CPFP = Coastal Plain Floristic Province. The full lists of vascular plant and vertebrate taxa endemic to the GCP and CPFP are in the Supporting Information (Appendices S1 and S2). Endemic = 90% or more of distribution occurs within the GCP or CPFP.

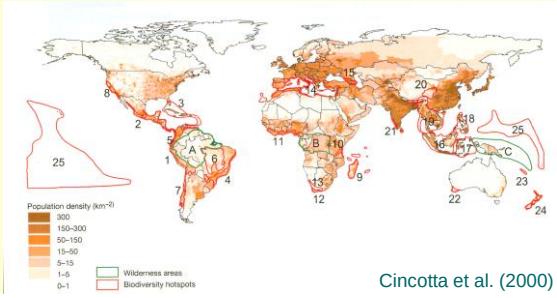
	Species richness		Endemics (%)	
	GCP	CPFP	GCP	CPFP
Vascular plants	6200	5470	1816 (29.3)	1625 (29.7)
Freshwater fishes (full species only)	424	364	*138* (32.5)	*83* (22.8)
Amphibians	122	120	57 (46.7)	44 (36.7)
	105	*105*	*45* (42.9)	*37* (35.2)
Reptiles	291	230	113 (38.8)	80 (34.8)
	177	*123*	*50* (28.2)	*33* (26.8)
Breeding Birds	N/A	N/A	31	43
	274	*233*	6 (2.2)	5 (2.1)
Mammals	306	204	114 (37.3)	70 (34.3)
	148	*85*	*9* (6.1)	5 (5.9)

Table 2 Extremes of habitat alteration and conversion for the North American (Geologic) Coastal Plain and three major vegetation classes: Forests, Grasslands, Marshes, and Glades, and Savannas/Woodlands. See Supporting Information (Appendix S3 and Table S3.1) for methods and more information on results.

Habitat	Area (km²)	Highly altered (%)	Converted (%)	Highly altered plus converted (%)
Forests	44894.25	29.04	43.47	72.50
Grasslands, Marshes, and Glades	11981.88	46.35	51.20	97.60
Savannas/Woodlands	43718.27	55.08	41.88	96.97
All Habitats (excluding water and sparsely vegetated areas)	161594.60	42.20	43.40	85.60

Humans and hotspots

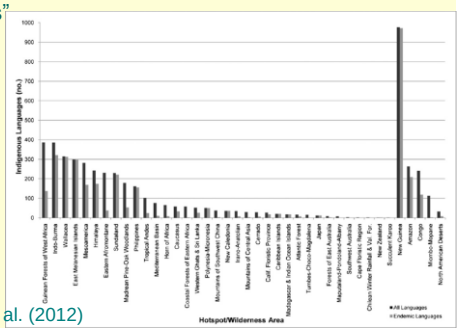
- In 1995, 20% of humans (1.1 billion) live in the hotspots; growth rates there (1.8% per yr) are higher than world-wide average (1.3% per yr)



Cincotta et al. (2000)

Languages and hotspots

- "A total of 3,202 languages, nearly half of those on Earth, currently are found in the 35 biodiversity hotspots"



Gorenflo et al. (2012)

War(?) and hotspots

- 80% of major armed conflicts between 1950 and 2000 took place in biodiversity hotspots

Hanson et al. (2009)

Figure 1. The world's 34 biodiversity hotspots (numbers) (Mittermeier et al. 2004) and the location of all armed conflicts with over 1000 casualties between 1950 and 2000 (points) (conflict data from Arnold 1991; Sarkees

Hotspots vs. NGO offices

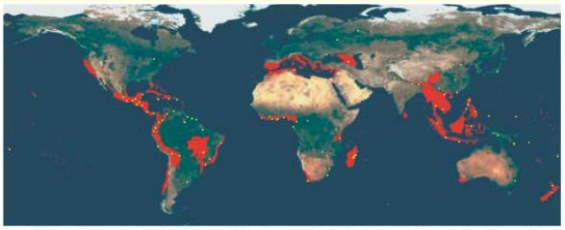
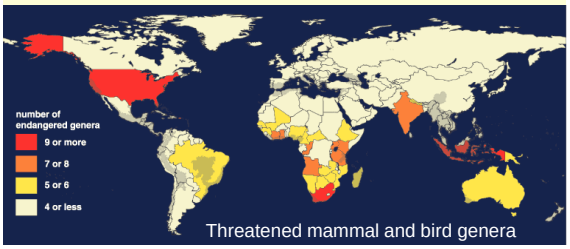


Figure 2. Biodiversity hotspots, as defined by Myers *et al.* 2000 *(red)*, span the globe, but they fall mostly in the tropics. The influence of Myers's hotspot concept is evident in the distribution of the office locations for the three largest nongovernmental conservation organizations (green dots)—Conservation International, The Nature Conservancy and the World Wildlife Fund—shown here with the many office locations in the United States and Western Europe excluded. (Background colors from satellite imagery, courtesy of ARC Science.)

Kareiva & Marvier (2003)

Biodiversity coldspots?

- Kareiva & Marvier (2003, Amer. Sci.)
- If hotspots are so important, what about the rest—are they then *coldspots*?
- Any problems with hotspots?



Now what should we do?

- The rest? Relative cost?