DIVERSITY

What is diversity?
What isn't diversity?

Antonyms: monotony, purity, similarity, **homogeneity**

Synonyms: variety, medley, divergence, difference, contrast, assortment, variance, **heterogeneity**

In ecological terms, diversity is usually a quantitative measure that is used in describing biotic entities: **communities** - collections of species in an area of interest;
genetic - variation within individuals and populations

Clearly, scale is important in any definition of diversity. Obviously one would expect to find that the variation at epsilon spatial levels is much greater than the variation at alpha spatial levels (what might be an example of where this is not true? - the boreal forest at an epsilon scale may have fewer species than an alpha-sized area in a tropical rain forest; a tropical coral reef sampled at the alpha scale may have more species than all of the Arctic ice pack). Example: Kentucky has about 130 tree species, whereas 10 hectares (10 x 2.47 acres) of tropical forest in Borneo has 1,000 species of trees! In addition, it matters whether we are comparing species within or between taxa - insect diversity will almost always be greater than the diversity of any other animal taxa within the same area of interest. Thus, scale is important when it comes to describing diversity - the unit of space as well as the unit of taxonomy must be defined before comparisons are made. Examples of such specificity:

Amphibians in a Kentucky cave
Small mammals in the Cumberland Plateau
Passerine (perching) birds in a forest clearcut
Vascular plants on a tropical island
Invertebrates from a Rocky Mountain stream
Fish from a creel sample
Abomasal parasites of a white-tailed deer
Abomasal parasites of a white-tailed deer population

Such descriptions depend on defining our area of interest and how it is sampled:
1) The spatial boundaries of an area
2) The temporal limits of an investigation (day, months, season, year, decade, century, epoch)
3) Taxonomic focus (species, genus, family, order, color, structure, process)
4) Species of interest must be readily identifiable
5) Importance values can be applied - biomass, abundance (ants v. elephants)
6) Can be within an area (alpha, gamma, epsilon) or a gradient (beta, delta)

More Diversity

Diversity Yardsticks:

- Richness
- H'
- Evenness (J')

Are highly diverse communities more "valuable" than less diverse communities?

Not necessarily – high values for diversity indices may be products of denatured landscapes: i.e. large artificial clearings in forests (cowbirds, cardinals, indigo buntings, common grackles), and intentional introductions (exotic fisheries Hunter example in text).

Local artificial increases in alpha and beta diversity may actually result in a decrease in Gamma diversity, especially if introduced species out-compete and replace natives.

Decreases in Gamma diversity are often a part of a process known as: **Relaxation** and in really severe cases as **Floral or faunal collapse** which results in furthering the **homogenization** of global diversity – (homogenization may be good for milk, but not much else).

Imagine yourself going home after a long day of work or school. You crack open a cold (or hot) one (knowing that alcohol, caffeine, tar & nicotine are poisonous to your personal life support systems),turn down the lights, flick on the tube or the internet, put your feet up, lower your heart rate, slouch into your worn-out couch or stratolounger. The result – RELAXATION. You are probably not in such great shape after the first soft taco and Limestone ale to defend yourself against an intruder or some other calamity. In a not so far-fetched analogy, native plant and animal communities have experienced loosened tensions and evolutionary ties. Ties and tensions that have held them together and promoted increased stability over millennia. **Ecological Relaxation**. Local examples include the explosion in abundance of meso-mammals (raccoons, opossums, foxes, coyotes) – when was the last time you saw a wolf or cougar run across the Mountain Parkway, or even heard of one in Kentucky? Another is the predominance of edge-inhabiting and exotic birds in our urban and suburban landscapes. Look at Kentucky's mixed mesophytic forest – Dutch elm disease, chestnut blight, dogwood anthracnose, and questionable forestry practices have reduced the diversity and eliminated some of the evolutionary and ecological processes of our forests.

Example from out of town: Florida has greater Beta bird diversity today than 100 years ago as the result of the importation of species from South America, Europe, Asia, Africa, etc., even though a number of native species are now extinct (ivory-billed woodpecker, Carolina parakeet, possibly American flamingo). At least 25 exotic bird species now breed in Florida; whereas only 2 are known to have gone extinct – thus the avifauna is much richer today in Florida – but more homogeneous in a global sense (gamma=global?). Havens for such exotics include Miami, Tampa, the Keys, and

agricultural land – places that have been severely **denatured** by people. Most of these species were intentionally brought in by people – what about the cattle egret? Usually, the species that do well in a new environment are super abundant to begin with, so it's not like we are creating new situations for uncommon species to make a comeback.

Rarity - Many species are inherently rare, and subject to greater extinction risk.

Why are big fierce animals so rare?
Top of trophic ladder
Wide-ranging
Slow to mature and reproduce
Solitary social/spatial arrangement

Often, such animals contribute very little in terms of numerical diversity to a community, habitat, or landscape. But they are very important from a conservation standpoint because of the **work** they do in the environment, and because they can be used as **"umbrella"** or **"flagship"** species for conservation efforts – that is, their successful management benefits many other species in the managed/protected landscape. Examples of umbrella species include:
cougar, black bear, river otter, gorilla, black rhino…

Services include **seed dissemination**, **prey regulation**, **successional arrest**, and the maintenance of **evolution**ary processes.

Traditionally, compelling arguments for protecting rare species were very subjective/qualitative – early on it was mostly game species that we concerned ourselves with (the only good wolf was a bad wolf; wolves & tree ring example?).

As conservation issues become more complicated and contentious, and opponents to endangered species become more vocal and organized, the burden of proof shifts increasingly to agencies and their administrators & scientists. Today, many quantitative models exist that calculate extinction probabilities, often known as Population Viability Analyses (PVAs) (Vortex, Ramas, and others). These are tools for better understanding the effects of various factors that might result in decreases or increases in numbers. They are best used in pointing out deficiencies in our knowledge. More on these later…

Arachnaphobia and The Medicine Man

Recall the term "Biodiversity" : Biotic + diversity, and that the basic currency for its measure is the species (what is a species?). Then recall that of the 10-30 million or so species on the planet, as few as 5% have been described.

As humans, most of us are incapable of considering more than one level of complexity simultaneously. Thus, when measuring biodiversity we choose some manageable subset of the total – species, genetic, community, order, family, genera, or guild. Today, we will look into a simple measure of life's richness, **species diversity**.

First, let's look at the places that people first became fascinated with life's endless variety. (aside about man vs. human, gender, cultural biases etc.)

Tropics are the hotbed of diversity

Tropical forests are the epitome of biodiversity and are universally appealing – especially to industrialized nations in temperate and boreal climates. Just as European settlers of North America found this continent's bounty limitless, so too have tropical rain forests seemed inexhaustible. The fallacy of this view is now vividly apparent.

Some of the products and well-known attributes of tropical rain forests include timber, fruit, wildlife, spices, orchids, drugs, primitive culture (malaria, yellow fever, ebola virus, bot flies, leeches, piranhas, poisonous snakes, frogs, etc.). During the 1970s tropical rain forests were estimated to be disappearing at a rate of 60 acres/minute.

According to P.W. Richards (**1952**:405), loss of rain forests has serious global consequences:
"The rain-forest flora with its immense wealth of species belonging to thousands of genera and scores of families has acted in the past as a reservoir of genetical diversity and ***potential*** variability. During at least the more recent epochs of the earth's history it has been a centre of evolutionary activity from which the rest of the world's flora has been recruited (consider the magnolias in Kentucky)…much of the flora of the temperate regions is derived directly or indirectly from the tropics…The tropical forest has thus played a part different from that of any other major plant formations, perhaps because evolution has not there been interrupted by seasonal checks to plant activity or by secular climatic changes such as glacial periods. It is also possible that the high and constant temperatures of the Rain forest are specially favourable to the survival of mutations…It is therefore likely that the destruction of the Tropical Rain forest accomplished during the last 100 years has changed fundamentally the future course of plant evolution and closed many avenues of evolutionary development"…

Another consequence is the impact on climate – recognized as early as 1912…Another is economic losses – raw materials, and erosion control.

More recently, we have come to recognize forests as important carbon sinks. The felling of forests without allowing them to return to old growth, increases the return of CO_2 to the atmosphere, and promotes global warming.

Tropical Rain forests are primarily equatorial in distribution (see handout) – hence, there is little or no seasonal effect – i.e. day length, temperature, & rainfall often are constant.

Tropical forests account for >50% of the world's forests. By turn of century only 30% will remain. Forest losses are due primarily to increasing human population

Felling & clearing for pasture (Burger King)

Logging for timber, paper, fuel wood – domestic and export

Began at first as selective & scattered (teak, mahogany); now increasingly intensive and "efficient" (cite Corkscrew Swamp Sanctuary)

Logging on the one hand mimics natural disturbance, however, even if the forest is allowed to regenerate it often returns to a much simpler, less diverse forest (dormant seeds) – any ideas as to why this might be true?

Entire animal communities become less diverse as structure & diversity decline

Climate may be influenced due to increased reflectivity of solar radiation – little light actually reaches the forest floor before it is absorbed or reflected.

Clearly, tremendous changes can be expected in the biodiversity of the tropics as the former oceans of forest are converted to patchwork islands like those in the developed nations. According to tropical ecologist T.C. Whitmore, "Man's dependence on other organisms and especially upon plants is such that unless attack on them is moderated, man's own continued existence is threatened."

Further, many forests that are allowed to remain will be plantations with reduced diversity. Tropical forest reserves will need to be extremely large to accommodate all of their wide-ranging and therefore inherently rare species:

Hornbill, tapir, elephant, tiger, jaguar, and many others.

Even trees often live at low species densities and thus require huge areas to maintain normal **demographics**. Forest fragmentation disrupts many processes: pollination, dispersal of progeny, migration, to name a few. It also threatens the existence of native hunter-gatherer cultures which are dependent on a diversity of fruiting trees, plant resins, and other plant products. **Ethnobotany**.

From Wilson 1992: "**a slice of the northern hemispheric gradient in breeding bird species using areas of roughly the same size**."

Greenland	56
Labrador	81
Newfoundland	118
New York State	195
Florida	***179*** what's going on here?
Guatemala	469
Columbia	1,525

Some 30% of the world's 9,040 bird species occur in the Amazon Basin…slides

Exercises in Imaginary Biology

As part of an evaluation of a new state-owned nature preserve in central Florida, environmental technician Aldo G. Snaptrap is given the responsibility of measuring the distribution and abundance of small mammals on the Newt Gingrich Non-Game Wildlife Management Area. This assignment was to include comparisons of diversity between 2 management subunits: a restored pine flatwoods site that was previously a cattle pasture (site 1), and a remnant patch of turkey oak-longleaf pine sandhill (site 2). After soaking in tomato juice for several hours to neutralize the aroma of spotted skunk, Aldo proceeds to compare the two sites based on the data collected on his one-kilometer long trapline (animals were caught in Sherman live traps, given individual markers, then released unharmed). The information will be used for an interpretive display and for setting future management goals.

Site 1 trap results

Species	**Common name**	**n**	**P_i**	**$\ln P_i$**	**$P_i \ln P_i$**
Sigmidon hispidus	Hispid cotton rat	4	.23	-1.47	-0.34
Peromyscus gossypinus	Cotton mouse	5	.29	-1.24	-0.36
Mus musculus	House mouse	2	.12	-2.12	-0.25
Peromyscus polionotus	Oldfield mouse	3	.18	-1.71	-0.31
Rattus rattus	Black rat	2	.12	-2.12	-0.25
Spilogale putorius	Spotted skunk	1	.06	-2.81	-0.17
				$-\Sigma =$	1.68
Totals		17		(H')	
$J'=H'/H'_{max}$ (n=2.8 each, P_i=.16, ln P_i=-1.8, max=1.72)				J'=	0.98

Site 2 trap results

Species	**Common name**	**n**	**P_i**	**$\ln P_i$**	**$P_i \ln P_i$**
Peromyscus polionotus	Oldfield mouse	13	.62	-0.48	-0.30
Podomys floridanus	Florida mouse	8	.38	-0.97	-0.37
				$-\Sigma =$	0.67
Totals		21		(H')	
$J'=H'/H'_{max}$ (n=10.5 each, P_i=.50, ln P_i=-.69, max=0.69)				J'=	0.97

Now, in terms of biodiversity, what should Aldo's management recommendations be? What might the interpretive signs indicate about the way the state will manage this preserve? What do we know about the natural history of the species in question?