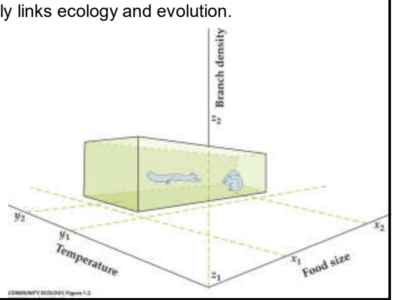
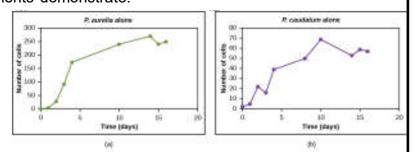
Niche – combination of multiple optima along many gradients

- The role an organism plays in the environment
  - All resources, interactions with biotic/abiotic components of the environment
  - **N-dimensional hypervolume**
    - Each dimension is a biotic or abiotic resource
- Note that niche theory tightly links ecology and evolution.

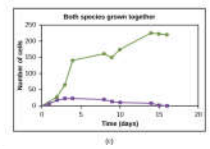


Gause's principle (competitive exclusion)

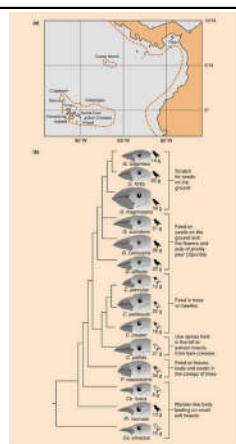
- No two species with same niche can coexist. One must, eventually, outcompete the other.
- The "winner" may be random (expected to be random if niches are identical) due to stochasticity in the environment.
- Simple mesocosm experiments demonstrate:



Note that even in this very simple mesocosm experiment, Gause was able to obtain coexistence (survival of *P. caudatum*) by changing environmental parameters through time.



- Many examples (Darwin's finches are one) demonstrate species change to reduce competitive pressure.
- Major niche axis = food (seeds of various sizes).
- Selection for specialization and divergence in beak size (review steps in the modern synthesis).
- Coexistence can happen, competition reduced.

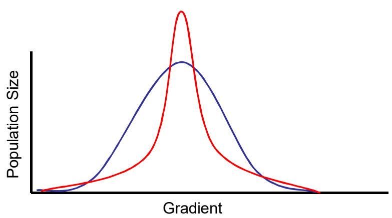


Paradox of the Plankton

- As a result…competitive exclusion is rarely observed. Some argue violations to Gause's principle are common.
- E.g. plankton communities:
  - Very diverse, very similar species, limited resource base, seemingly homogeneous environment
  - Answer (?) - On the **<u>scale</u>** the organisms experience the ocean, it is quite patchy
  - In other words, this only seems like it violates Gause's principle…

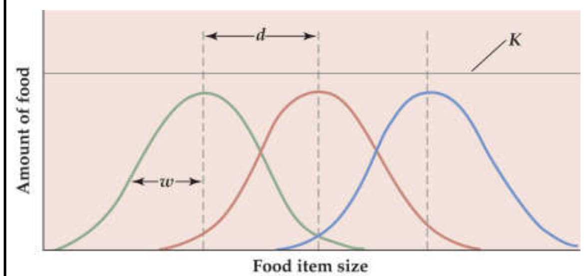
Niche Width

- Niche Width – range of gradient(s) over which a species occurs and is abundant.
- Fundamental vs. realized niche
- Tolerant vs. intolerant species
- Generalist – jack of all trades, wider range of optima, wider niche
- Specialist – narrower range of optima, expect narrow niche



Niche Width

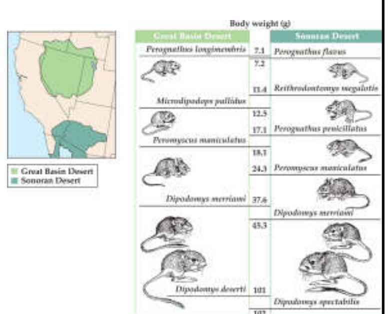
- Coexistence requires some difference among species, how much?
- Complete niche overlap → competitive exclusion
- Niche metrics for quantifying the extent of overlap (and thus competition)
  - *d*: distance between niche optima
  - *w*: width of niche (wider = more generalist)



COMMUNITY ECOLOGY, Figure 1.4

Hutchisonian Ratios

- **Guilds** – groups of co-occurring species that use similar resources.
- Species in the same guild tend to differ in size by a factor of 2 (Hutchisonian Ratio).
- Indicator of **limiting similarity** – minimal niche similarity allowed for coexistence.



COMMUNITY ECOLOGY, Figure 1.3

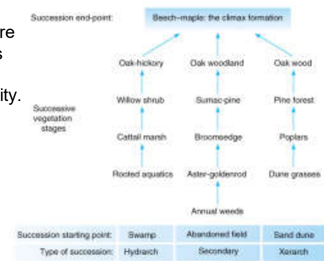
Community Ecology

How do interactions among species determine distribution and abundance of populations in a particular area or habitat?

Population and Community Ecology

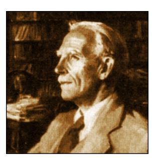
History of Community Ecology

- **1916 - Frederick E. Clements.** "Plant succession: an analysis of the development of vegetation" – a community is analogous to an organism, all component species are interdependent. Succession stages are predictable, progressing from bare ground to the climax community. Origin of Gaia hypothesis.
- **1926 - Henry Gleason.** "The individualistic concept of the plant association" - communities are unique, not analogous to superorganism. Individual species reproductive, competitive and dispersal abilities drive community structure. Basis for the continuum concept of succession.

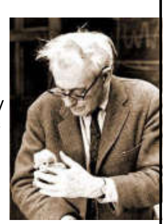


History of Community Ecology

- **1935 - Arthur Tansley**. "The use and abuse of vegetational concepts and terms" – originated ecosystem concept. Climate, plants and animals function as parts of a system, thus having functional relationships. Emphasized the evolving nature of communities. No monoclimax, tendency to move towards equilibrium (poly-climax hypothesis).

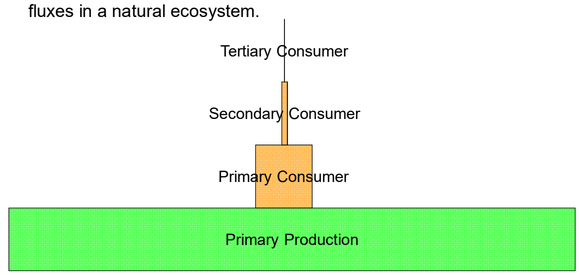


- **1959 - G. Evelyn Hutchinson.** "Homage to Santa Rosalia or why are there so many kinds of animals?" - species diversity is a function of complex trophic interactions and niche diversification. Communities may achieve some level of stability. Emphasized the mosaic nature of the environment.



History of Community Ecology

- **1942 - Raymond Lindeman.** "The trophic-dynamic aspect of ecology" - Viewed ecosystems in terms of energy and nutrient flow and cycling among tropic levels.
- **1957 - Howard Odum**. "Trophic structure and productivity of Silver Springs, Florida" – early application of Lindeman's trophic-dynamics concept. Energy flow diagrams, quantitative measure of energy fluxes in a natural ecosystem.

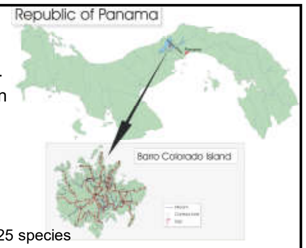


Biodiversity

- Simplest form - number of species
- 1st problem – what is a species?
  - 1.4 million described species
  - Estimated 11 million undescribed
- 2nd problem – researcher taxonomic bias
  - 8 million insects
  - 1 million fungi
  - 500,000 nematodes
  - 400,000 bacteria
  - 50,000 vertebrates (about 90% described)
- 3rd problem – artificial boundaries to communities

Community Ecology Data

- Smithsonian Research Institute, very complete, publically available dataset.
- Tree counts from 50, 1 hectare plots in a regular grid covering the whole island
- Abundance of 225 species across 50 plots

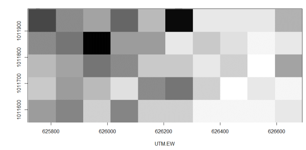


Plot	Acalypha.macrosta	Adelia.triloba	Aegiphila.paname	Alchornea.costaric	Alchornea.latifolia
1	0	0	0	2	0
2	0	0	0	1	0
3	0	0	0	2	0
4	0	3	0	18	0
5	0	1	1	3	0
6	0	0	0	2	1
7	0	0	1	0	0
8	0	0	0	2	0
9	0	5	0	2	0
10	0	0	1	2	0
11	0	0	0	10	0
12	0	1	1	3	0
13	0	1	1	1	0
14	0	0	0	4	0
15	0	2	0	2	0
16	0	2	0	2	0
17	0	0	1	2	0
18	0	1	1	0	0
19	0	0	1	1	0

→ 225 species

↓ 50 plots

Tabernaemontana arborea



Biodiversity

- Number of species
- Genetic diversity
- Indices of diversity:
  - Species richness (S)
  - Shannon Index (H`)
  - Simspon's Index (D)
    - Where n_i=individuals of species I
    - S = number of species
    - N = total number of individuals
    - P_i = relative abundance of each species

$$H` = -\sum_{i=1}^{S} p_i \ln p_i$$

$$D = \frac{1}{\sum_{i=1}^{s} p_i^2}$$

Equitability

- Measure of the evenness of species abundances within the community.
- Maximum = D or H if all species abundances the same
- Equitability is a percentage of the max.

$$E = \frac{D}{D_{\max}} = \frac{1}{\sum_{i=1}^{s} p_i^2} * \frac{1}{s}$$

$$J = \frac{H`}{H`_{\max}} = \frac{-\sum_{i=1}^{S} p_i \ln p_i}{\ln S}$$