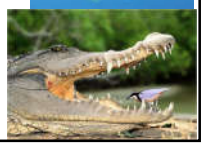
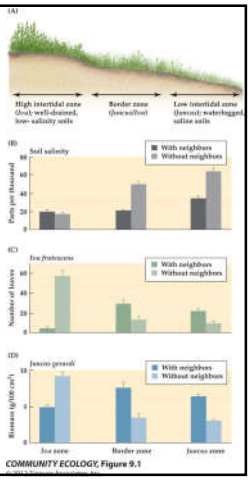
Definitions

- Previous interactions were generally negative
  - **Predation** (+/-)
  - **Parasitism** (+/-)
  - **Competition** (-/-)
- Not all species interactions are negative.
- Positive species interactions have generally not been well studied, slow to be integrated into theory.
- **Commensalism** (+/0)
- **Symbiosis** (+/+)



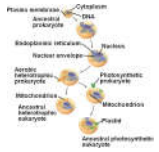
Definitions

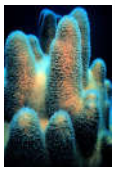
- **Mutualism** - pairwise interaction where both species benefit
  - Can occur at a distance (e.g. seed dispersers)
- **(Habitat) Facilitation** – pairwise interaction where one (typically) species benefit.
  - Often defined by the presence of one species enhancing the survival and fitness of a neighboring species.
- **Symbiosis** – type of mutualistic relationship where one species often lives in or on another.
  - **Endosymbiosis**

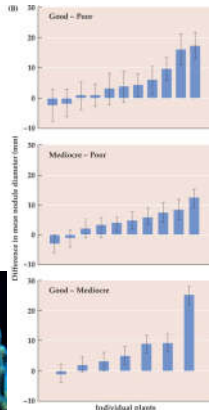


Evolution of Mutualism

- Like anything else, evolution of mutualism linked to tradeoffs.
- Best viewed as **Reciprocal exploitation** where both species benefit.
- Other species viewed as a resource.
  - Role in protist evolution
  - Impacts on diversity

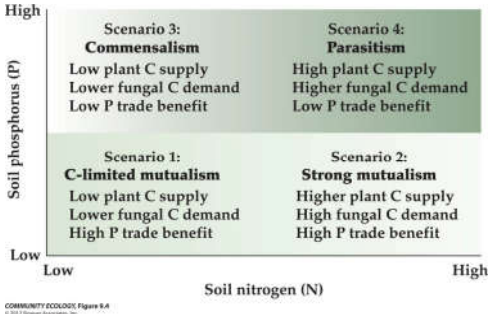






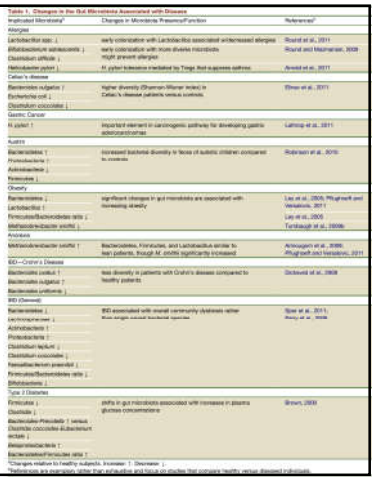
Evolution of Mutualism

- Ecological conditions may alter the relative benefits, change relationship to commensalism or even parasitism.
  - Plants provide C, fungi provide P:



Human Example

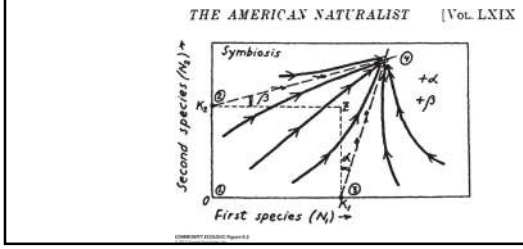
- Human GI track has well over 1000 species, 10^{14} (100 trillion) organisms
- But microbiome changes with diet, has clear impact on health.
- Likely established in utero, certainly early after birth.
- Fecal microbiota transplants



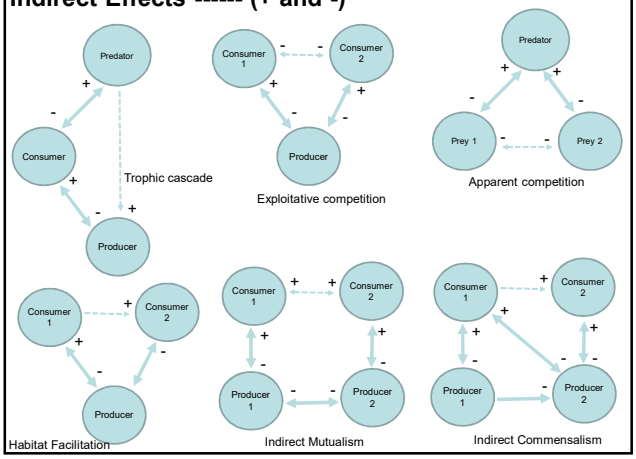
The Impact of the Gut Microbiota on Human Health: An Integrative View

Integrating Positive interactions into Models

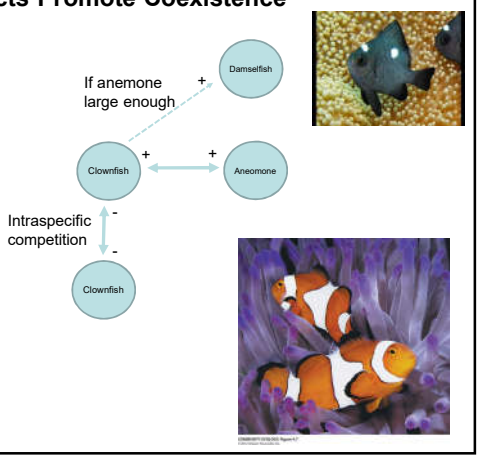
- Interspecific models modified to make interaction positive:
- $\frac{dN_1}{dt} = r_1 N_1 \left(\frac{K_1 - N_1 + a_{12} N_2}{K_1}\right)$
- Mathematically, this has the effect of increasing K for both species. Change from negative to positive competition.



Indirect Effects ------ (+ and -)



Indirect Effects Promote Coexistence



Direct/Indirect Effects Overview

Indirect Effects in Marine Rocky Intertidal Interaction Webs: Patterns and Importance

Bruce A. Menge

Ecological Monographs, Vol. 65, No. 1. (Feb., 1995), pp. 21-74.

MODELS OF INDIRECT EFFECT SEQUENCES

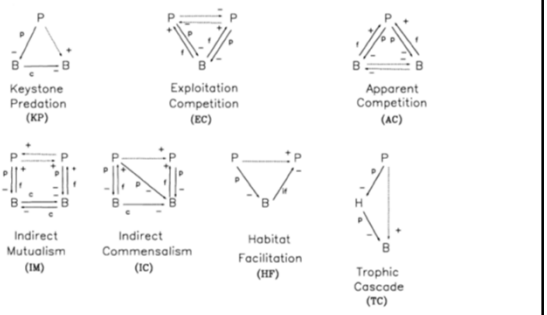
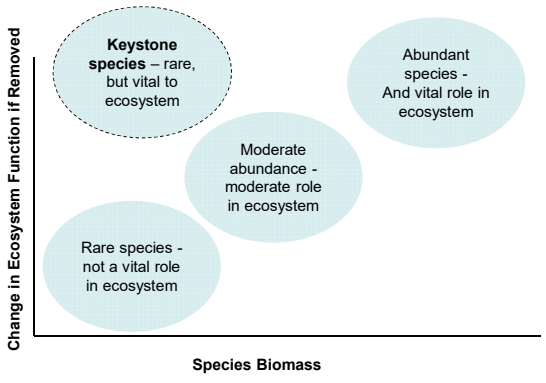


FIG. 1. Models of indirect effect sequences. P, predator; H, herbivore; B, basal species. Solid arrows represent direct effects, dashed arrows represent indirect effects. +, positive effect; −, negative effect. p, predation; c, interference competition; f, provision of food; if, inhibition of feeding.

Ecosystem Engineer

- Species that changes the physical nature of a habitat that allows other species to exist.
- Usually animals
  - Burrow, construct, dislodge, move large components (as a species) of the environment.

Keystone Species



Clements-Gleason Revisited

- Climax vs. individualistic hypothesis of community structure

Succession – community changes through time

- Definitions
  - Primary
  - Secondary
  - Autogenic
  - Allogenic
  - Degradative (heterotrophic)

Potential mechanisms driving succession

- Colonization-competition trade off
- Facilitation
- Combination of tolerance, competition and facilitation

Succession Models

- Horn (species replacement, Markov Chain)

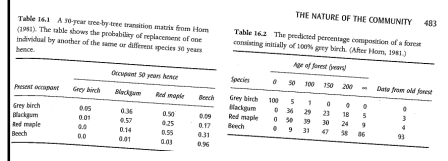


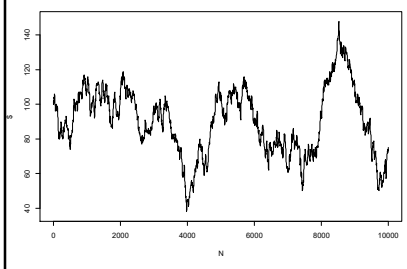
Table 16.1 A 50-year tree-by-tree transition matrix from Horn (1981). The table shows the probability of replacement of one individual by another of the same or different species 50 years hence.

	Occupant 50 years hence			
Present occupant	Grey birch	Blackgum	Red maple	Beech
Grey birch	0.05	0.36	0.50	0.09
Blackgum	0.01	0.57	0.25	0.17
Red maple	0.0	0.14	0.55	0.31
Beech	0.0	0.01	0.03	0.96

Table 16.2 The predicted percentage composition of a forest consisting initially of 100% grey birch. (After Horn, 1981.)

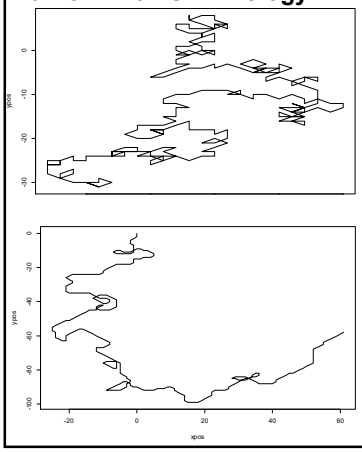
	Age of forest (years)					
Species	0	50	100	150	200	∞ Data from old forest
Grey birch	100	5	1	0	0	0
Blackgum	0	36	29	23	18	5 3
Red maple	0	59	39	30	24	9 4
Beech	0	9	31	47	58	86 93

Markov Chains



Simple gambling example: Start with $100, make a series of 50:50 bets. The amount of money you have is randomly determined, but at any given time is constrained by what you had at the previous time.

Markov Chains in Biology



Random walk: start a coordinate 0,0. Pick one of 8 random directions and go to that point. Your current position is related to your previous position, but movement is random.

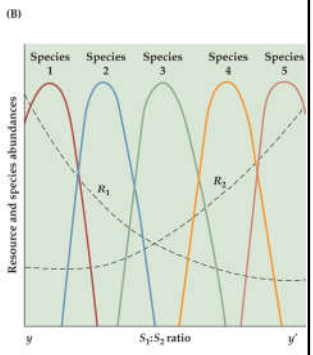
8	1	2
7		3
6	5	4

Correlated random walk: Your direction is correlated with your last move.

Broad applications in evolutionary biology.

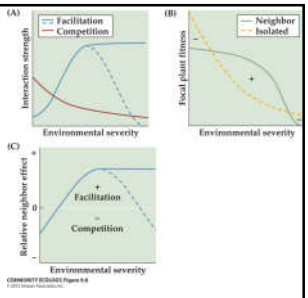
Succession Models

- Tillman Resource Ratio Hypothesis (R*)



Stress Gradient Hypothesis

- Early colonization driven by tolerance to conditions.
- Early colonizers reduce stress through various mechanisms (facilitation).
- Facilitation reduces environmental harshness, increasing the importance of competition.
- "Neighbor" effect switches from + to – across harshness gradient.

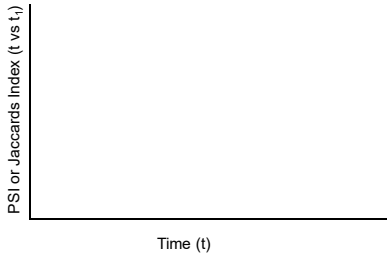


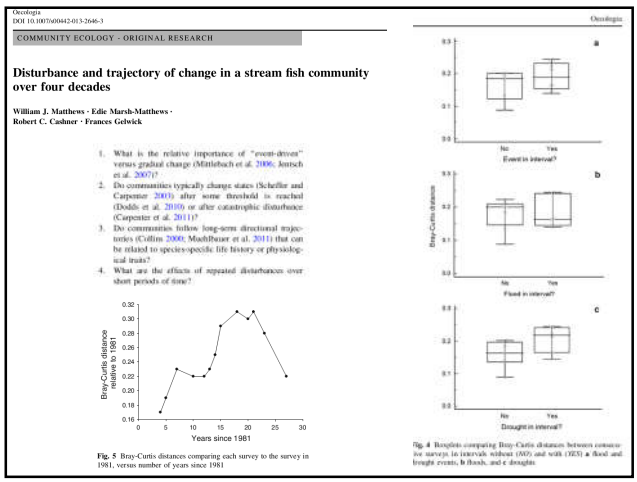
Review Concept – Detecting Succession

- Quantitative and qualitative differences in community composition.

$$PSI = \sum_{i=1}^{s} \min P_i$$

$$Jaccards = \frac{a}{a+b+c}$$





Oecologia
DOI 10.1007/s00442-013-2646-3

COMMUNITY ECOLOGY - ORIGINAL RESEARCH

Disturbance and trajectory of change in a stream fish community over four decades

William J. Matthews · Edie Marsh-Matthews · Robert C. Cashner · Frances Gelwick

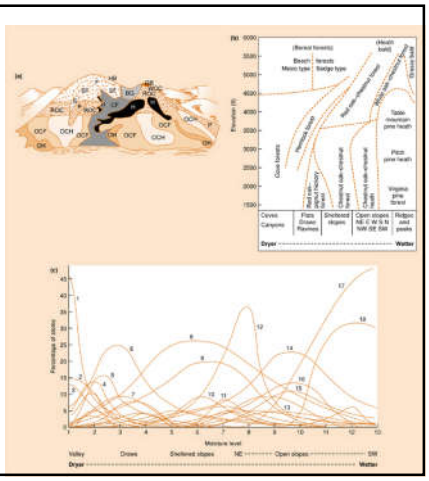
1. What is the relative importance of "event-driven" versus gradual change (Mittelbach et al. 2006; Jentsch et al. 2007)?
2. Do communities typically change states (Scheffer and Carpenter 2003) after some threshold is reached (Dodds et al. 2010) or after catastrophic disturbance (Carpenter et al. 2011)?
3. Do communities follow long-term directional trajectories (Collins 2000; Mudrabaser et al. 2011) that can be related to species-specific life history or physiological traits?
4. What are the effects of repeated disturbances over short periods of time?

Fig. 5 Bray-Curtis distances comparing each survey to the survey in 1981, versus number of years since 1981

Fig. 4 Boxplots comparing Bray-Curtis distances between consecutive surveys in intervals without (NO) and with (YES) a flood and drought events, b floods, and c droughts

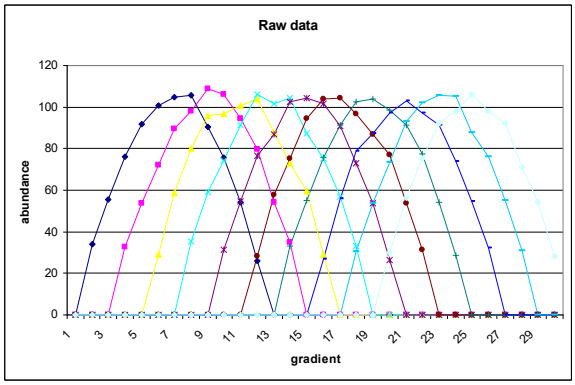
Gradient Analysis

- Direct vs Indirect



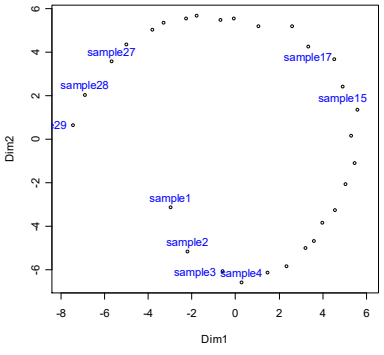
Sample community data, 29 samples across a gradient, colored lines represent abundance of 10 species.

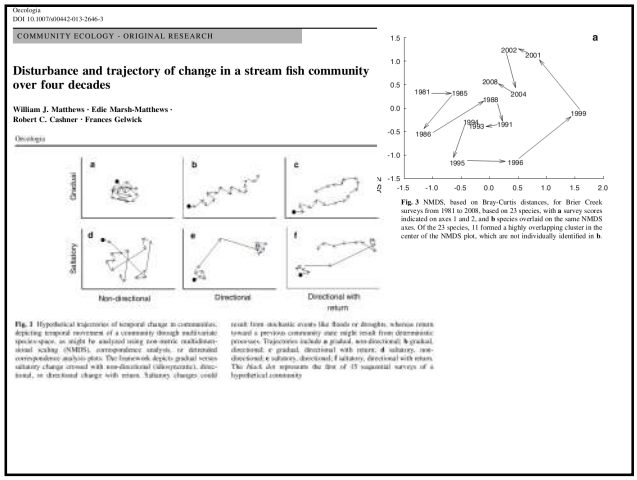
Note: species all show unimodal distribution along gradient.



Ordination

- Visual representation of species x sample matrix in two dimensions.
- Distance among points (samples) is analogous to dissimilarity
- Wide variety of techniques





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Oecologia

Fig. 1 Hypothetical trajectories of temporal change in communities, depicting temporal movement of a community through multivariate species-space, as might be analyzed using non-metric multidimensional scaling (NMDS), correspondence analysis, or detrended correspondence analysis plots. The framework depicts gradual versus saltatory change crossed with non-directional (idiosyncratic), directional, or directional change with return. Saltatory changes could result from stochastic events like floods or droughts, whereas return toward a previous community state might result from deterministic processes. Trajectories include **a** gradual, non-directional; **b** gradual, directional; **c** gradual, directional with return; **d** saltatory, non-directional; **e** saltatory, directional; **f** saltatory, directional with return. The *black dot* represents the first of 15 sequential surveys of a hypothetical community

Fig. 3 NMDS, based on Bray-Curtis distances, for Brier Creek surveys from 1981 to 2008, based on 23 species, with **a** survey scores indicated on axes 1 and 2, and **b** species overland on the same NMDS axes. Of the 23 species, 11 formed a highly overlapping cluster in the center of the NMDS plot, which are not individually identified in **b**.

Predation and Community Structure

- Predation increases diversity through reduced intraspecific (fewer density dependent effects) and interspecific (less competitive exclusion) competition
- Pisaster starfish, one of the first documented keystone species.

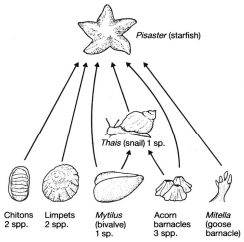

Figure 21.3. Paine's rocky shore community. (After Paine, 1966.)

Paine (1966) – starfish prey on superior competitors, make room for competitive subordinates.
Experimental removal of starfish reduced diversity from 15 to 8.