SPECIES ABUNDANCE and DIVERSITY

Species abundance

- Relative representation of a species in a particular ecosystem

Most species are moderately abundant; few are very abundant or extremely rare.

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The Commonness, And Rarity, of Species

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THE COMMONNESS, AND RARITY, OF SPECIES

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The Lognormal Distribution

How do we think about the abundance of organisms?

Most species had intermediate coverage.

“bell-shaped,” or “normal” shaped distribution pattern

lognormal distribution.

Ecologists have found that the more you sample a community, the more species you will find.

The common species show up in even small samples, but a great deal of sampling effort is needed to capture the rare species.

Most species in well-studied communities are moderately abundant.

Species Diversity

A combination of the number of species and their relative abundance defines species diversity. Ecologists define species diversity on the basis of two factors:

(1) the number of species in the community, which ecologists usually call **species richness**, and

(2) the relative abundance of species in communities, or **species evenness**.

A Quantitative Index of Species Diversity

Ecologists have developed many indices of species diversity, the values of which depend on levels of species richness and evenness. The most commonly used index is **the Shannon-Wiener index, *H′*.**

$$H' = -\sum_{i=1}^{s} p_i \log_e p_i$$

Environmental Complexity

Species diversity is higher in complex environments.

What does nutrient availability have to do with environmental complexity?

Increasing nutrient availability whether due to natural variation or fertilization, reduces the number of limiting nutrients. Eventually, when or where all nutrients are abundant, light becomes the single limiting resource. Under these conditions the algal or plant **species most effective at competing for light will dominate the community** and species diversity will decline. Increased nutrient availability is also associated with reduced fungal diversity.

Disturbance and Diversity

Intermediate levels of disturbance promote higher diversity.

The Nature and Sources of Disturbance

What is disturbance? What constitutes disturbance varies from one organism to another and from one environment to another. A disturbance for one organism may have little or no impact on another, and the nature of disturbance may be quite different in different environments.

Wayne **Sousa** (1984), who examined the role of disturbance in structuring natural communities, defined disturbance as "**a discrete, punctuated killing, displacement, or damaging of one or more individuals (or colonies) that directly or indirectly creates an opportunity for new individuals (or colonies) to become established**."

P. S. **White** and S. **Pickett** (1985) defined disturbance as **"any relatively discrete event in time that disrupts ecosystem, community or population structure and changes resources, substrate availability, or the physical environment."**

White and Pickett listed 26 major sources of disturbance, roughly divided into **abiotic** forces, such as fire, hurricanes, ice storms, and flash floods; **biotic** factors, such as disease and predation; and human-caused disturbance.

We will focus our discussion of disturbance on two characteristics: frequency and intensity.

The Intermediate Disturbance Hypothesis

Joseph Connell (1975, 1978) **high diversity is a consequence of continually changing conditions**

How can intermediate levels of disturbance promote higher diversity?

Connell suggested that at intermediate levels of disturbance, there is sufficient time between disturbances for a wide variety of species to colonize but not enough time to allow competitive exclusion.

Disturbance by Humans

The effects of disturbance by humans are all around us.

Housing developments cover the countryside as human populations continue their rapid growth. Deforestation continues at an alarming rate in both temperate and tropical regions.

Industries pollute air and water.

Human disturbance threatens thousands of species with extinction. The International Union for Conservation of Nature lists habitat destruction by humans as the most serious threat to endangered species worldwide (IUCN 2007).

SPECIES INTERACTIONS and COMMUNITY STRUCTURE

Food Chain

Food Web

Community Webs

A food web summarizes the feeding relations in a community.

Strong Interactions and Food Web Structure

Robert Paine (1980) suggested that, in many cases, the feeding activities of a few species have a dominant influence on community structure; **strong interactions** that depend not on the quantity of energy flow but rather degree of influence on community structure.

Foundation species are those that have substantial influences on community structure as a consequence of their high biomass—for example, abundant phragmites, an abundant tree in a forest, or a coral on a reef.

Indirect Interactions

Indirect interactions between species are fundamental to communities. Food webs emphasize *direct* trophic interactions between species. **Direct interactions** between two species, including competition, predation, herbivory, and mutualism, involve positive or negative effects of one species on another without the involvement of an intermediary species. However, direct interspecific interactions can also result in ecologically significant *indirect* interactions between species.

In **indirect interactions**, one species affects another through a third, intermediary species. Indirect interactions include trophic cascades, apparent competition, and indirect mutualism or commensalism.

Keystone Species

The feeding activities of a few keystone species may control the structure of communities. Robert Paine (1966, 1969) proposed that the feeding activities of a few species have inordinate influences on community structure, **keystone species.**

Paine's keystone species hypothesis emerged from a chain of reasoning.

1. Predators might keep prey populations below their carrying capacity.

2. The potential for competitive exclusion would be low in populations kept below carrying capacity.

3. If keystone species reduced the likelihood of competitive exclusion, their activities would increase the number of species that could coexist in communities. In other words, Paine predicted that some predators may increase species diversity.