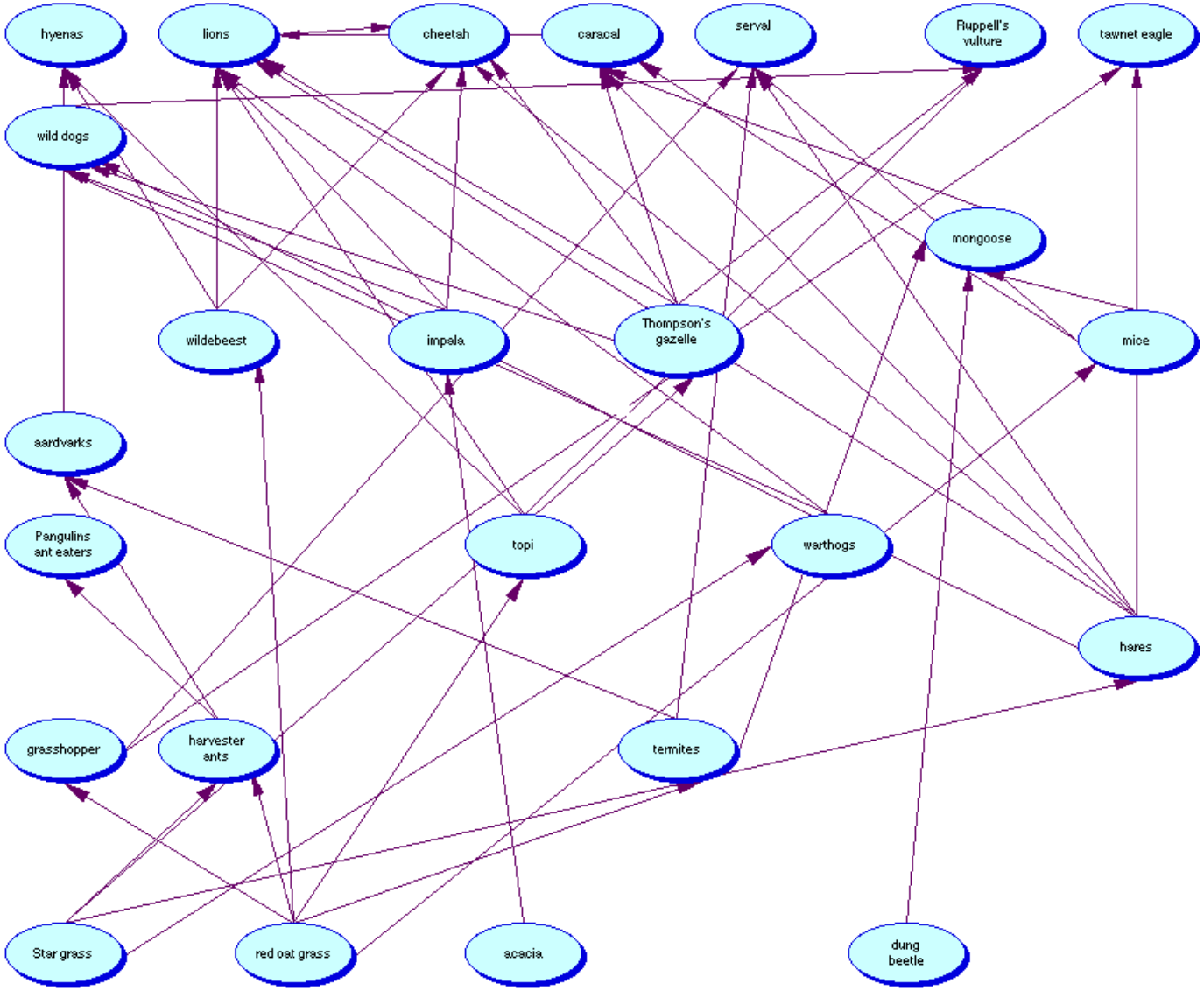


Ecology – Communities

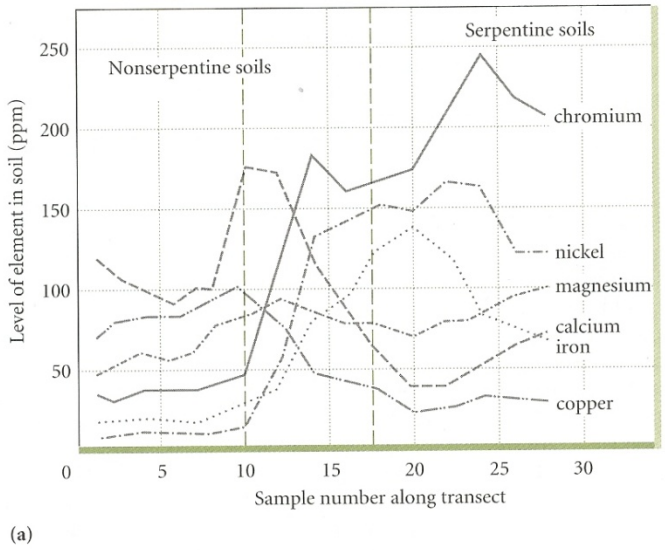
Communities?

- How do we define the term community?
- Here we are looking at multiple species interacting in a given environment
- Definition of community boundaries and community membership is often very difficult **and** certainly, communities are dynamic entities

Is there structure to the community?

- What do we mean by structure?
- Communities can be either **open** or **closed** entities
- Boundaries are generally defined by ecotones. What are ecotones and is this a clearly definable feature?

One of the nicest demonstrations of ecotones is right here in Oregon



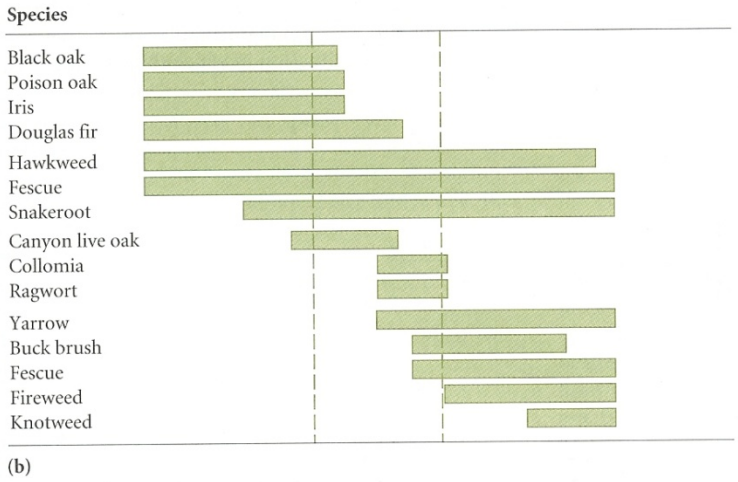
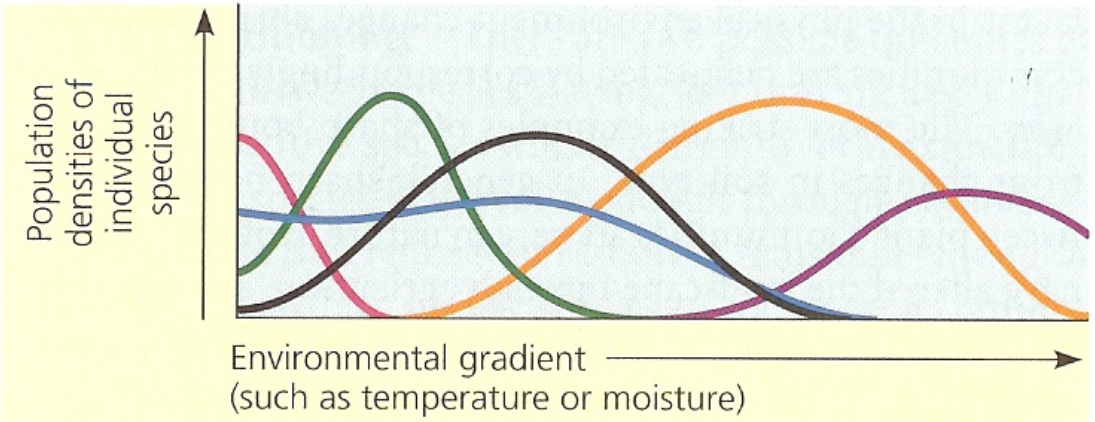


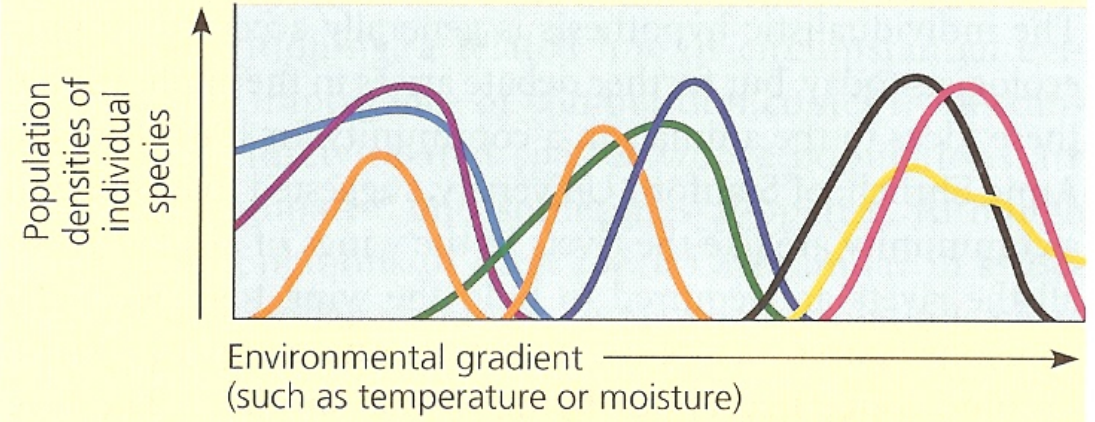
FIGURE 26-5 An ecotone resulting from soil conditions: (a) changes in the concentration of elements in the soil and (b) replacement of plant species across the boundary between nonserpentine (sample numbers 1 to 10) and serpentine (sample numbers 18 to 28) soils in southwestern Oregon. The transect diagrammed here is somewhat atypical in that magnesium does not increase as abruptly as usual across the serpentine ecotone. (*After White 1971.*)

Historically…

- What causes communities to contain certain species, or groups of species? **(Please keep in mind that we are looking at a group of populations at one point in time and evolutionary/geological histories may be as important as any other factor)**
- There are two competing explanations –
  - **The individualistic hypothesis or the redundancy model**
  - **The interactive hypothesis or the rivet model**
- How would we evaluate the data in light of these competing explanations?



(a) Individualistic hypothesis. The individualistic hypothesis proposes that species are independently distributed along gradients and that a community is simply the assemblage of species that occupy the same area because of similar abiotic needs.



(b) Interactive hypothesis. The interactive hypothesis suggests that communities are discrete groupings of particular species that are closely interdependent and nearly always occur together.

What is the most common condition?

- Most ecologists agree that the **individualistic or redundancy model** is closer to reality than the interactive model, but it is not always black and white!
- There are a number of examples where we ***can*** delineate ecotones and suites of species, ***suggesting*** support for the interactive or rivet model, and in some instances, it is biotic

We do need to beat this again

- Naturally occurring ecotones help define community boundaries and reflect these semi-isolated areas or patches, a meta-*community* sort of arrangement
- What happens when we “create” a division by subdividing an existing area?
- That is, **habitat fragmentation**. We will see this on Friday when we see the potential effects on residents due to edge effects and the influences that ecotones have on the community

The amount of "*edge*"

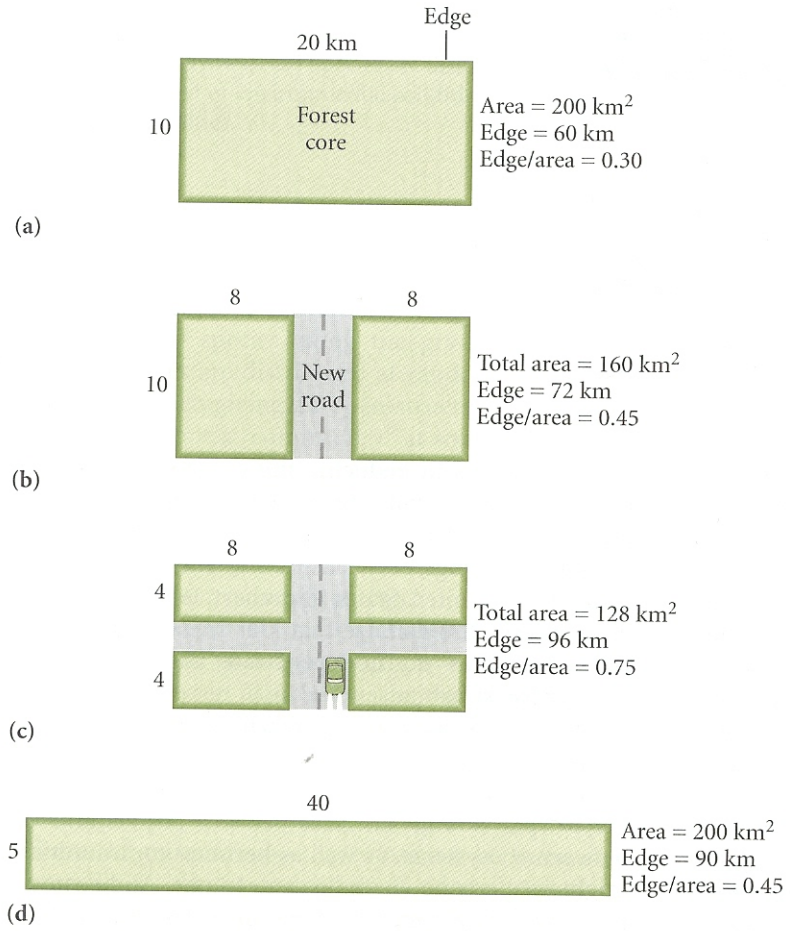
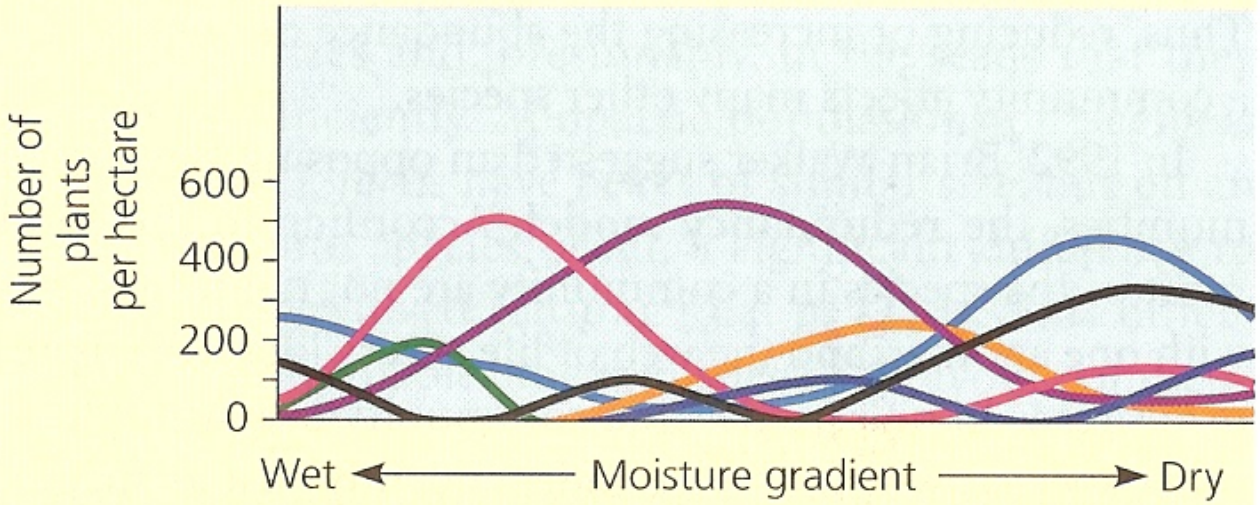


FIGURE 26-6 Schematic representation of how the amount of edge and interior space changes as a hypothetical forest becomes more and more fragmented. The original forest (a) has an area of 200 km² and a total edge of 60 km, with an edge/area ratio of 0.30. A 4-km wide swath is cleared through the middle of the forest to construct a highway (b), resulting in a fragmented forest having two areas of 80 km² each (160 km² total forest area). The total amount of edge in the fragmented forest is 72 km, with edge/area = 0.45. A 2-km path then bisects the forest at right angles to the highway, resulting in four equal-sized forest fragments (c), each 32 km² in area (128 km² total area). This fragmented forest has a total of 96 km of edge, with edge/area = 0.75. A long, narrow forest (d) having the same total area as the forest shown in panel a will have a third more edge (total edge 90 km), with edge/area = 0.45.

Community Structure as a Function of Environmental Continua

- The concept of discrete ecotone definition and therefore community boundaries is significantly less common than one might hope
- We tend to see gradual replacement of forms based upon tolerances to environmental features, much like we see in the predictions of the individualistic hypothesis of community structure

Look at some real data



(c) Trees in the Santa Catalina Mountains. The distribution of tree species at one elevation in the Santa Catalina Mountains of Arizona supports the individualistic hypothesis. Each tree species has an independent distribution along the gradient, apparently conforming to its tolerance for moisture, and the species that live together at any point along the gradient have similar physical requirements. Because the vegetation changes continuously along the gradient, it is impossible to delimit sharp boundaries for the communities.

There are other considerations

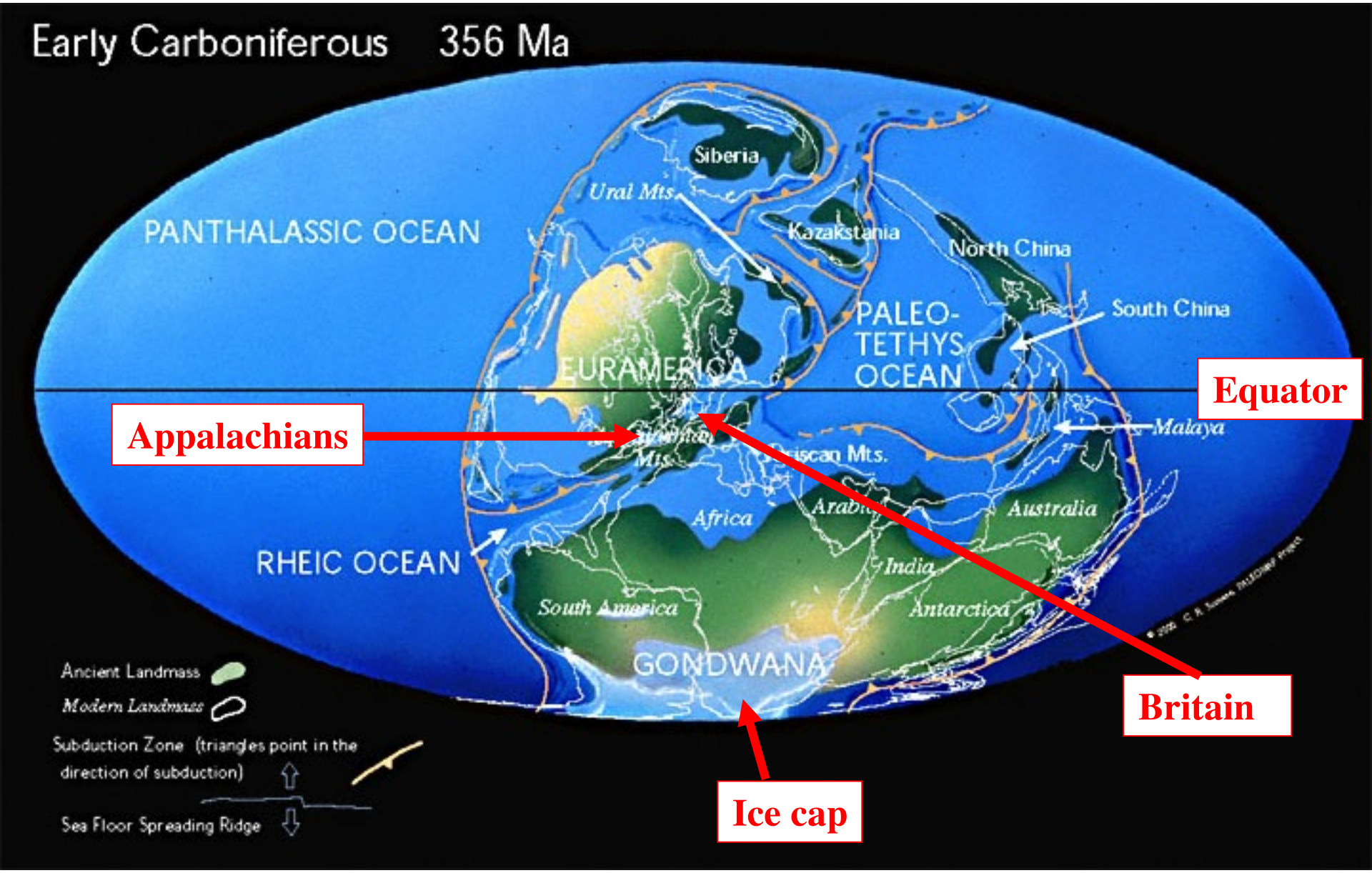
- Community structure and composition is not a static situation
- Species come and go due to extinctions, dispersal (colonization) and cladogenic origin of new forms
- But first, we must also consider the distribution of species due to historical environmental changes over geologic time

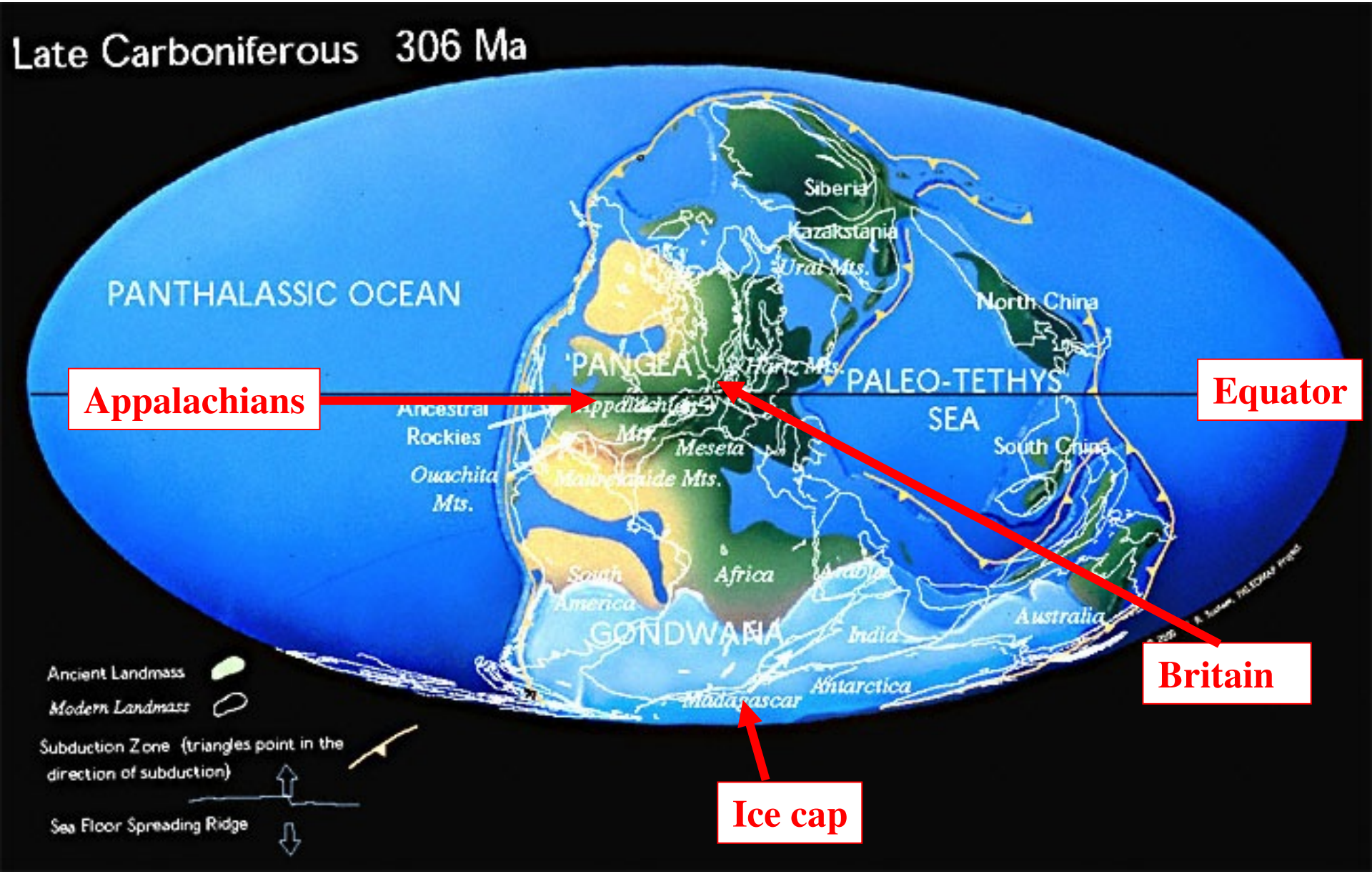
Short-term and Long-term

- Consider the potential influences of climatic change over varying lengths of time – and here, short-term is on the order of thousands of years
- Changing conditions in global temperature regimes has given us periods of glaciation and subsequent interglacial periods.
- So, what are the potentials associated with these dramatic climate changes?

On the *long* side of things

- Consider continental drift and the movement of land masses
- Regardless of the glacial/interglacial cycle, if you are on the equator, you are going to be warm
- But, the distribution of land masses is not fixed and on a long-term basis, this drastically influences community structure


Early Carboniferous 356 Ma
PANTHALASSIC OCEAN
Siberia
Ural Mts
Kazakstania
North China
South China
PALEO-
TETHYS
OCEAN
EURAMERICA
Equator
Appalachians
Malaya
Africa
Australia
India
South America
Antarctica
GONDWANA
RHEIC OCEAN
Britain
Ice cap
Ancient Landmass
Modern Landmass
Subduction Zone (triangles point in the direction of subduction)
Sea Floor Spreading Ridge


Late Carboniferous 306 Ma
PANTHALASSIC OCEAN
Siberia
Kazakstania
Urat Mts.
North China
PANGEA
Hartz Mts.
PALEO-TETHYS SEA
South China
Appalachians
Equator
Ancestral Rockies
Appalachian Mt.
Meseta
Ouachita Mts.
Mauritanide Mts.
South America
Africa
Arabia
GONDWANA
India
Australia
Antarctica
Madagascar
Britain
Ice cap
Ancient Landmass
Modern Landmass
Subduction Zone (triangles point in the direction of subduction)
Sea Floor Spreading Ridge

How do we describe the community

- The standard sorts descriptions of communities we might find reflect membership in this unit
- Historically, this consisted of only lists of the species present and numerically, the number of different species and/or the number of individuals (mostly what we will do on Friday)
- We are now a bit more sophisticated (at least ***we*** think so)

The issue of community composition

- When we look at communities, if the dominant form is not accurately representing the community, then how do we do this – and how can we describe the number of species and relative abundances in these communities?

How do we compare communities?

- Now we will focus on methods of analyzing and comparing communities
- We will be studying and comparing these data with a variety of analytical procedures called diversity indices

Let us look at some of the methods

- Historically, there were (and in simple cases, are) two commonly employed measures in the study of survey data
- First, the number of different species, also known as the **species richness**
- Alternatively, we could look at the **abundance of organisms** in a given community – sort of back to our dominance considerations

But either alone is not satisfying

- These measures give us *some* information, but we can have similarities among communities, with very different component parts
- Certainly, species richness and abundance contain information, but not as much as the combination of these features

Comparative procedures

- Once we have gone out in the field and performed our detailed survey of the organisms under study, we are ready to go forward with different methods of comparing our samples

Let us look at the indices

- When we look in the ecological literature, we commonly see two measures, the Shannon-Weiner Index and Simpson's Index
- The foundation for these measures is very similar, but they differ with regard to some key conceptual and logical considerations

Look at the Shannon-Weiner (or Shannon-Weaver, or, or…)

- We know the calculation for this measure is based upon the proportion of each species considering the total number of individuals
- $H = -\Sigma p_i \log_e p_i$
- This calculation, in a proportional sense, gives a smaller range of values and places some emphasis on the occurrence of rare species in development of this value. This measure is very sensitive to the overall number of species
- Rare species do figure into the calculation and *add* to the diversity index

Simpson's Index

- The calculation of ***D*** or the dominance, is simply the inverse of the summation of the proportions squared, that is $\boldsymbol{D} = 1/\Sigma(\boldsymbol{p_i})^2$
- This calculation is interesting in that identical evenness gives an index equal to species richness
- And, the rare species contributes little to the values associated with the index, i.e. low evenness yields a proportionately very small index value
- Rare species tend to add very little to the value of the calculated dominance index

Now, we have indices for each of the communities of interest

- What is next?
- How similar are the communities? Or better yet, are there significant differences between these communities?
- In a statistical sense, we can do this with a simple *t*-test format as long as we control for variances

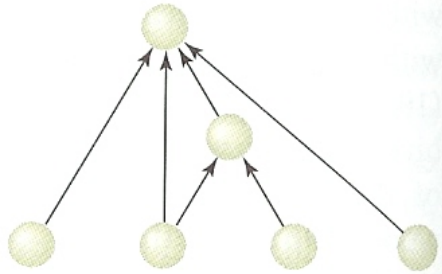
A couple of thoughts

- Notice that most of our measures are **taxonomic**, i.e. the number of species is important in these calculations
- The alternative is to look at ecological diversity. **What is ecological diversity?**
- Would you expect there to be a correlation between taxonomic and ecological diversity measures?

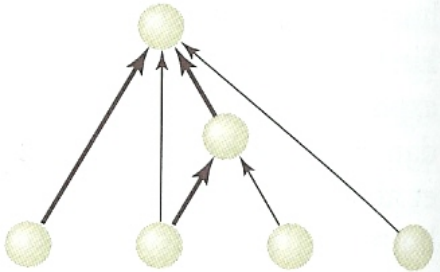
Structure of the Community

- What if we want a detailed analysis of the community itself, that is, what is going on inside the community?
- The most common method is **Food Web Analysis** to elucidate interactions among the members of the community and ecosystem
- These analyses are really **two-stage**; 1) description of the relationships to discover patterns of interactions, and 2) evaluation of the importance of the relationships discovered above

(a) Connectedness food web



(b) Energy web



(c) Functional food web

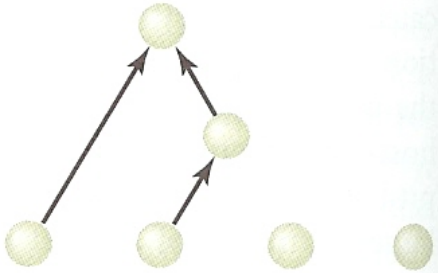


FIGURE 27-15 Three types of food webs. (a) Connectedness food webs display all of the trophic interactions in the community without reference to their strengths. (b) Energy flow webs quantify the connections between populations by the flux of energy between consumer and resource. The heavier the arrow, the greater the energy flux. (c) Functional food webs show those interactions most important to the structure of the community.

We will consider much of this with regard to ecosystems

- We can make some rather sweeping generalizations when we look at food webs
- First, most communities do not have that many trophic levels, now what was the foundation for the number of levels? Consider this in light of the **bottom up proposal**
- One interesting proposal about food webs has focused on the complexity and stability
- What would you expect to be the capacity to recover for a complex food web? What would you expect the sensitivity to disturbance for a complex food web?

Couple of other generalizations

- When one observes simple vs. complex food webs, the densities of links among members remains about constant
- The constant connectance hypothesis suggests that the number of links increases as the square of the number of species (**most species exhibit only about two links, regardless of the complexity of the food web**), but as the number of species increases, so do the links
- Also, in general, the **proportion** of organisms in the top, intermediate and basal levels remains about constant from community to community

But, certainly there are exceptions

- One of the most interesting demonstrations of interactions has been looked at with sea stars
- Remember those predators that can mask the effects of other interspecific interactions? This is the keystone species concept, a prediction of the **top down model**
- *The predator*, based upon what it eats, defines the structure of the community

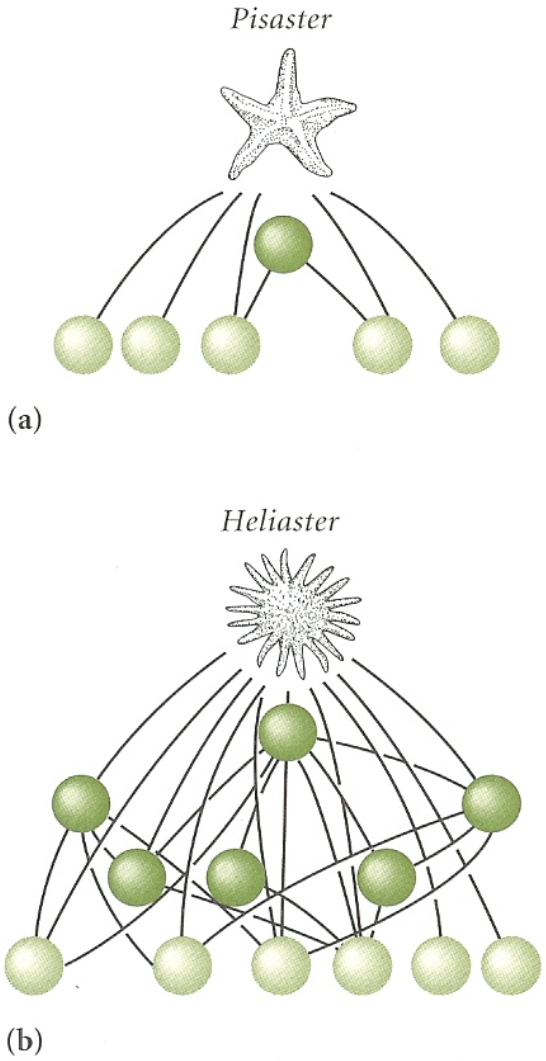


FIGURE 27-20 Intertidal food webs dominated by keystone predators: the starfishes (a) *Pisaster,* on the coast of Washington, and (b) *Heliaster,* in the northern Gulf of California. The lowest trophic levels of these food webs include herbivores such as chitons, limpets, herbivorous gastropods, and barnacles (light green circles). (*After Paine 1966.*)

Stability in Structure?

- We have to constantly keep this in mind because of the importance of our perspective and predictions about communities and ecosystems
- Communities are dynamic entities and the view of a stable, climax community may be the exception rather than the norm
- That is, succession may be an on-going process without a particular end-point

Why?

- The earth is not a static place. It changes, both seasonally and in geologic time
- Perhaps more importantly, organisms do not just live in a habitat. Species interact and modify the habitat in which they live
- Let us watch some short videos regarding the interaction of life and the physical environment (Gaia hypothesis Daisyworld)