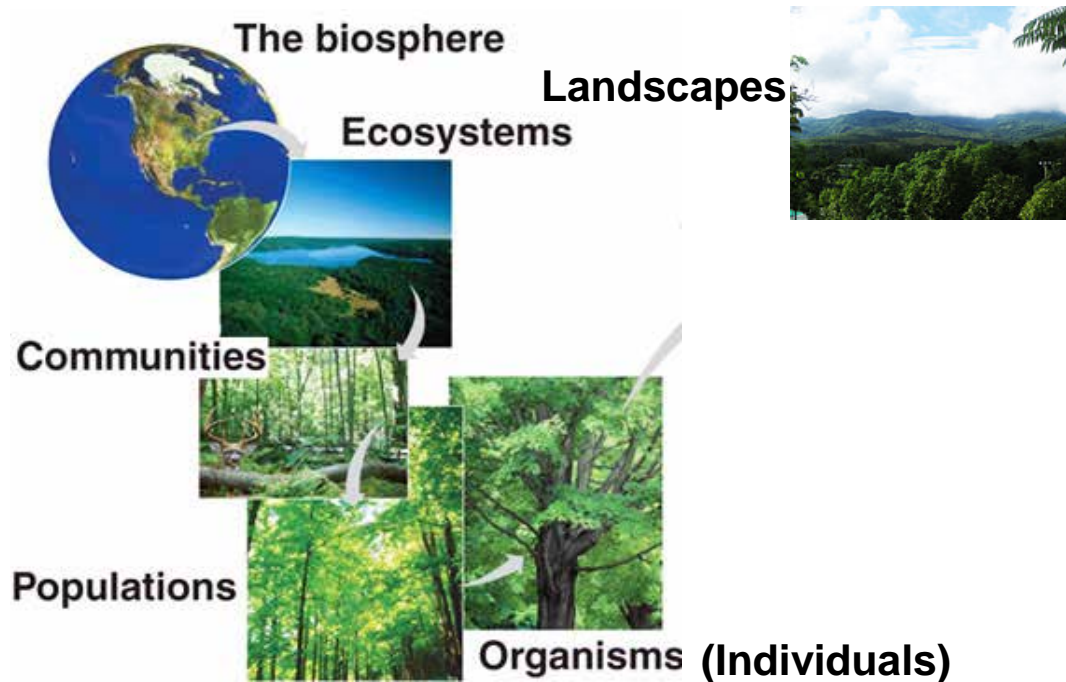


# Community Ecology in a Restoration Context

- Objectives:
  - How can the foundations of and theory in community ecology ↔ restoration ecology ↔ ecological restoration?
    - Community ecology theory and concepts (with a plant bias)
      - Backbone of a large and diverse discipline
      - Three-filter framework
        - » Minus disturbances and succession (to be covered next week)
    - Restoration questions that can be addressed in a community ecology context

# Community Ecology in a Restoration Context

- Ecological Hierarchy



# Community Ecology in a Restoration Context

- Communities and Community Ecology
  - Collection of species/populations interacting directly & indirectly in the same place & time
  - Description & quantification of natural assemblages of different species/populations (ideally w/ mechanisms)

***Acacia koa***  
**”dominated”**  
**community**



# Community Ecology in a Restoration Context

- Community characteristics
  - Biological structure largely determined by regional mix of species, & their local interactions
    - Observation & description of biodiversity
      - Composition and abundance
      - Richness and evenness
      - Typically, few species are abundant and most are rare
  - Biological structure constrained by abiotic factors
    - 3 (of the 5) State Factors: climate, topography, and parent material
    - Provides underlying mechanisms responsible for general patterns in biodiversity

# Community Ecology in a Restoration Context

- Community characteristics
  - Organisms alter the environment for other species
    - Can be beneficial or not
  - Within a given environment, communities are primarily shaped by biotic interactions between  $\geq 2$  populations
    - competition, predation, commensalism, mutualism, etc.
  - Succession creates temporal and spatial variability
    - Disturbances initiate succession
    - Primary vs. secondary succession
  - An ecological law provided by community ecology?
    - The species-area curve ( $S = cA^z$ )
      - Number of species scales with local habitat area
    - Has been used to estimate local species richness for ecological restoration projects

# Community Ecology in a Restoration Context

- Communities are complex & dynamic
  - Spatial, temporal, environmental, genetic, & demographic variability
  - Biotic Interactions (direct & indirect)
  - Change over time
    - Natural disturbances and succession
  - *“A central issue in community ecology is understanding the factors that govern the composition and abundance of species in ecological communities.”*
    - Much of community ecology still being developed, debated, etc.

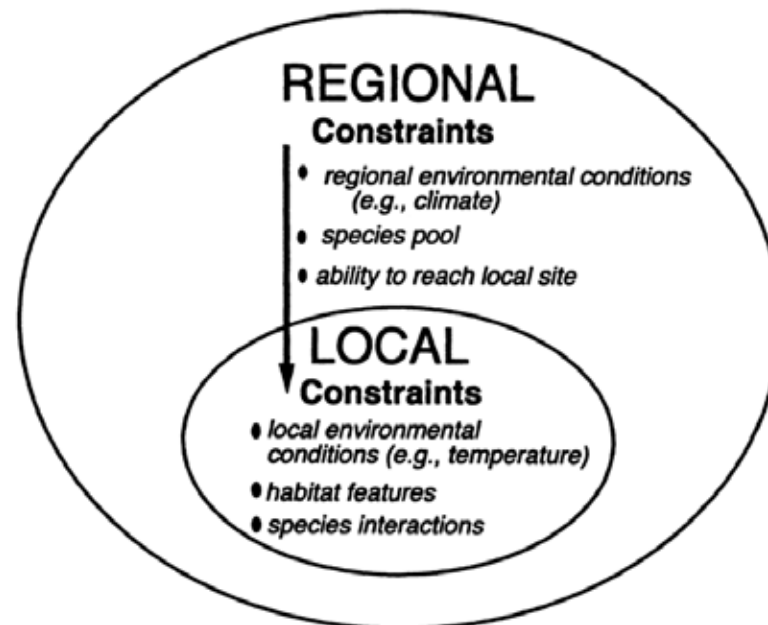
# Community Ecology in a Restoration Context

- Relevance of community ecology to restoration
  - Restoration often involves a focus on multi-species assemblages
    - I.e., populations of co-occurring species
  - Restoration needs to be informed by:
    - Population Ecology
      - Population processes (including intraspecific interactions)
    - Community Ecology
      - Interspecific interactions
      - Habitat and resource dynamics
      - Disturbance and successional theory
  - Community ecology provides the opportunity to integrate across these concepts in a restoration context

# Community Ecology in a Restoration Context

- Constraints to restoration of ecological communities
  1. Regional constraints (regional abiotic env., potential species, & dispersal limitations)
  2. Local constraints (biotic interactions & local abiotic env.)
  - Together, determine species present, the ecological community, and, to at least some degree, the outcome of ecological restoration

Community Restoration =  $f$  (regional + local constraints)

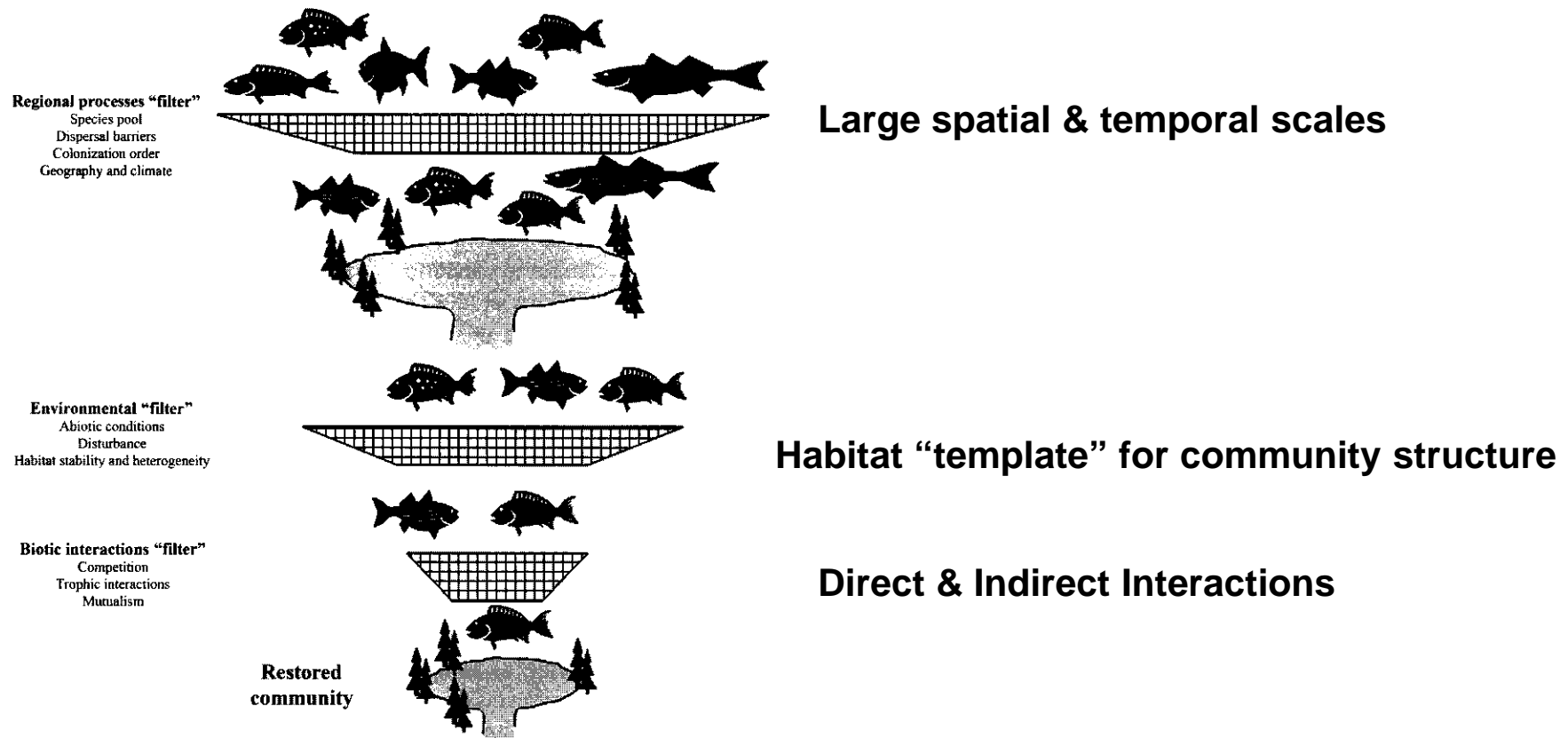


(Palmer *et al.* 1997)



# Community Ecology in a Restoration Context

- 3 filter framework (updated version of Palmer et al. (1997))

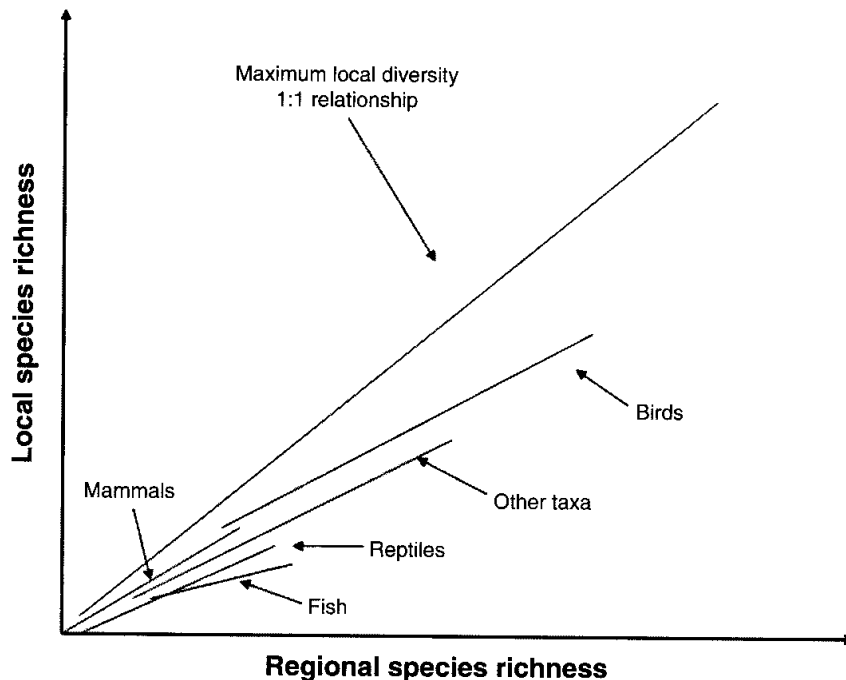


# Community Ecology in a Restoration Context

- 3 filter framework
  - Species diversity is a function of many biotic & abiotic factors working at different spatial & temporal scales
    - What regional processes determine potential species composition?
    - What environmental conditions and habitat characteristics favor species survival and influence community structure?
    - How do biotic interactions shape community structure?
      - Long believed to be the key to understanding community composition

# Community Ecology in a Restoration Context

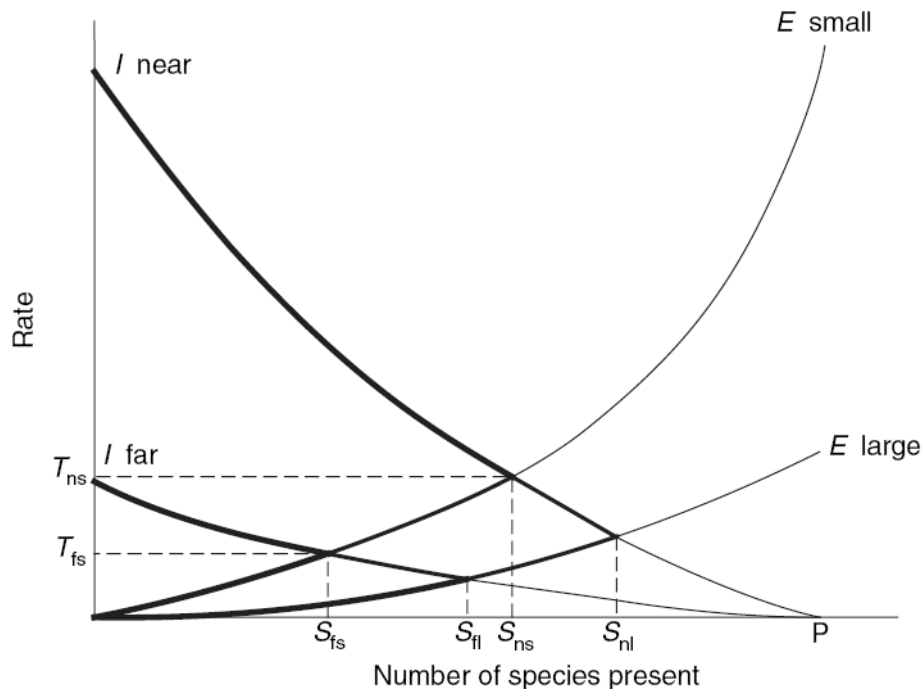
- 3 filter framework: Regional Processes “filter”
  - Regional species pool
    - A very good predictor of local species pool
    - Local richness always lower than regional richness because rare species seldom “make it” (i.e., disperse and survive)



(Menninger & Palmer 2006)

# Community Ecology in a Restoration Context

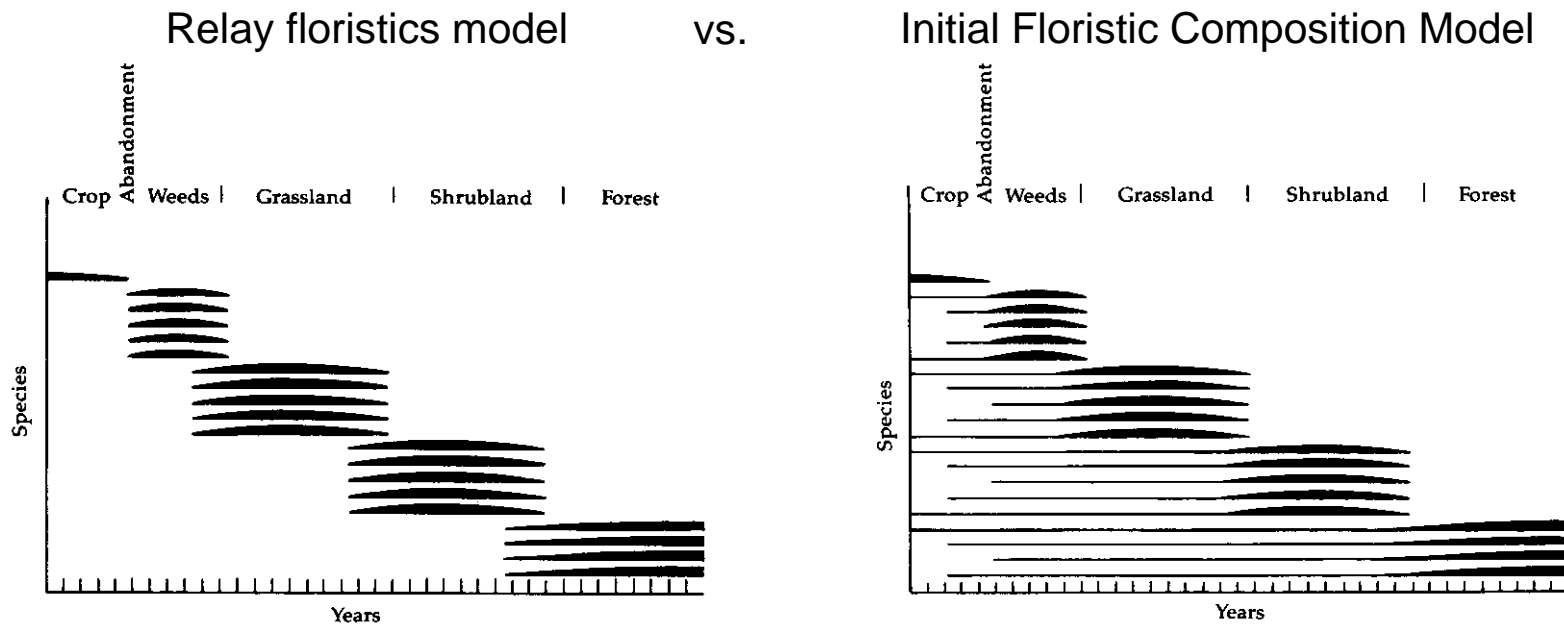
- 3 filter framework: Regional Processes “filter”
  - Dispersal
    - Island Biogeography theory (IBT) very relevant to restoration of fragmented habitats
      - # of species present is a function of distance to remnant habitat & size of habitat to be restored



(MacArthur and Wilson 1967)

# Community Ecology in a Restoration Context

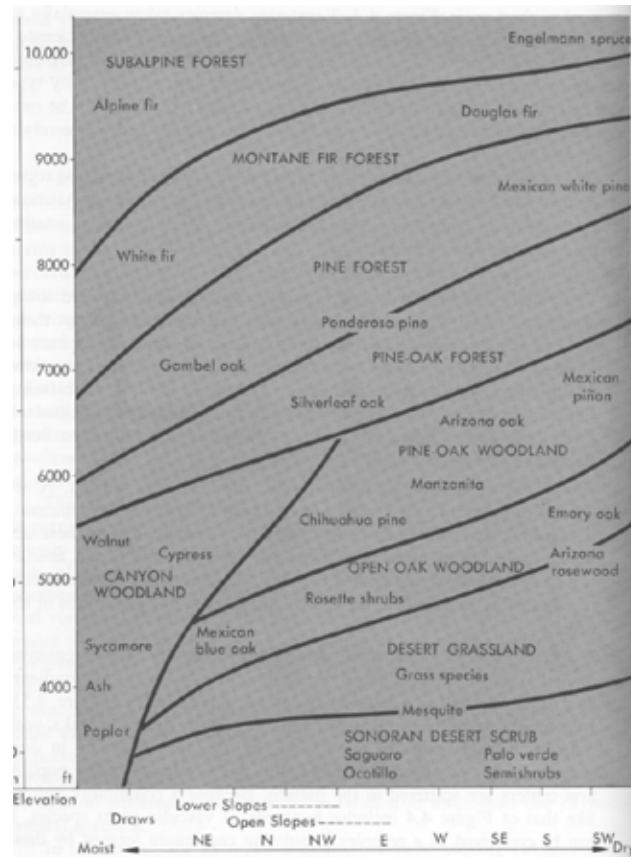
- 3 filter framework: Regional Processes “filter”
  - Colonization sequence (not in Palmer et al. (1997))
    - Species alterations to environment **AND/OR** competitive edge?
    - Early thought: Relay Floristics Model
    - Later & more Current Thought: Initial Floristic Composition Model (w/ a splash of Relay Floristics)



(Barbour *et al.* 1999)

# Community Ecology in a Restoration Context

- 3 filter framework: Environmental “filter”
  - Abiotic filters recognized very early on as important drivers of community composition at local scales



(Whittaker 1975)

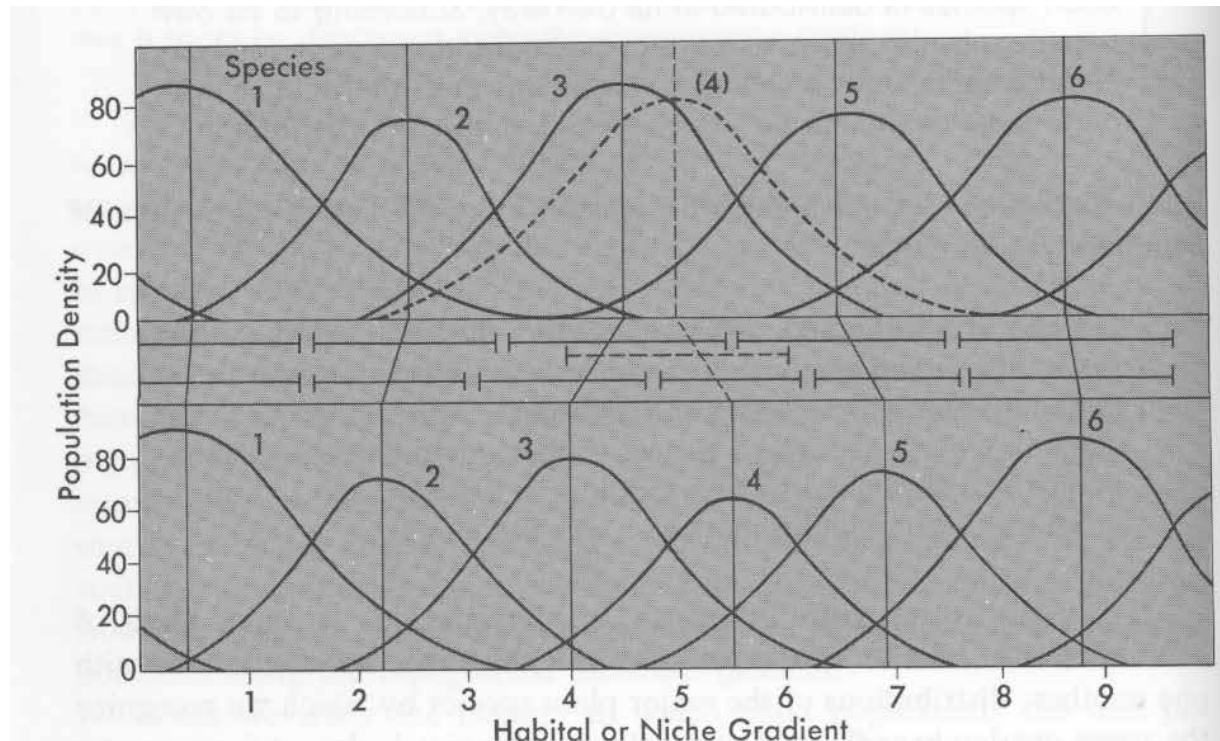
# Community Ecology in a Restoration Context

- 3 filter framework: Environmental “filter”
  - Natural disturbance regimes

**Coming to Sherman 111 next week...**

# Community Ecology in a Restoration Context

- 3 filter framework: Environmental “filter”
  - Habitat Heterogeneity
    - Species diversity typically increases with habitat heterogeneity
      - Increases physical space, refuges, resource availability, and ecological niches

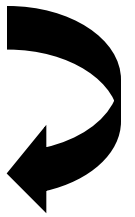


(Whittaker 1975)



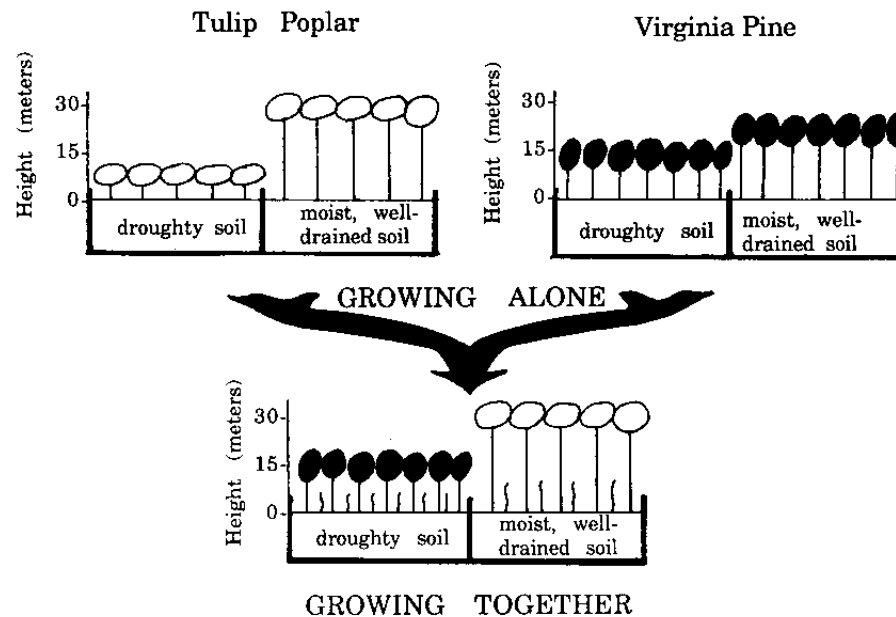
# Community Ecology in a Restoration Context

- 3 filter framework: Environmental “filter”
  - Biotic modifications increase habitat heterogeneity
    - 1° Succession following glacial retreat



# Community Ecology in a Restoration Context

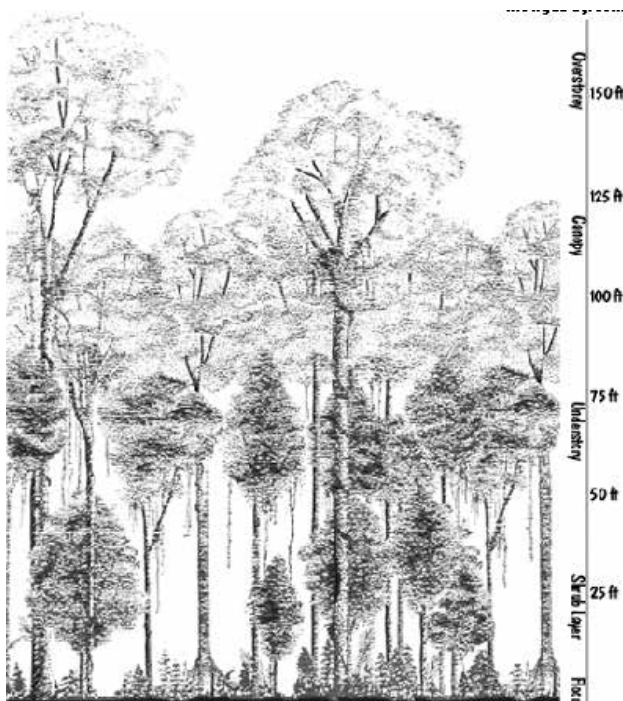
- 3 filter framework: Biotic Interactions “filter”
  - Competition
    - Presence determined by competitive ability → Evolution
    - Competitive Exclusion Principal



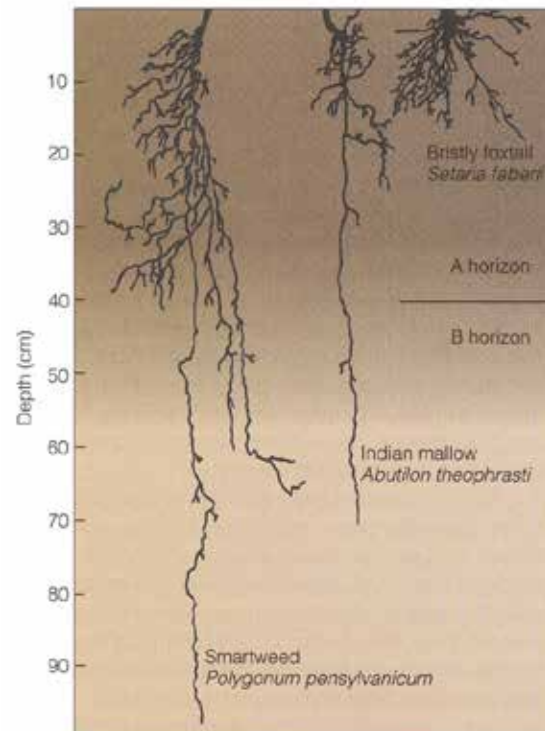
# Community Ecology in a Restoration Context

- 3 filter framework: Biotic Interactions “filter”
  - Competition
    - Resource partitioning often explains species co-existence

Light Partitioning

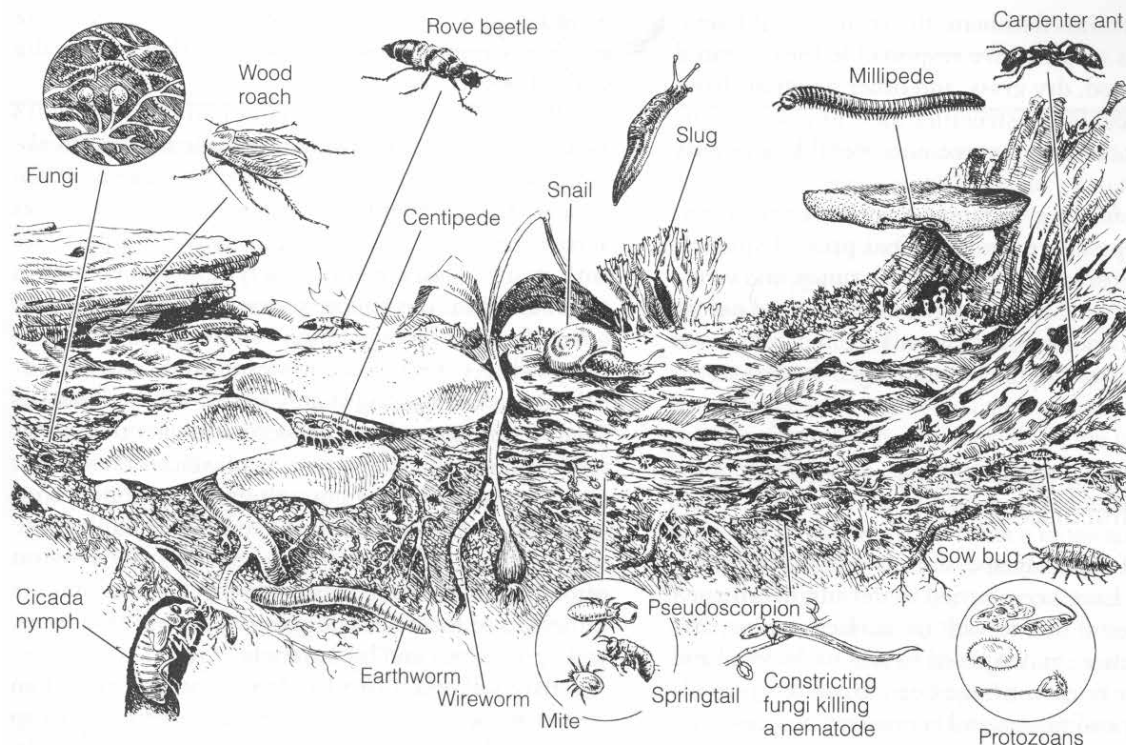


H<sub>2</sub>O/Nutrient Partitioning



# Community Ecology in a Restoration Context

- 3 filter framework: Biotic Interactions “filter”
  - Trophic Interactions
    - Strong “top-down” & “bottom-up” control over communities
      - More diverse and abundant species assemblage



# Community Ecology in a Restoration Context

- 3 filter framework: Biotic Interactions “filter”
  - Mutualisms are widespread and important biotic interactions determining species existence
    - Facilitation
    - Symbiotic relationships

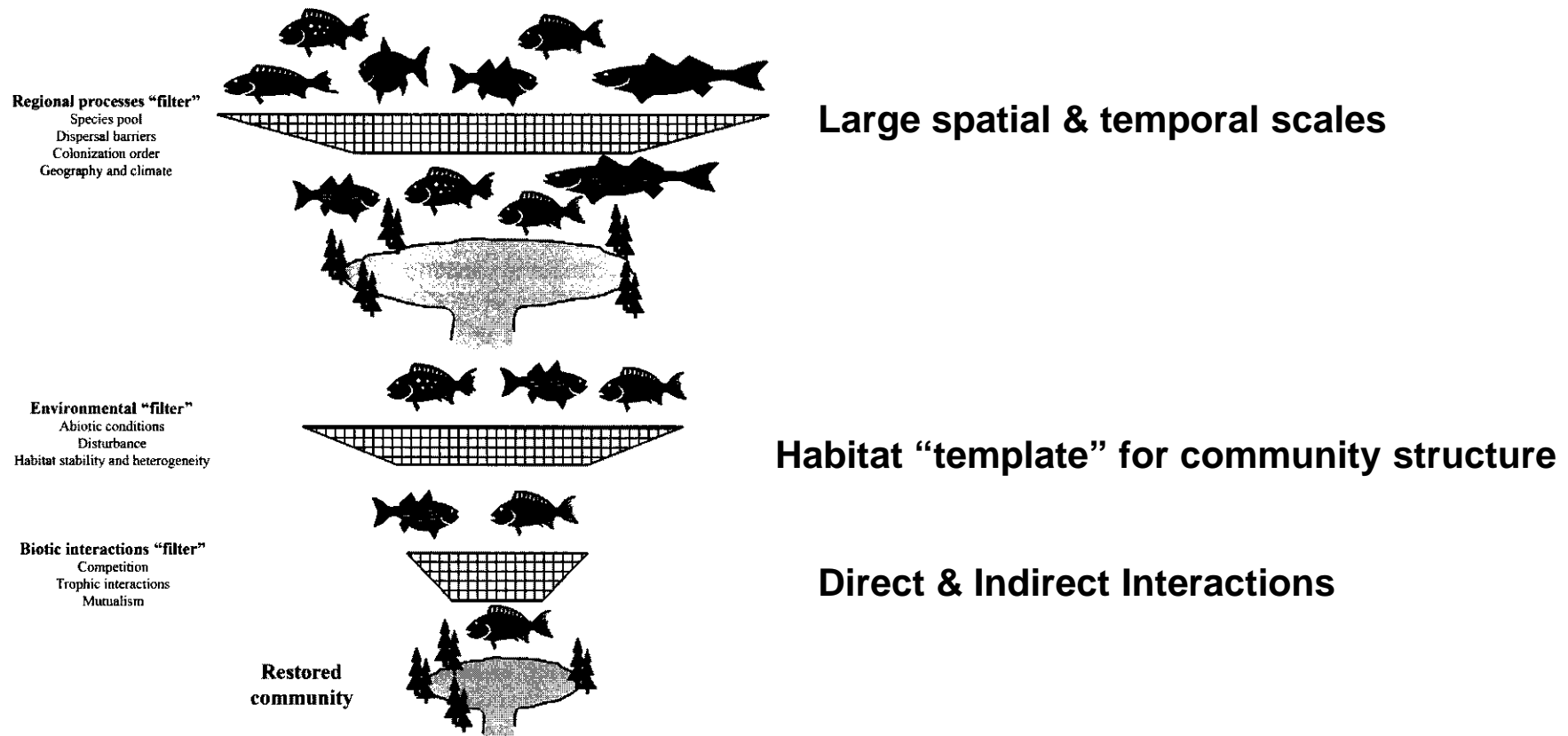
N fixation  
root nodule  
in *A. koa*



Mycorrhizae

# Community Ecology in a Restoration Context

- 3 filter framework (updated version of Palmer et al. (1997))

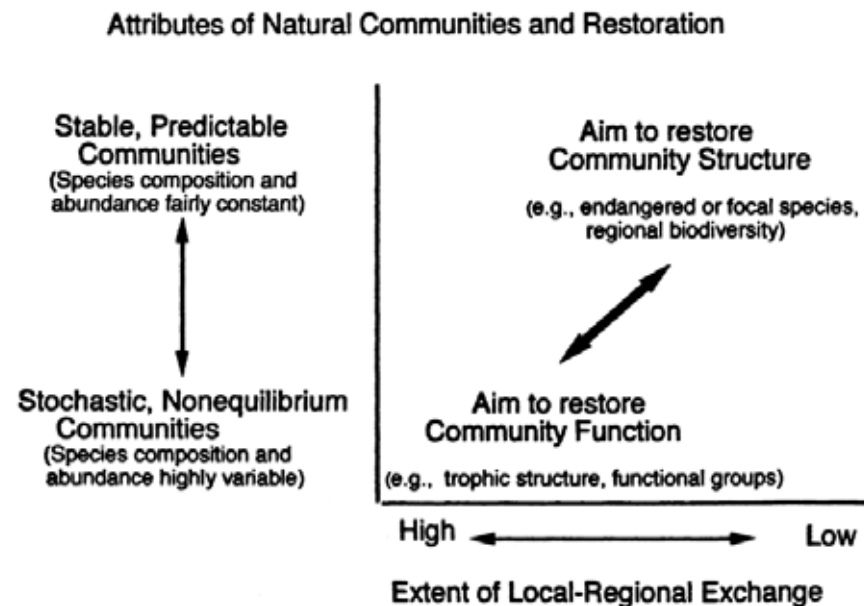


# Community Ecology in a Restoration Context

- Assembly Rule(s) vs. Unified Neutral Theory of Biodiversity
  - Is community composition primarily a function of competition (and/or predation)? → local filter
    - Yes, for at least some systems (e.g., *Pinus contorta* forests)
    - End result of succession is at least somewhat predictable
  - Or is it simply a function of random chance of dispersal (and speciation and extinction)? → regional filter
    - Yes, for at least some systems (e.g., rocky intertidal pools)
    - End result of succession is almost completely unpredictable
  - See *Science*, 2 October 2009 (Volume 326, Issue 5949, p. 33-35)

# Community Ecology in a Restoration Context

- Community Restoration
  - Capacity to restore ecological communities will vary:
    - Attributes of natural community, regional & env. filters, degree of degradation, etc.
    - Restore community structure vs. community function?
      - Palmer et al. (1997) say it should depend on where you are on this figure





# Community Ecology in a Restoration Context

- Restoration from a community ecology perspective
  - What are appropriate restoration endpoints/references?
    - If most natural systems are characterized by lots of inherent variability, how can theory inform practice?
    - What are acceptable levels of variability in restored ecosystems?
  - What are the benefits and limitations of using species composition / biodiversity measures as endpoints?
    - Can community stability be increased by adding more species?  
Adding particular species?
      - Requires info on functional redundancy among species
      - Often times, one or a few species play a disproportionate role in a community

# Community Ecology in a Restoration Context

- Restoration from a community ecology perspective
  - Should focus be on restoring structure (e.g., species composition) or function (e.g., material & energy flows)?
    - How much of the community needs to be established initially for the site to ultimately support the desired structure &/or function?
      - Functional redundancy, keystone species, hidden/cryptic species
  - Is restoration of habitat a sufficient approach to reestablish species composition (and function)?
    - Are untested assumptions about physical habitat structure warranted and applicable to restoration ecology?
      - “Field of Dreams” (i.e., build it and they will come in the sense that if you provide the right habitat, the species will come on their own)
      - As habitat heterogeneity increases, so does biological diversity

# Week 5 Readings/Lecture Slide Highlights

1. Communities are highly variable in space and time (i.e., communities are in a constant state of flux), and this variability should be explicitly considered at all stages of ecological restoration (e.g., choice of reference site, target species selection, monitoring, etc.).

# Week 5 Readings/Lecture Slide Highlights

2. The regional species pool determines the potential members of a given ecological community. What members of the regional pool actually become established is largely a function of dispersal and colonization ability (including colonization sequence).

# Week 5 Readings/Lecture Slide Highlights

3. Local environmental filters constrain species composition from the regional pool, where successful species will be those where the physiology of the species matches the abiotic features of the site. In general, increased habitat heterogeneity will increase species diversity via increased niche space.

# Week 5 Readings/Lecture Slide Highlights

4. Within regional and local environmental filters, biotic interactions play a large role in determining species composition. Biotic interactions can be negative (e.g., competition, predation) or positive (mutualisms), and as such can hinder or enhance the success of a given species/community.

# Week 5 Readings/Lecture Slide Highlights

5. Community structure includes composition, diversity, and the relative abundance of species. Restoration of community structure, therefore, should include consideration of all three of these aspects of community structure. For most communities, one or a few species are dominant and the rest are rare.