Ecological recovery in the aftermath of the 1980 eruption of Mount St. Helens:
Lessons learned during the 39 years of research, questions remaining, & paths ahead

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AGU Session: The Global Scientific Legacy of the 1980 Eruption of Mount St. Helens: A 40-Year Perspective

Lessons learned

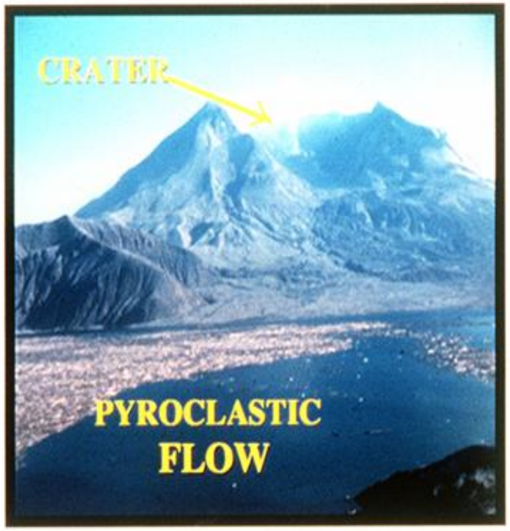
- **Diversity of disturbances**
- **Importance of survivors & legacies**
- **Unique successional processes**
- **Constraints of long-term ecological research**

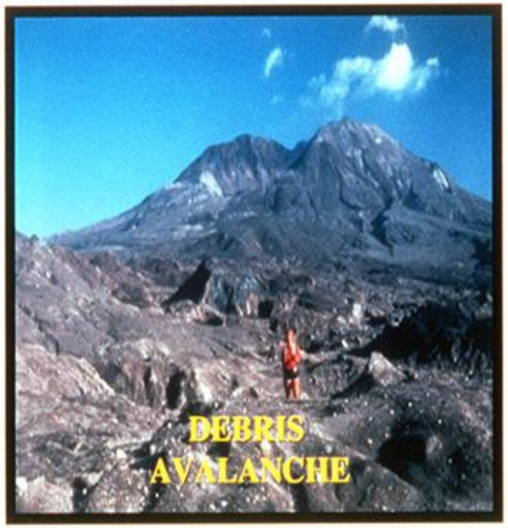
Source: Dale & Crisafulli (2018)

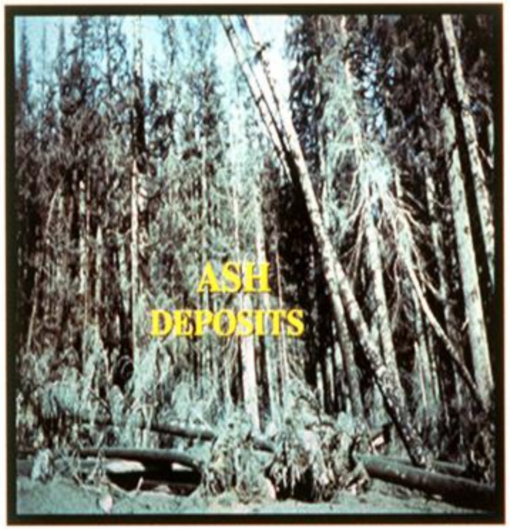
Disturbance effects varied by

- **Type of event**
  - Volcanic process
  - Flow path
- **Mechanism**
  - Heat
  - Burial
  - Impact force
  - Abrasion
- **Intensity**
  - Within a disturbance type, decreased with distance from crater
  - Topography provided some protection

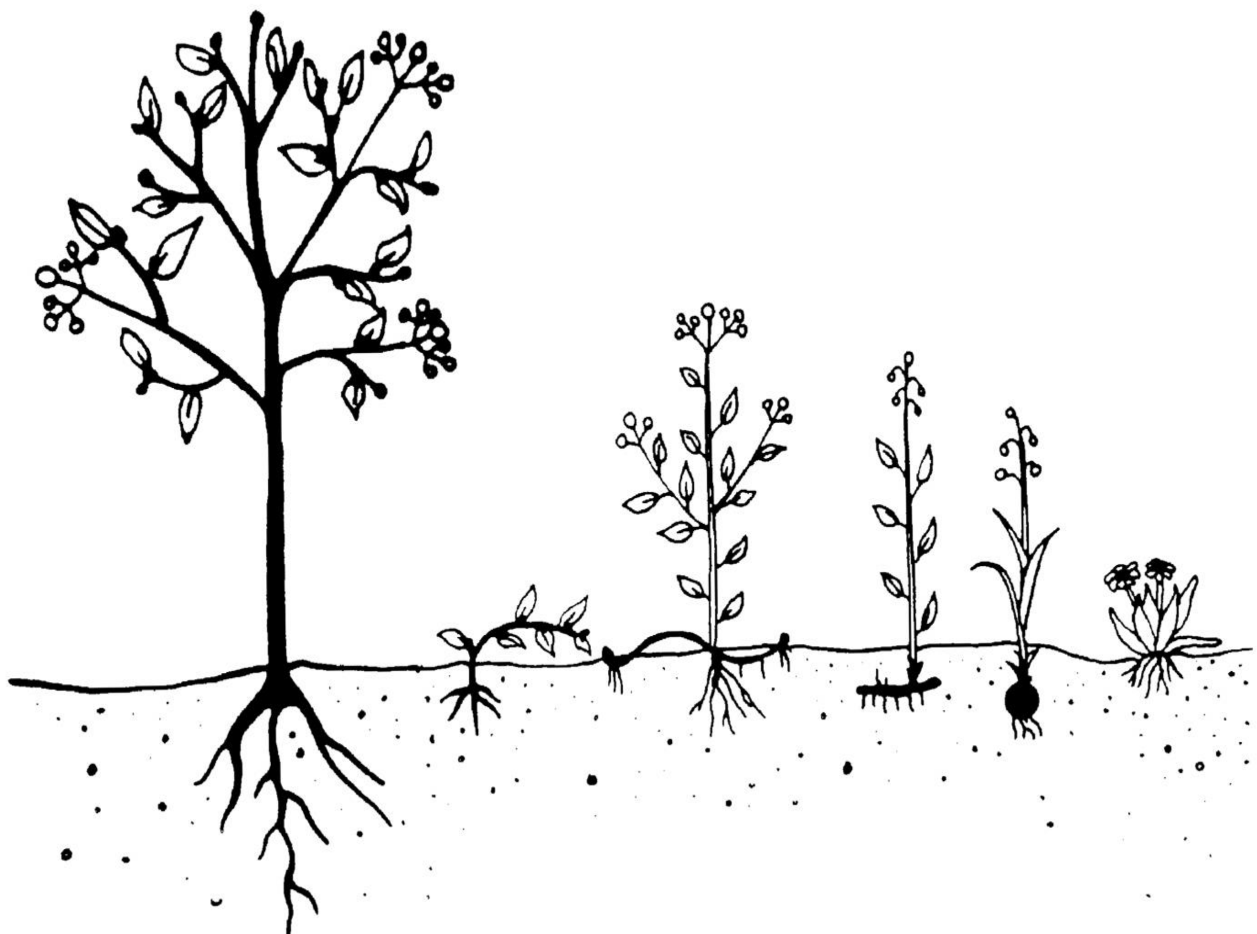
DISTURBANCES CREATED BY THE MOUNT ST. HELENS ERUPTION





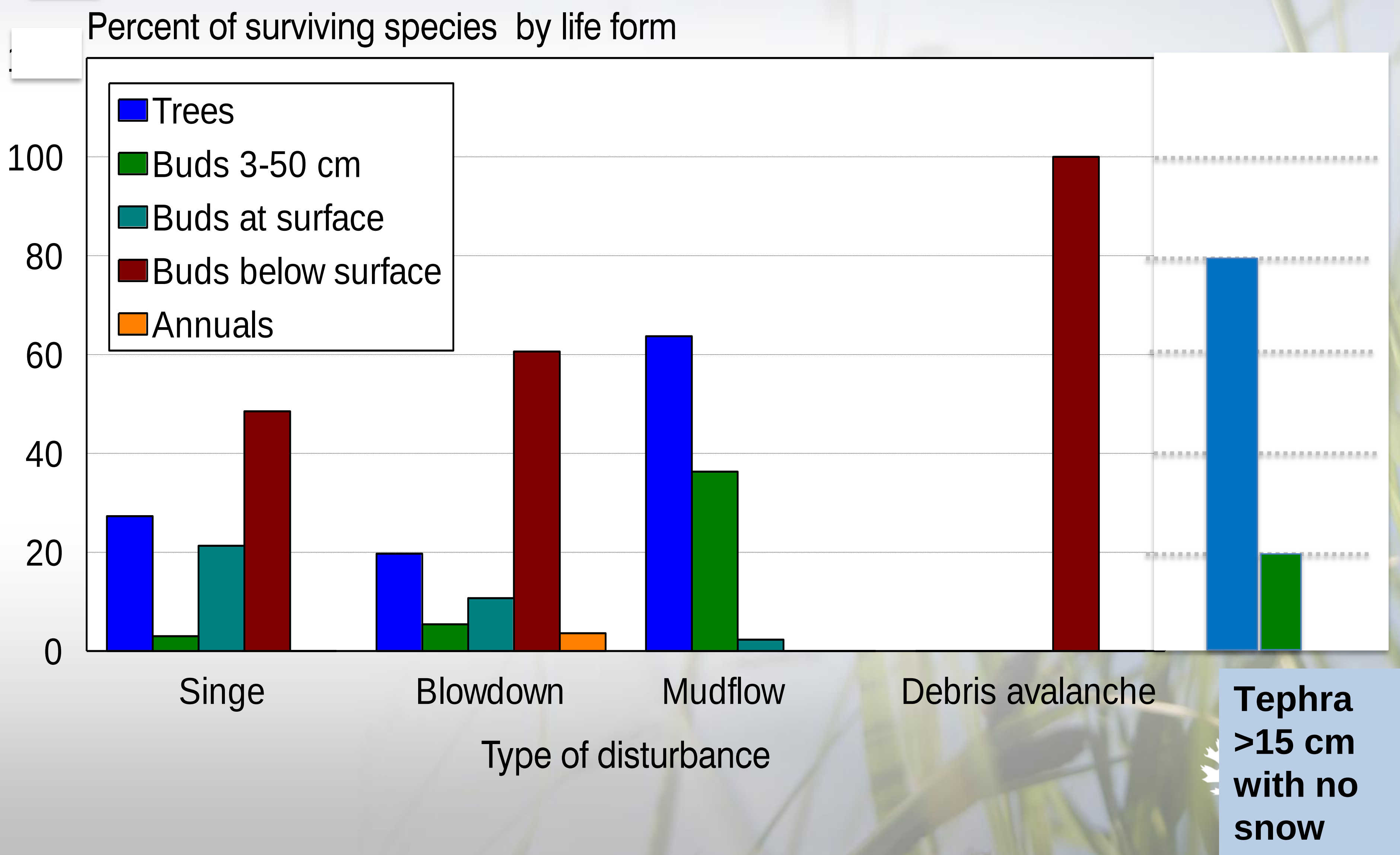


Raunkier's (1934) life forms relate to survival of disturbance



Effects of biological attributes on survival

- Life form



Effects of biological attributes on survival

1. Life form
2. **Life history**
   - Many anadromous fish were at sea
   - Many migratory birds had not yet returned
   - Eggs and resting stages of zooplankton had settled to the bottom of lakes

Heart Lake in 2004

Effects of biological attributes on survival

1. Life form
2. Life history
3. **Organism size**
   - Large species and individuals had greater mortality in blast area
   - Tall trees survived mudflows that buried herbs and shrubs

Scorch Zone at Ghost Lake in 2004: noble fir survived under snow

Effects of biological attributes on survival

1. Life form
2. Life history
3. Organism size
4. **Habitat associations**
   - Species that live below ground survived in soils or large logs
   - Low stature plants had heavy mortality in tephra fall zone whereas erect shrubs & trees survived

Tephra fall zone in 1981

Successional processes

1. **Influence of survivors**
   - Differed by disturbance type
     - Roots wads in mudflow
     - Animals in refugia in blast zone
     - Intact communities under snow in blowdown area
   - Roles
     - Source populations for adjacent areas
     - Improvement of site conditions
     - Establishing linkages among biota
     - Providing habitat or food resources
     - Consumers
       - Herbivores
       - Predators
       - Scavengers
       - Decomposers

Successional processes

Sticky seed traps caught plumed wind dispersed seeds

1. Influence of survivors
2. **Dispersal pattern & rate influenced by**
   - Source population distance
   - Wind pattern
   - Landscape permeability
   - Species & propagule mobility

Successional processes

Spirit Lake experienced dramatic reduction in clarity & then gradual clearing

1. Influence of survivors
2. Dispersal
3. **Site improvement**
   - Initial substrates had
     - Low nutrient status
     - Little moisture holding capacity
     - Limited shade
     - But were permeable
   - Improvements occurred via
     - Weathering
     - Decomposition
     - Mixing of soils (e.g., by Northern pocket gophers)
     - Water flow that removed fines
     - Suspended particles settling to the bottom of lakes

Successional processes

1. Influence of survivors
2. Dispersal
3. Site improvement
4. **Establishment**
   - Requires suitable conditions
   - Habitat structure was a predictor of vertebrate establishment
   - Species characteristics promoted or limited establishment
     - Attaining sexual maturity in larval stage
     - Ability to fix nitrogen

Successional processes

1. Influence of survivors
2. Dispersal
3. Site improvement
4. Establishment
5. **Biotic interactions**
   - Diverse types of succession occurring
     - Increases in diversity and cover over time
     - Both “early” and “late” successional species present from beginning
   - Sparse system yet rich with interactions
     - Predation
     - Herbivory
     - Mutualisms
     - Parasitism

Lupine have nitrogen fixing ability

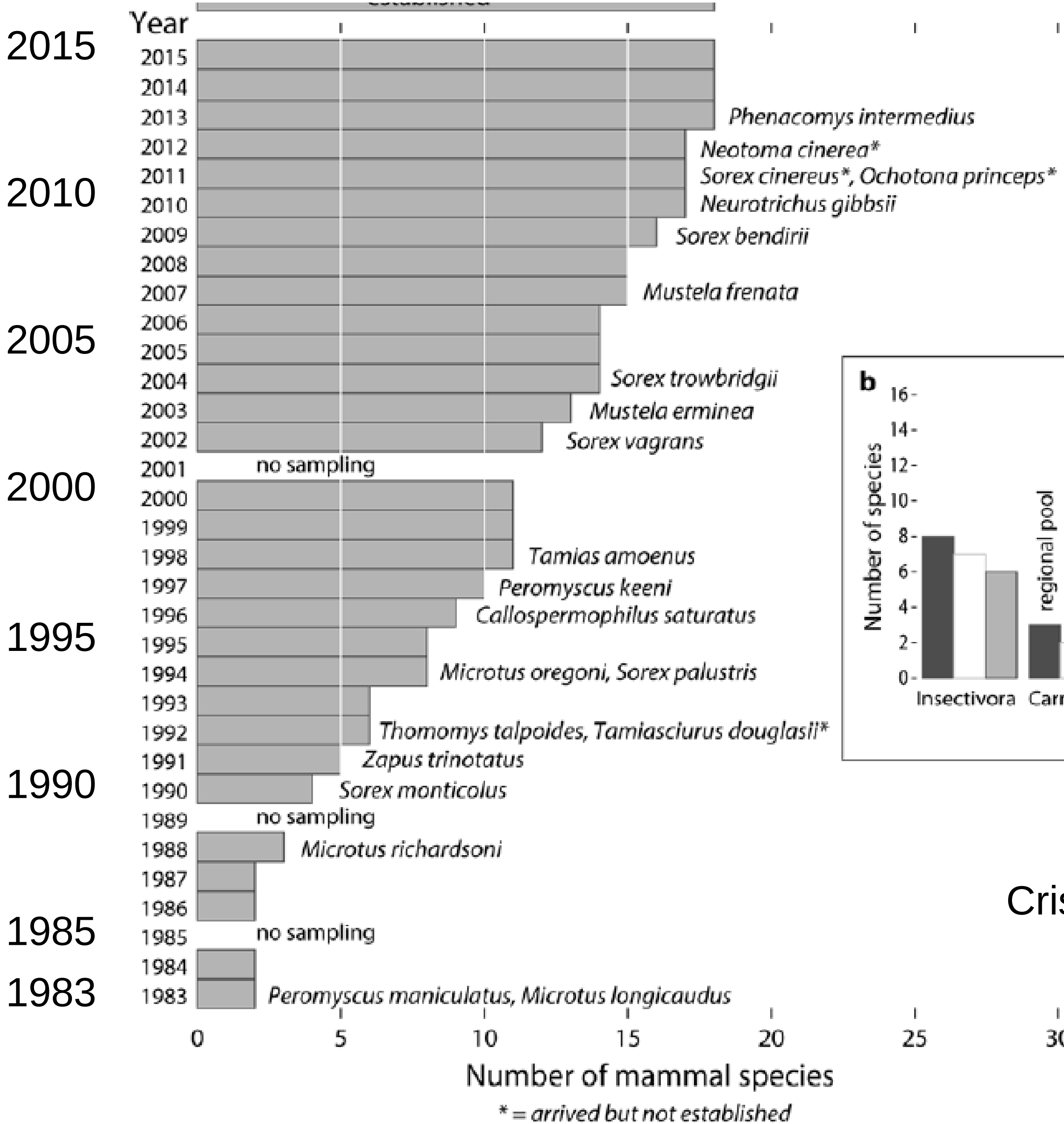

Red alder (*Alnus rubra*):
• high germination rate
• fast-growing native sp
• early-maturing
• nitrogen-fixing tree.
Tallest red
alder in 1995

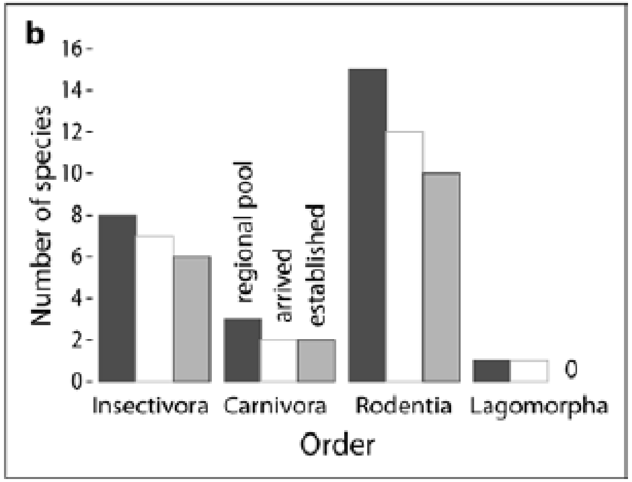
Successional processes

1. Influence of survivors
2. Dispersal
3. Site amelioration
4. Establishment
5. Biotic interactions
6. **Species accrual & community structure: all disturbance types increased in**
    - Number of species
    - Vegetation cover as influenced by
        - Amount of survivors
        - Growth form
        - Herbivory
    - Complexity of vegetation structure
    - Abundance of animals
    - Community complexity

Elk became prolific

Small mammal species accrual rate (1983-2015) on Pumice Plain





Crisafulli et al. (2018)

Could aerial application of plant seeds lead to vegetation cover that would reduce erosion?

- Emergency funds were available
- Soil Conservation Service (SCS) proposed a $16.5 million for seeding nonnative-grass/legume/fertilizer mix over much of the area
- The 2nd International Congress of Systematic and Evolutionary Biology "*vigorously opposes any proposal for mass seeding of grasses or any other species on the newly created substrate*."
- $2 million aerial application by the SCS over about 8,660 ha in the fall of 1980.

Role of nonnative species on debris avalanche deposit

- Source of nonnatives
  - Seeding of portion of area by Soil Conservation Service
  - Natural dispersal

Not seeded

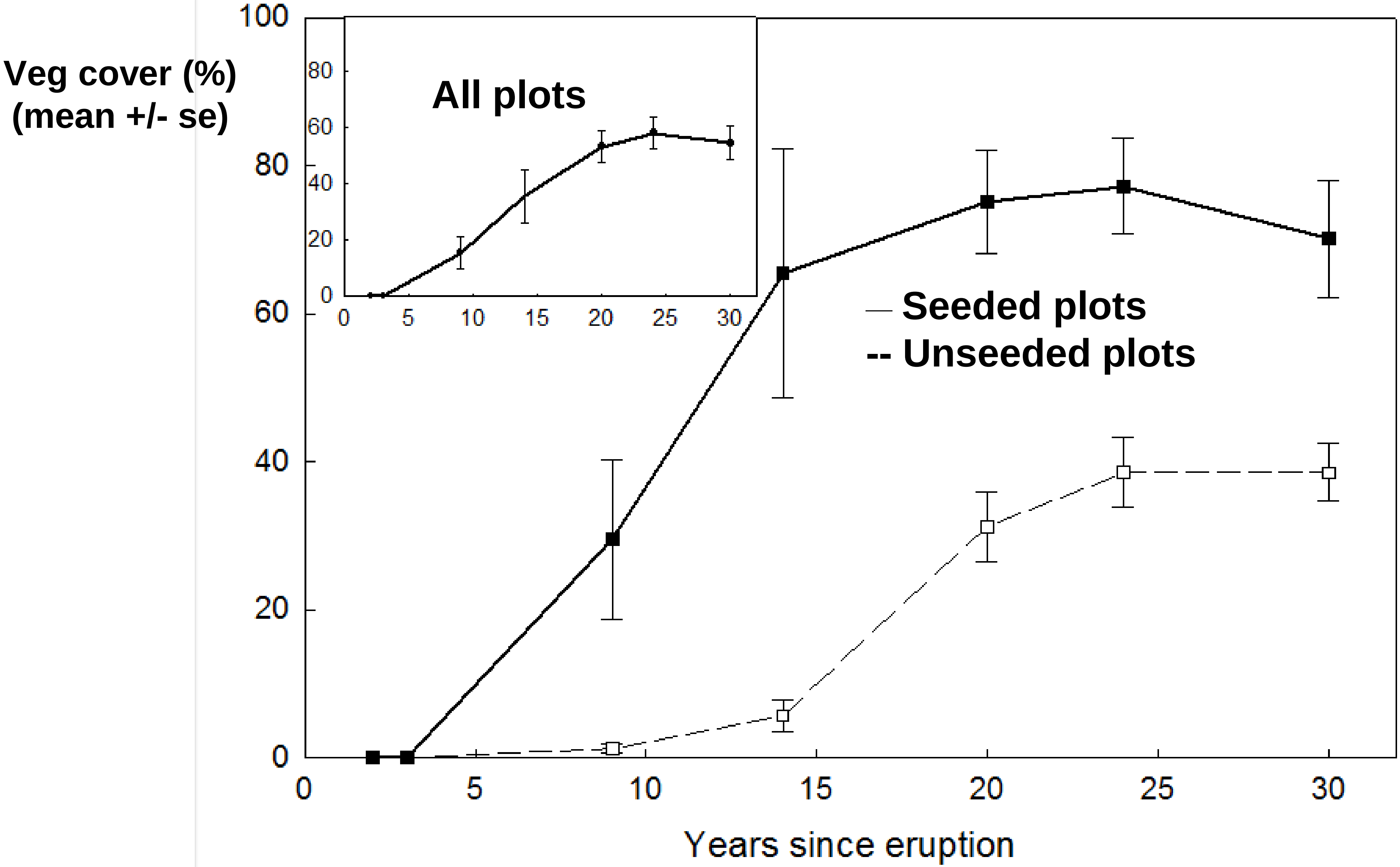
Seeded in 1980

1989

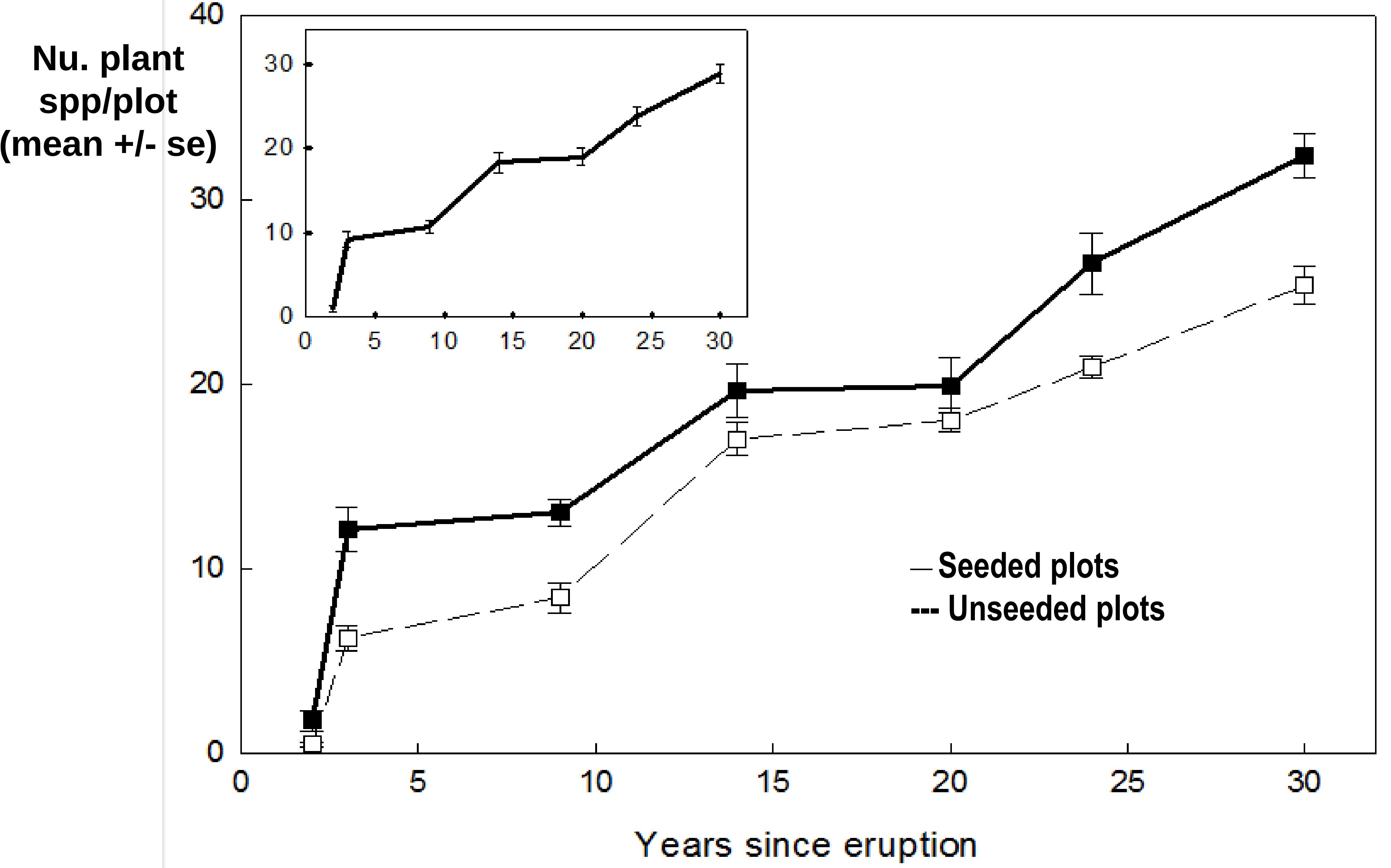
2004

2010

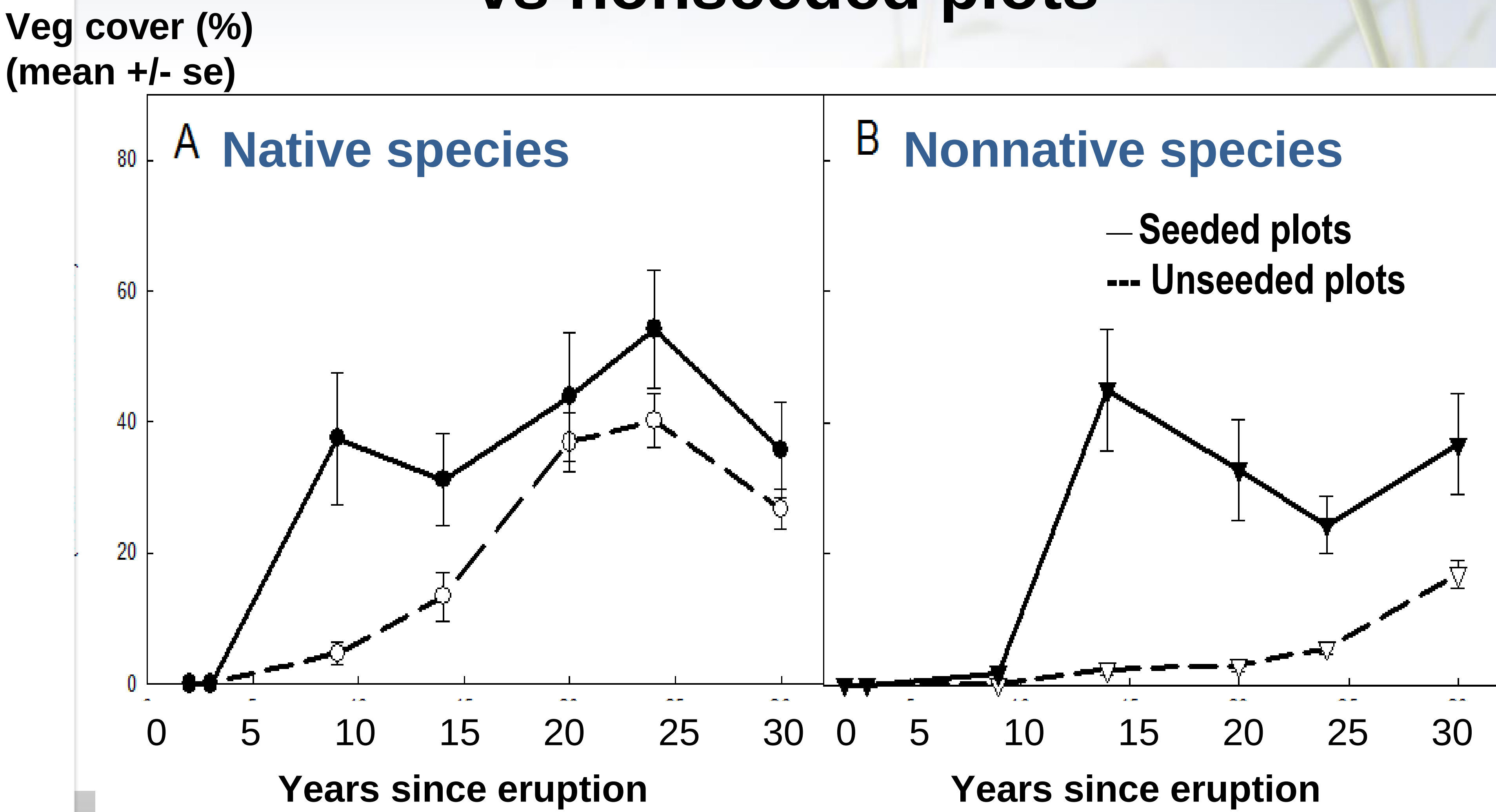
Vegetation cover is greater on seeded plots



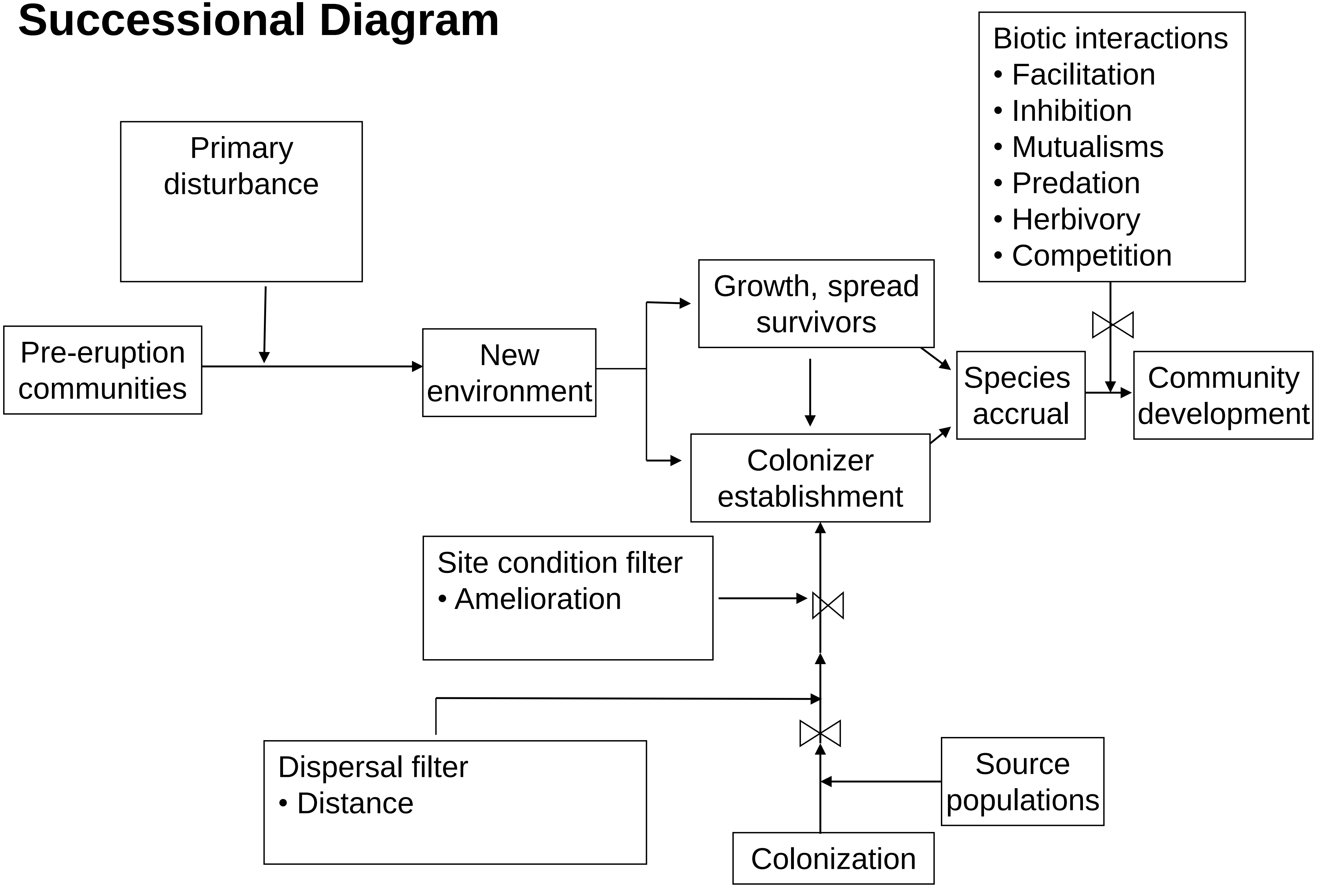
There are more plant species per plot on seeded plots



Vegetative cover is greater for both native & nonnative species on seeded vs nonseeded plots

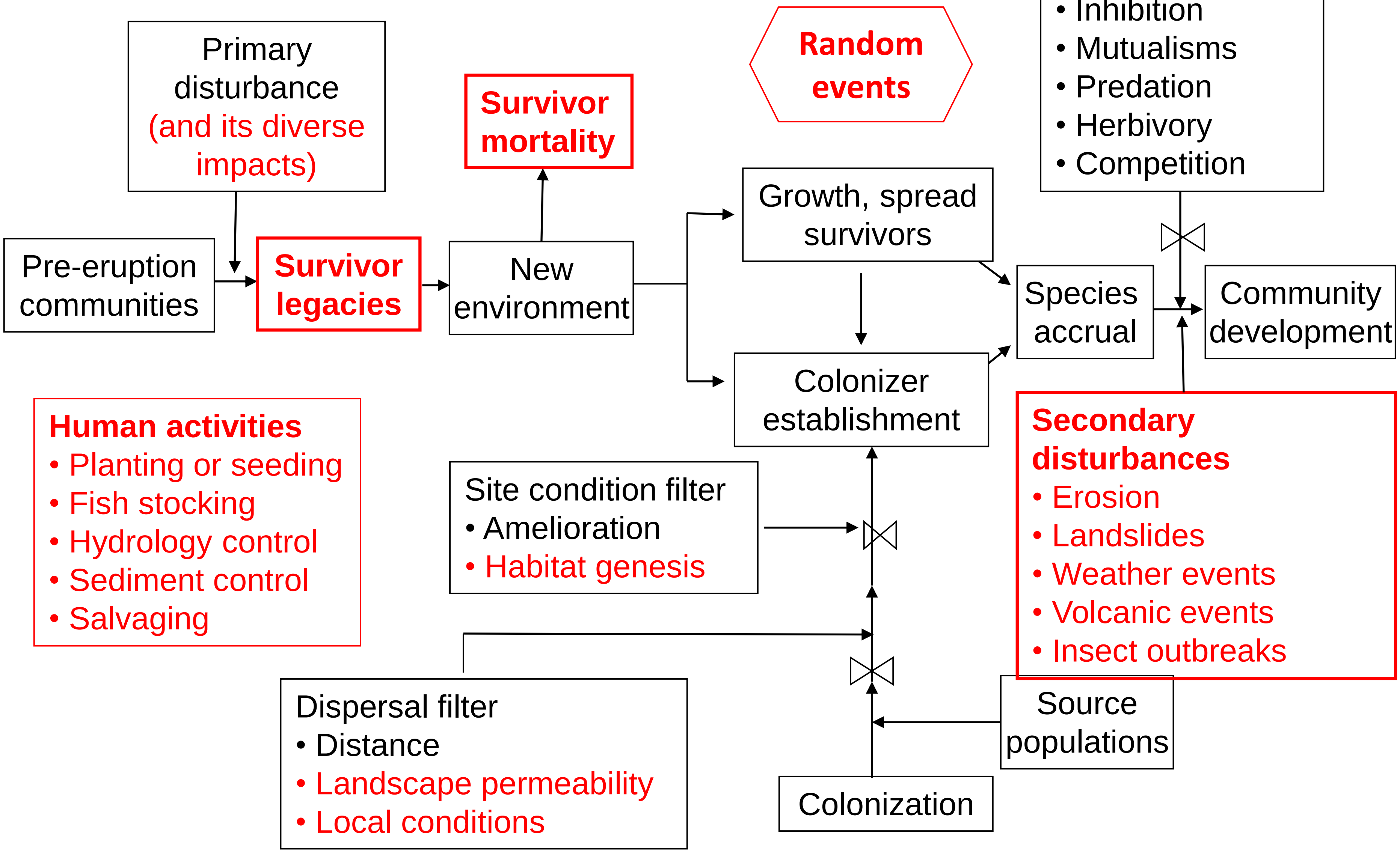


Successional Diagram



Successional Diagram*

(new ideas fostered by lessons from Mount St. Helens)



Dale & Crisafulli
2018

***Spatial and temporal variation influence rates and processes**

Challenges of long-term ecological studies

- **Ongoing disturbances**
  - Mudflows
  - Droughts
  - Human activities
- **Loss of permanent plots**
  - 62 of original 103 plots retained
- **Difficulty of securing funding**
  - Relied on skilled volunteers
  - Logistical support provided by USDA
- **Changes in taxonomy**
  - 35% of plant species have changed
- **Changes in technology**
  - No GIS or GPS when we began
  - Data records are updated to new formats

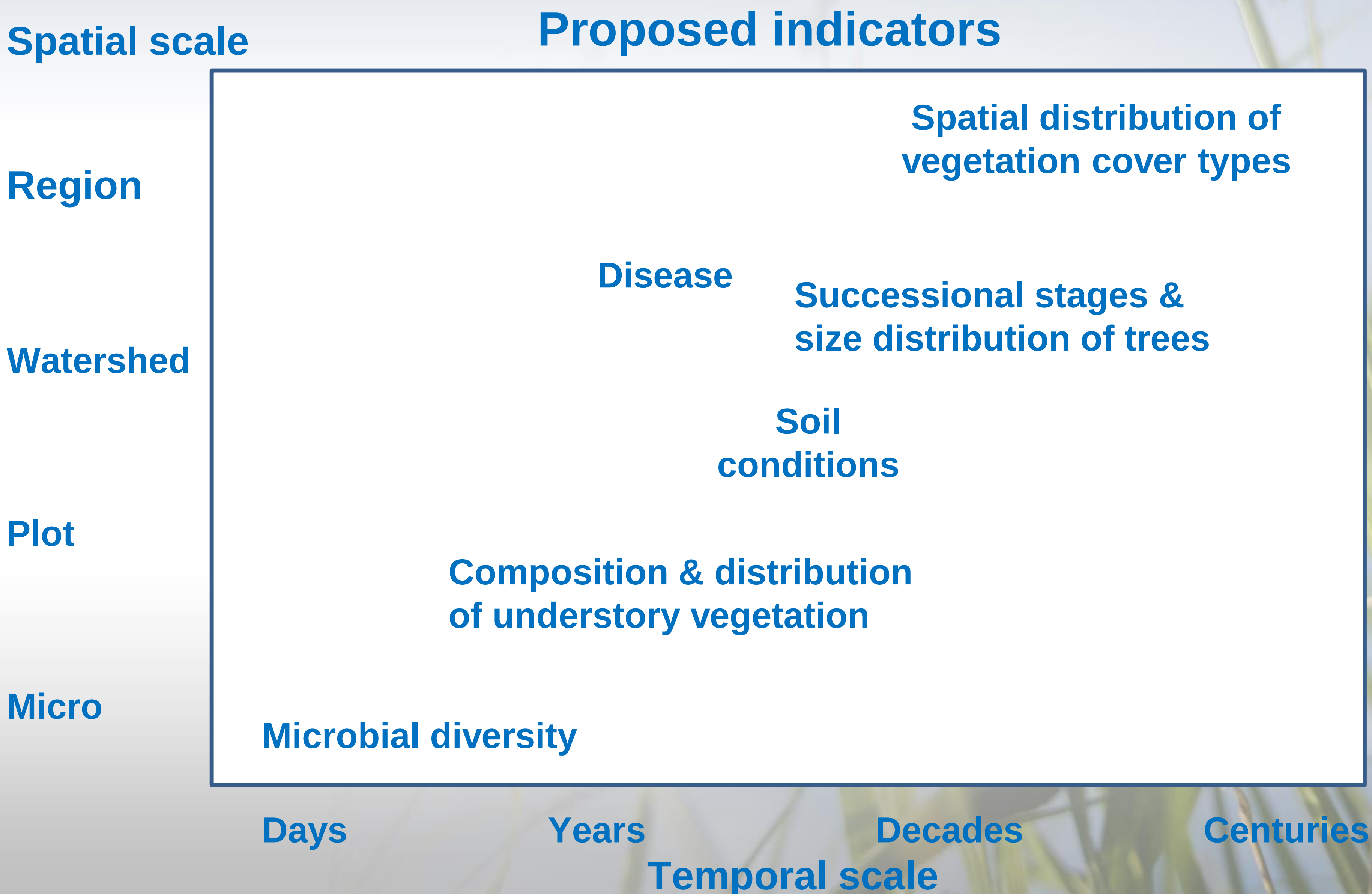
MSH anniversary cakes

2013

2014

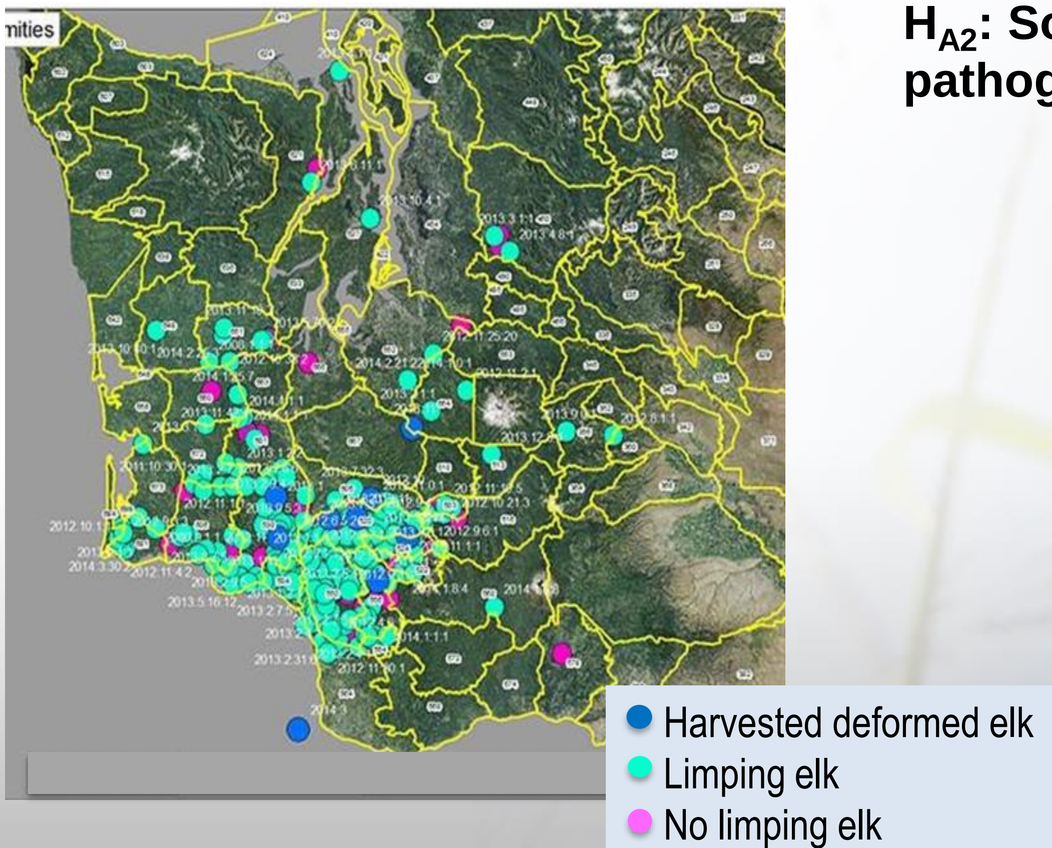
2015

Remaining questions - Q1. What indicators can predict ecological resilience to disturbance?



Q2: What is relationship between ecological conditions & elk hoof disease?

Hoof deformities reported in 2014
(Wa Dept Fish & Wildlife)



H_o: Poor soils & congregation of elk at MSH induces **nutrient deficiency** that weakens elk so they are susceptible to the disease.
H_{A1}: Deficiency in minerals contributes to increased elk susceptibility to disease.
H_{A2}: Soil characteristics promote pathogen survival.

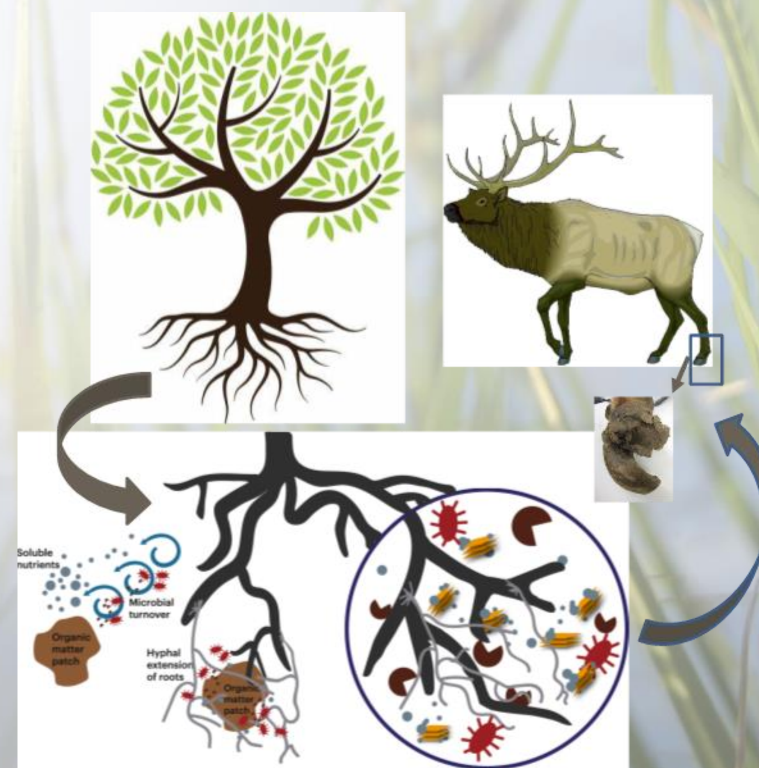


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Photo: August 2015