Succession & disturbances in a restoration context

- What is a (natural) disturbance?
  - Relatively discrete event in time that disrupts ecosystem, community and/or population structure, and changes substrate and resource availability, and the physical environment

Succession & disturbances in a restoration context

What are some natural disturbances?

Succession & disturbances in a restoration context

- Invasive Species – interact with disturbance

Feral Cattle

Quadrastichus erythrinae

Pennisetum setaceum

Feral Pigs

Psidium cattleianum

Succession & disturbances in a restoration context

- Anthropogenic disturbances



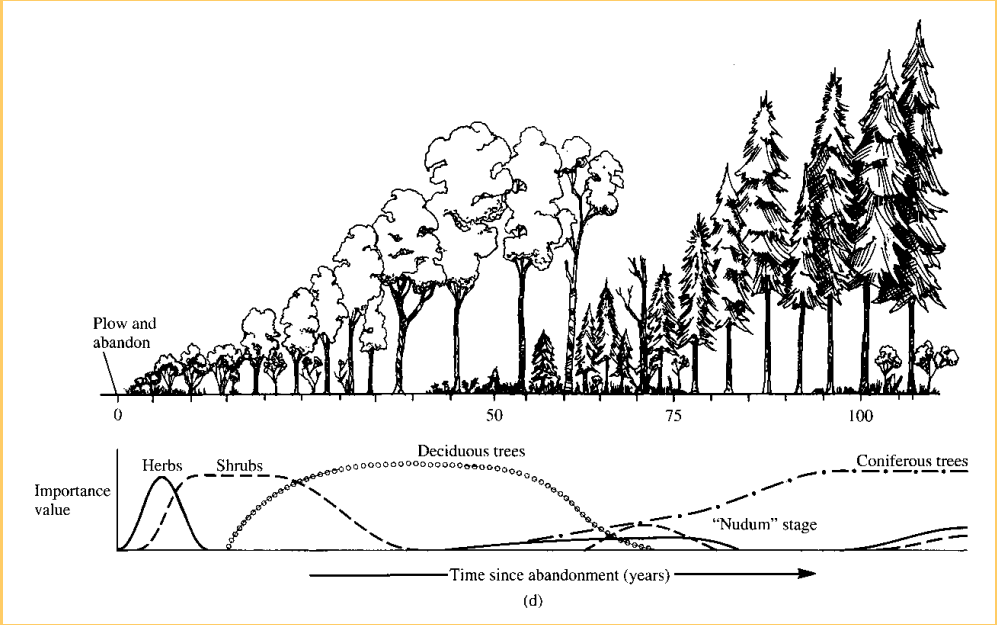


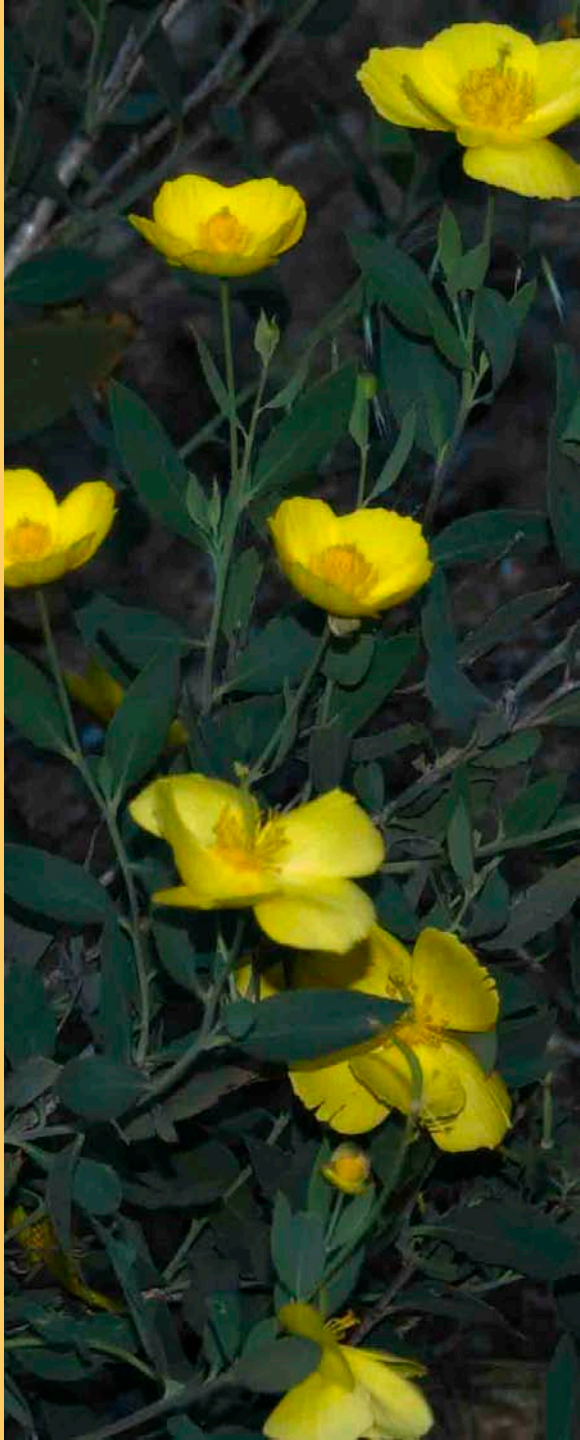
Succession & disturbances in a restoration context

- Disturbance “resets” the successional clock
  - Natural disturbances
    - Play a large role in shaping ecological communities
    - Eliminated from, introduced to, and/or drastically changed in many ecological systems
      - Restoration often involves restoring natural disturbance regimes and/or eliminating those that are not natural
  - Anthropogenic disturbances
    - Most often detrimental
      - Restoration will typically involve removing disturbance
        - » Fire
        - » Nonnative herbivores

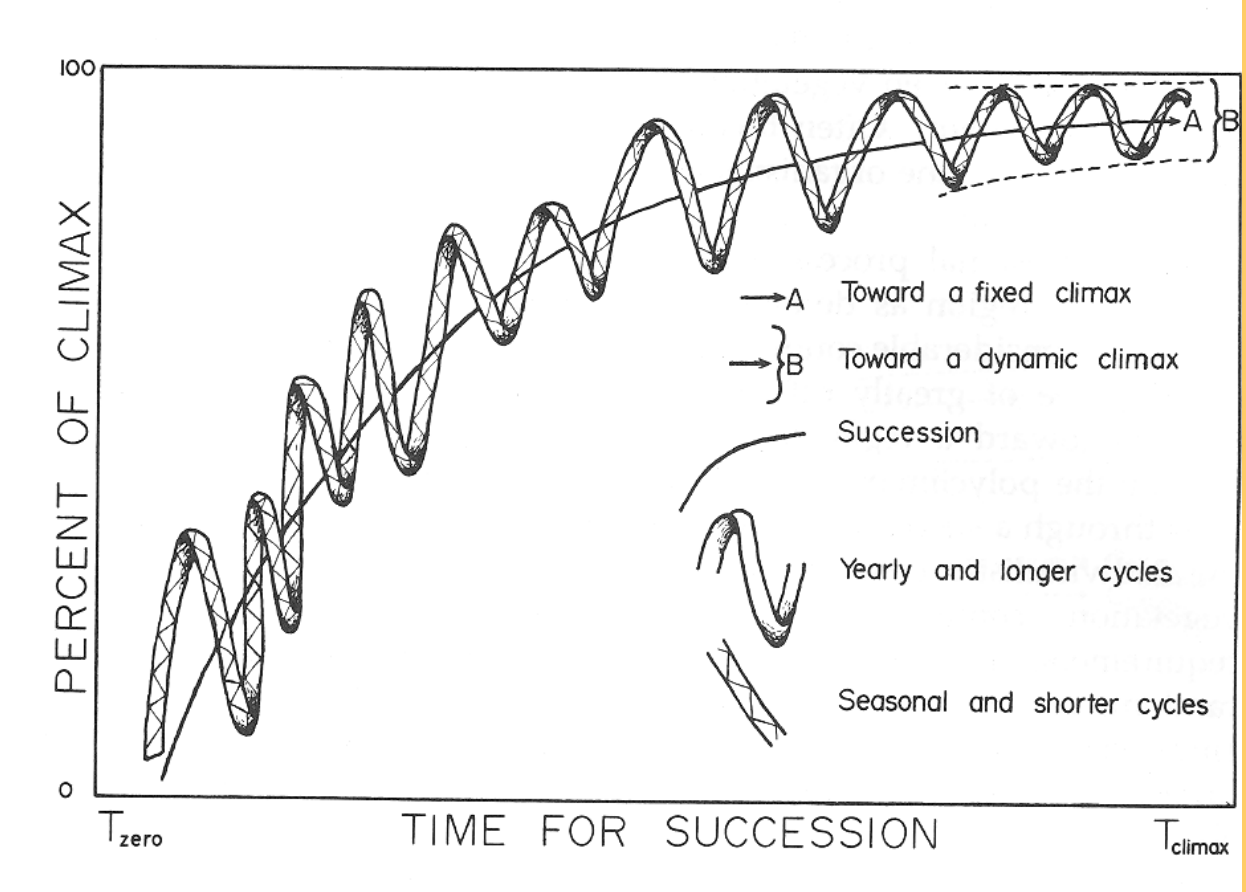
Succession & disturbances in a restoration context

- What is ecological succession?
  - Directional change in species composition, structure, and resource availability over time that is driven by biotic activity and interactions, and changes in the physical environment





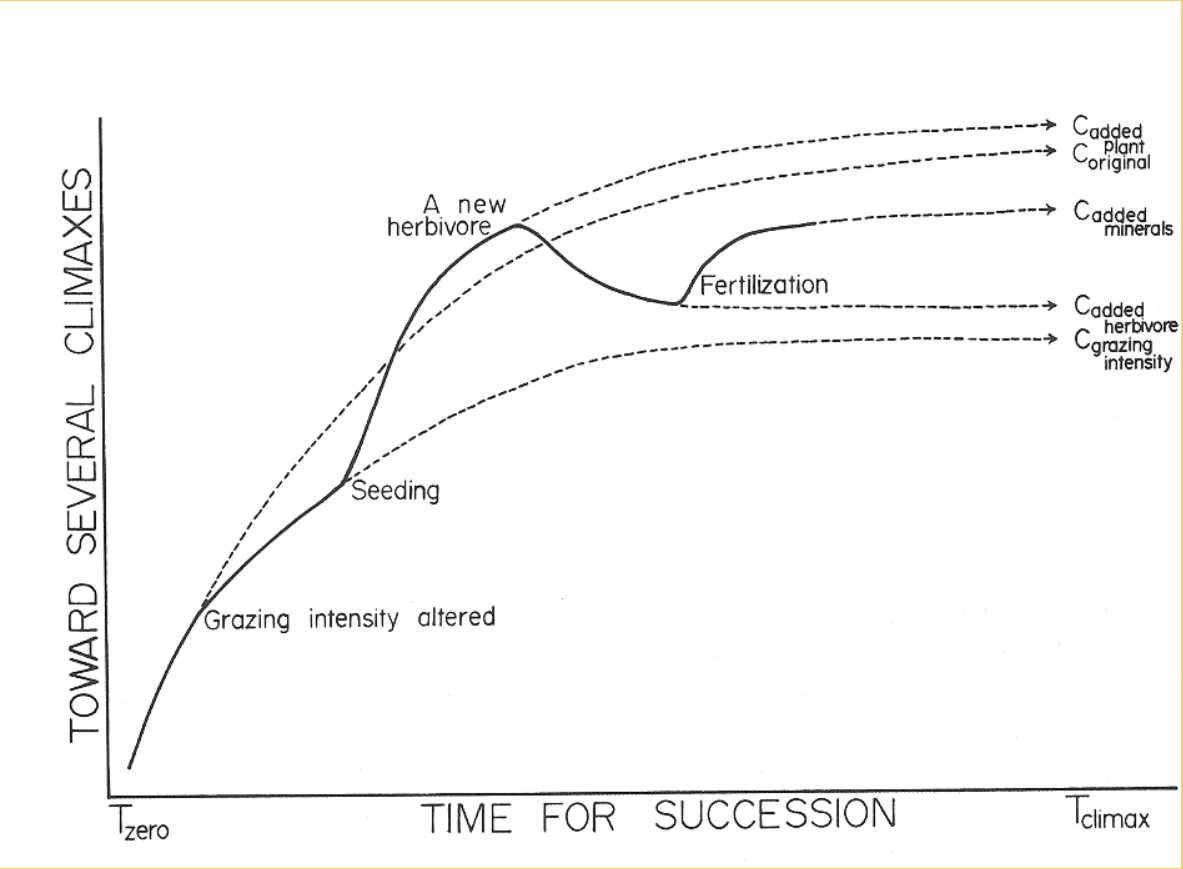
Succession & disturbances in a restoration context



Inherent Variability

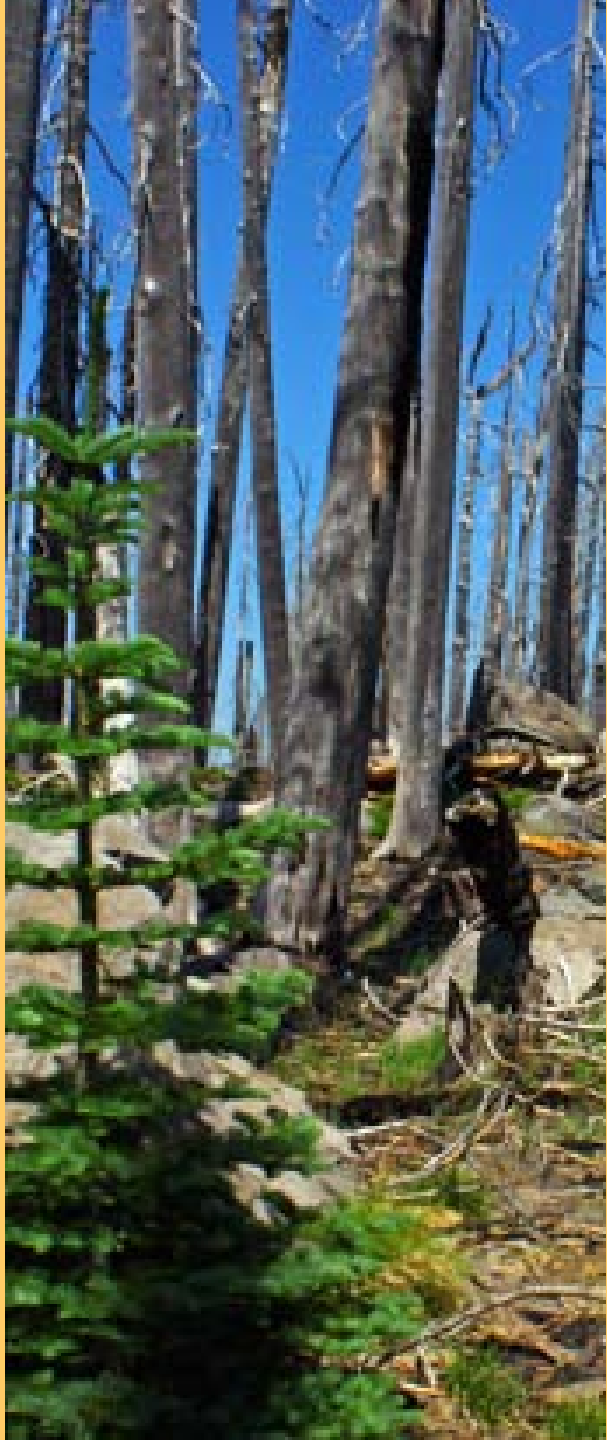
Succession & disturbances in a restoration context

Multiple Steady States



Dynamic nature of ecological systems

- Single Equilibrium Endpoint
  - Return to a pre-disturbance state following disturbance
    - Steady directional change to a single endpoint
    - Predictable consequence of species interactions
    - Strong internal regulation via negative feedback mechanisms
  - Restoration can accelerate succession by skipping some points along the continuum
    - e.g., Restoring fire and flood regimes
    - Really depends upon level of degradation and isolation



Succession & disturbances in a restoration context

- Multiple Equilibrium States
  - Change is discontinuous, abrupt and has multiple trajectories
  - System can become so degraded that it is very difficult to restore
    - Ecological threshold crossed
  - Irreversible shifts in species composition
  - Restoration must identify + feedbacks that maintain a degraded state, and eliminate them
    - e.g., invasive species/wildfire cycle in Hawai‘i

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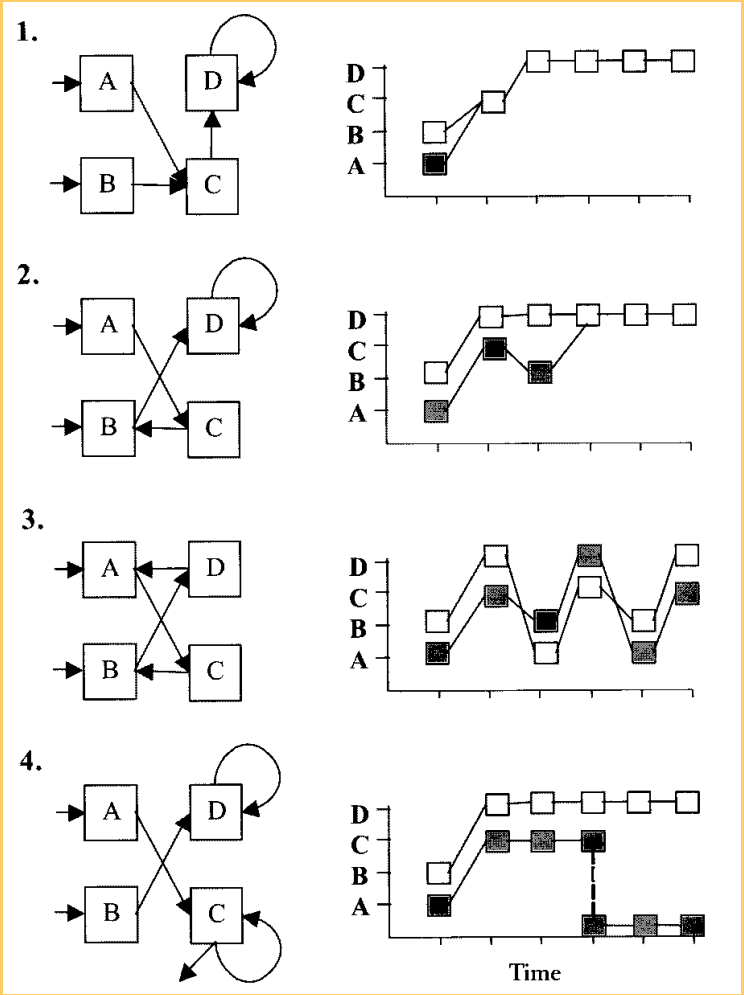
Succession & disturbances in a restoration context

Multiple Steady States (Suding & Gross 2006)



Convergent trajectories: One steady state – reaches equilibrium

Initially divergent trajectories converge to one equilibrium state

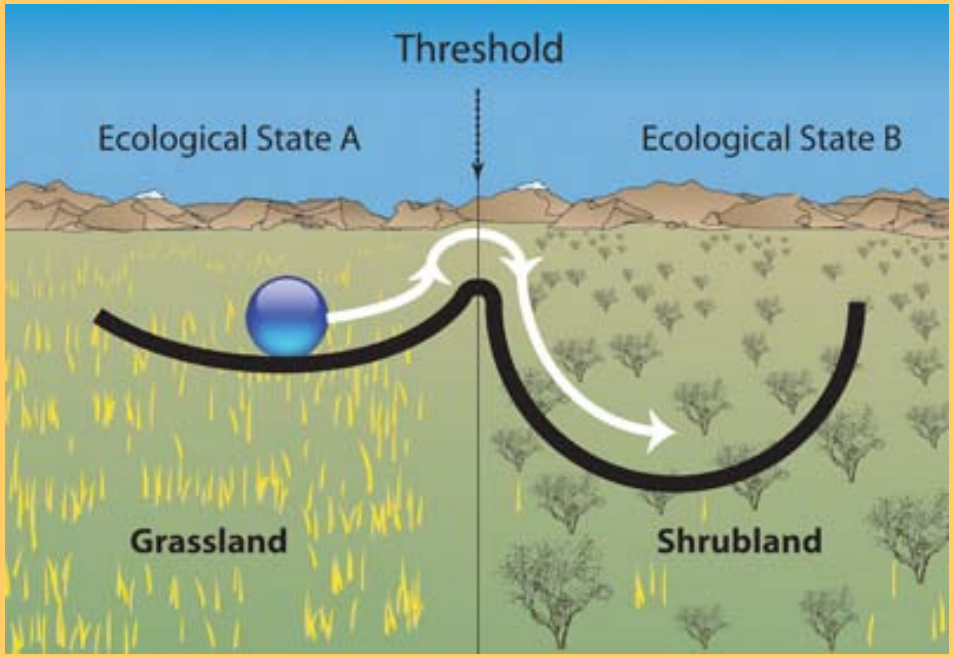
Divergent trajectories never converge and never reach equilibrium

Divergent trajectories – two different stable states

Succession & disturbances in a restoration context

Ecological Threshold

- The point at which a relatively small change in external conditions causes a rapid change in an ecosystem.
- When an ecological threshold has been passed, the ecosystem may no longer be able to return to its state



Succession & disturbances in a restoration context

- Persistent Non-equilibrium State
  - Assumes external factors (e.g., chance and bio. legacies) are more imp. than internal factors (e.g., biotic interactions)
  - Unpredictability of succession
  - Divergent, cyclic or arrested trajectories
  - Chance colonization, unpredictable disturbances
  - Restoration perspective
    - Fragmented areas, loss of propagule source, highly variable abiotic environment
    - Function instead of species assemblages

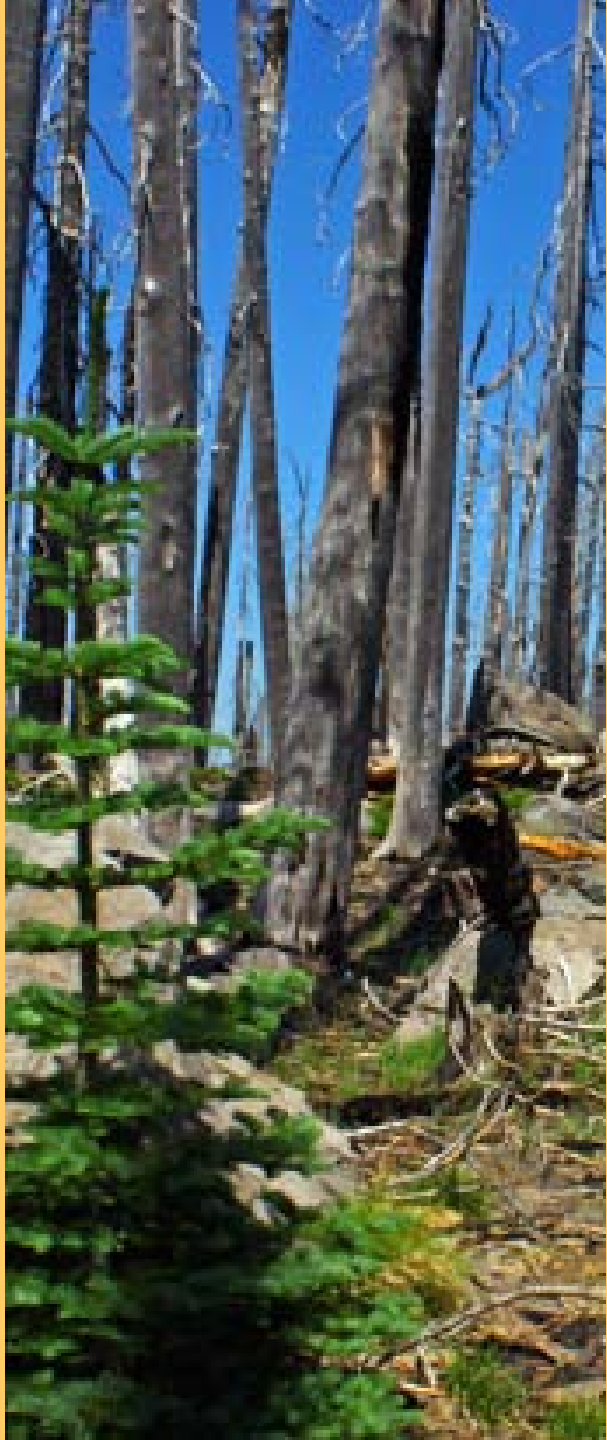
What do we really see in nature?

Succession & disturbances in a restoration context

- Succession and natural disturbances
  - Must understand theory to restore most ecological systems
    - » Types, rates, etc.
    - » Natural vs. anthropogenic
  - Can restoration be accelerated by manipulating succession and/or disturbances?
    - » Eliminating vs. restoring disturbances
- Multiple states, ecological thresholds, and restoration trajectories
  - The ever-changing nature of ecological systems

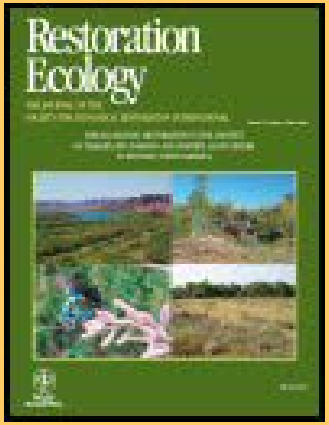
Succession & disturbances in a restoration context

- Species occurrence during succession is a function of:
  - What can gets there & establishes (dispersal and colonization; regional and abiotic filters)
  - What can survive & reproduce (competition; abiotic and biotic filters)
  - Colonization sequence matters



Succession & disturbances in a restoration context

- Ecological systems are dynamic and ever-changing
  - Disturbance regimes are natural
  - Increasingly altered by human activities
  - No simple or universal answers to guide restoration
    - Often system dependent
    - General conceptual framework still debated



Succession & disturbances in a restoration context

- How can theory advance restoration science and practice?
  - *How do degraded ecosystems recover?*
  - *Can we predict the endpoints of pathways?*
  - *How do dynamics that occur on very different scales of space and time relate to one another?*
  - *How much variability does an ecological system require for adequate recovery and adaptive capacity for change in the future?*

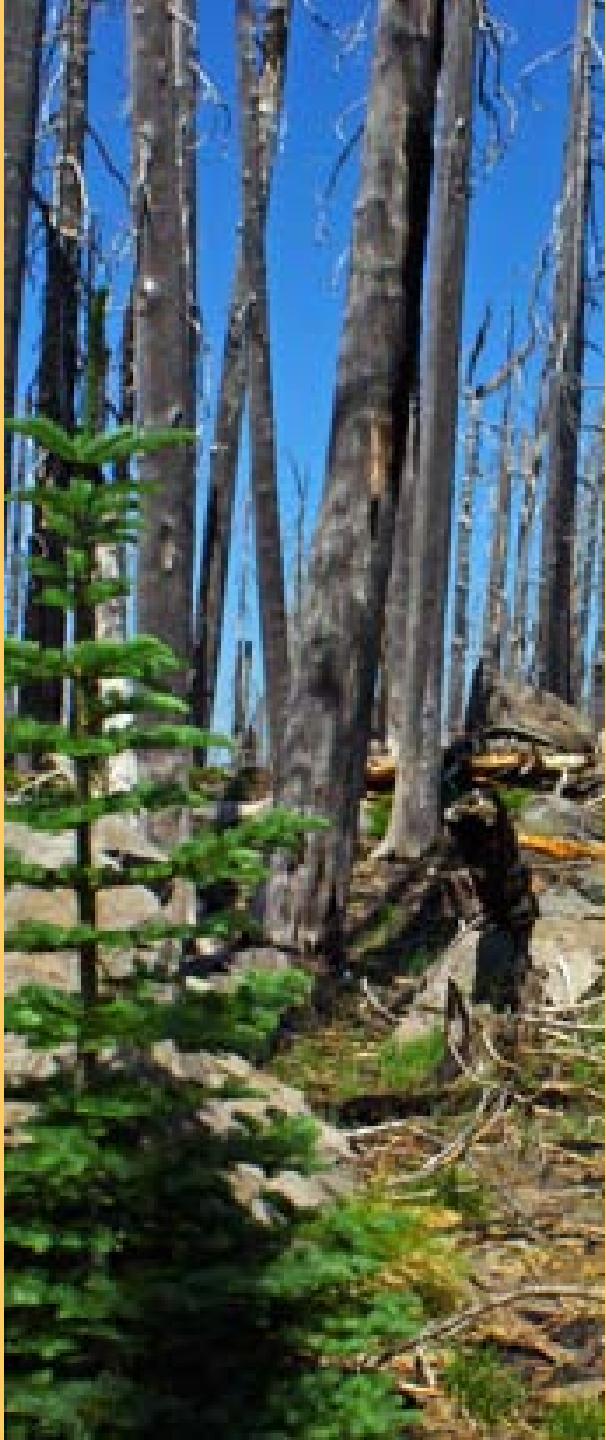
Succession & disturbances in a restoration context

So what do we DO?

“It Depends…….”

- Biology of individual species
- Species interactions
- Invasive species
- Abiotic environment
- Nutrient availability

etc….
etc….
etc….



Succession & disturbances in a restoration context

- **Disturbance Regimes**
  - **Frequency (how often)**
  - **Severity (effect on the landscape)**
  - **Size**
  - **Seasonality**
  - **Intensity**

Succession & disturbances in a restoration context

Example 1: Pinyon Pine/ Juniper Woodland
Fire Suppression and Conifer Encroachment

Problem: Reduced fire frequency, altered hydrology, change in species composition

Solution: Restore fire regime – young pinyon pine and juniper are killed by fire

- erosion and runoff
- seed source

Succession & disturbances in a restoration context

Example 2: Sand Barren Prarie (Midwest) (from reading)
Fire Suppression and Increased Woody Vegetation

Problem: Reduced fire frequency, change in species composition

Solution: Restore fire regime???
Salix resprouts – fire alone will not remove woody vegetation –
- mechanical or chemical removal

Succession & disturbances in a restoration context

Example 3: Invasive Tropical Grassland (Hawaii)
Increased fire frequency and nonnative grass invasion

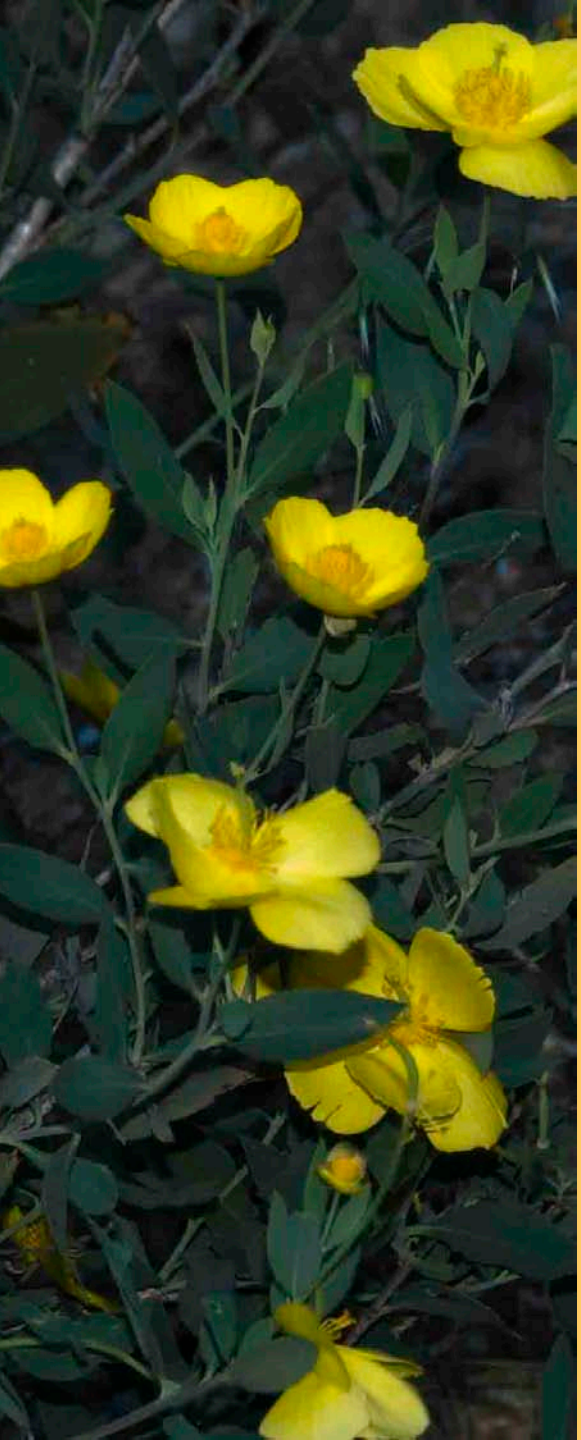
Problem: Increased fire frequency, invasion, ecological threshold crossed

Solution:

- Remove Fire
- Restore Native Woody Composition
- Lots of ongoing management and hope for the best!

- **8 essential steps to any ecological restoration project**

1) a clear rationale as to why restoration is needed
2) an ecological description of the site designated for restoration
3) a statement of goals and objectives of the restoration project
4) a designation and description of the reference system
5) an explanation of how the proposed restoration will integrate with the landscape and flows of organisms and materials
6) explicit plans, schedules and budgets for site preparation, installation and post-installation activities, including a strategy for making mid-course corrections (adaptive management)
7) well-developed and explicitly stated performance standards, with monitoring protocols for project evaluation
8) strategies for long-term protection and maintenance



Next Time:

Invasive Species and Restoration

Ecological Attributes of Restored Systems