A SYSTEMS PERSPECTIVE ON ECOLOGICAL RESTORATION:

A PROPOSAL TO SHIFT THE CURRENT HISTORIC CLIMAX-COMMUNITY RESTORATION MODEL TO A FUTURE ECOSYSTEM BASED MODEL

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INTRODUCTION
Restoration Ecology

- An essential component to any comprehensive conservation program
- Provides a powerful insight into community dynamics and ecosystem function
- Provides a material system to test ecological theory
- Provides opportunity for humans to participate in ecological stewardship

W. R. Jordan III 1997
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- We have become proficient at establishing 20 – 30 species per community

- A diverse restoration might include 50 species when, however, the real potential is 250 + species
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- We have become proficient at establishing 20 – 30 species per community
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**Therefore most restoration projects ...**
- Lack structural heterogeneity inherent to reference models
- Lack functional diversity inherent to reference models
- Are dominated by a few aggressive species
- Recover slowly, if at all, from disturbance
- Are continually threatened by exotic species
Why?

Most ecological restorations fail to achieve desired results.
Why?

1. Continual focus on climax community ecology to achieve steady state results resistant to change
   - No consideration to ecosystem or landscape ecology
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   - No consideration of current & future environmental constraints
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2. Continual Focus on Historic Reference Models
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3. Continual Focus on Aesthetic Services
   - No consideration of additional ecosystem service including:
     - Energy sequestration and transformation
     - Nutrient sequestration and cycling
     - Soil building and retention
     - Water infiltration and purification
     - Food and textile production
     - Aesthetic, cultural, and spiritual services
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- Since it’s the goal of every project to create a desirable, stable, and sustainable system.

- The remainder of this presentation will explore a theoretical platform, based on a systems perspective, on how we might design and manage restorations.
A systems perspective can help restorationists design resilient sustainable systems via:
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- 4. Replace current focus on community ecology with a focus ecosystem ecology

Fred Clements ~ Community Ecology
BACKGROUND
Genesis

Some of the first ecological restorations occurred in the 1930s @ the University Wisconsin-Madison Arboretum

But then ....

WWII

Modernism (Space Race)

Environmental Movement 1968 - 1975

Hippies, idealist & other freaks -1975 -1985 Current

Civilian Conservation Corps provided the labor needed to establish the ecological communities at the Arboretum. Circa 1935-1941
Period Of Invention

• Emergence

- Environmental Movement 1970s
- A gradient ($$)
- Early practitioners set out to restore Midwest prairies
- 5-10 years for feedback from original efforts
- 5-10 years of adjustment and feedback (Active Adaptive Management)
- Feedback constructs an ecological restoration paradigm
This is what we do

Companies A, B, C, ...

Customer Inputs

Temporal & Spatial Constraints

Government Constraints

Academic Inputs

Feedback and The Current Paradigm (Domain)
Advancements have been made in the mechanics

- Site Diagnostics
  - Historic Context
  - Soil Analysis
  - Landscape Influences

- Site Preparation
  - Herbicide
  - Plowing
  - Hydrology
  - Soil Amendments

- Seed
  - > Quality
  - > Increased Quantity
  - > Variety

- Planting Techniques
  - Drills
  - Packing

- Maintenance
  - Fire

- Monitoring
Current Paradigm

- “The science of prairie restoration is done”
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4. Replace current focus on community quality models with ecosystem process based models
A systems perspective can help restorationists design resilient sustainable systems by:

• 1. Replace current ecological resistance models (one stable state) with models that stress ecological resilience (multiple stable states)

• Ecological Resilience is: “The ability of an ecosystem to absorbed disturbance and still maintain ecosystem function” (Holling 1973)

Assumption
• > Resilience equals
  – > Ecosystem function
  – > Ecosystem service
Ecological Resilience By

- Increase species from 30 species to 150+
  - Locate seed for diverse planting
  - Extend genotypic range 150 miles
  - Consider naturalized and adventive species (Poa, Festuca, Hordeum ...)
  - Establish seed production for “lesser” species (FQI < 5)

- Focus on Functional Diversity

- Incorporate Functional Redundancy
  - Several species that perform the same function

- Focus on process instead of outcome
  - Set the control for the heart of the sun

- Restore disturbance regime
  - Functional diversity is only possible with disturbance regime
Functional Attributes. This is a partial list of attributes commonly assigned to describe functional groups.

- **Functional Groups**
  - Phenological attributes
    - Annual
    - Biennial
    - Perennial
    - Spring Ephemeral
    - Cool Season
    - Warm Season
    - Evergreen

- **Environmental Attributes**
  - Wet Tolerant
  - Dry Tolerant
  - Shade Tolerant
  - Sun Tolerant
  - Grazing Tolerant and Intolerant
  - Fire Tolerant and Intolerant
  - Saline Tolerant

- **Morphological Attributes**
  - Shallow Fibrous Root System
  - Deep Fibrous Root System
  - Shallow Tap Root System
  - Deep Tap Root System
  - Graminoid
  - Herbaceous
  - Woody
  - Erect
  - Prostrate

- **Physiological Attributes**
  - Nitrogen Fixers
  - C4 Species
  - C3 Species
The Top Twenty Hits for a Wet-Mesic Prairie

- Marsh Milkweed (Asclepias incarnata)
- New England Aster (Aster novae angliae)
- White Wild Indigo (Baptisia leucantha)
- Tick Trefoil (Desmodium canadense)
- Joe Pye Weed (Eupatorium maculatum)
- Boneset (Eupatorium perfoliatum)
- Sunflower (Helianthus grosseserratus)
- Blue Lobelia (Lobelia siphilitica)
- Monarda (Monarda fistulosa)
- Yellow Coneflower (Ratibida pinnata)
- Black-Eyed Susan (Rudbeckia hirta)
- Rosin Weed (Silphium integrifolium)
- Compass plant (Silphium laciniatum)
- Cup plant (Silphium perfoliatum)
- Stiff Goldenrod (Solidago rigida)
- Meadow Rue (Thalictrum dasycarpum)
- Blue Vervain (Verbena hastata)
- Golden Alexanders (Ziza aurea)
- Big bluestem (Andropogon gerardii)
- Canada Wildrye (Elymus canadensis)
- Switch Grass (Panicum virgatum)
- Cord Grass (Spartina pectinata)

Black-Eyed Susan (Rudbeckia hirta)
• Andropogon gerardi *
• Anemone canadensis
• Apocynum cannabinum
• Asclepias syriaca
• Aster novac-anglia *
• A. simplex
• Calamagrostis canadensis
• Comandra richardsiana
• Cirsium muticum
• Desmodium canadense *
• Dodecathon meadia
• Equisetum arvense
• Erigeron strigosus
• Eupatorium maculatum *
• Fragaria virginiana
• Gallum boreale
• Gentiana andrewail
• Helianthus grosseserratus *
• Heuchera richardsonii
• Hypoxis hirsuta
• Iris shrevei
• Lathyrus palustria
• Liatris pycnostachya
• Lobelia spicata
• Monarda fistulosa *
• Muhlenbergia racemosa
• Oxypolis rigidior
• Pedicularis lanceolata
• Phlox pilosa
• Pycnanthemum virginianum
• Ratibida pinnata *
• Rudbeckia hirta *
• Salix humilis
• Saxifraga pensylvanica
• Solidago gigantea
• Spartina pectinata*
• Spiraea alba
• Thalictrum dasycarpum*
• Thelypteris palustris
• Tradescatia ohiensis
• Veronicastrum virginicum
• Viola cucullata
• Zizia aurea*
- Acornus calamus
- Agrostis (5 sp) **
- Alisma subcordatum
- Aster puniceus
- Aster simplex
- Aster umbellatus
- Bidens (6 sp)
- Caltha palustris
- Epilobium glandulosum
- Echinochloa sp **
- Eleocharis (4 sp) **
- Earagrostis hypnoides **
- Fragaria virginiana **
- Galium (3 sp)
- Geum (2 sp)
- Glyceria (2 sp) **
- Impatiens capensis **
- Iris Sp.
- Juncus (6 sp) **
- Lathyrus (2 sp)
- Leersia (2 sp) **
- Lycopus (2 sp) **
- Lythrum alatum
- Mentha arvensis **
- Mimulus ringens **
- Muhlenbergia (2 sp) **
- Osmunda cinnamomea
- Penthorum sedoides
- Phlox (2 sp)

90 additional species
Obl & Facw / FQA =/< 5

** = Modal Species > 50%
Presence Values
> System Resilience

Increased tolerance to disturbance

• Historic Disturbance:
  – Muskrat
  – Beaver
  – Bison
  – Elk
  – Voles
  – Fire
  – Drought
  – Flood
  – Freeze

• Assumption:
  • A site with a 150 species is more likely to resist or rebound from disturbance than a site with 50 species
A systems perspective can help restorationists design resilient sustainable systems by:

- 2. Replace current historic rational with future oriented ecosystem service rational
Restorationists need to consider the current context in which restoration takes place
Currently, the first step is to identify existing environmental constraints and try to overlay historic plant associations to these constraints.
A systems perspective would identify current and predict future environmental constraints and associated plant communities.
Millennium Assessment Reports (2003)

- Energy Sequestration
- Energy transformation
- Nutrient Sequestration
- Nutrient Cycling
- Soil Retention
- Soil Building
- Water Retention
- Water Purification
- Climate Amelioration
- Food Production
- Textile Production
- Aesthetic
- Cultural
- Spiritual
A systems perspective can help restorationists design resilient sustainable systems by:

- 3. Replacing current static climax community models with dynamic adaptive cycle models
Current Restorations
Target a dominant climax community as the project outcome
No memory or \( (r) \) species
No recovery species
A perturbance can push the desired outcome past a threshold

Lacking
Lesser species,
Memory species,
Seed banks
Annuals
Biennials
early successional perennials, the system may end up in a:

LESS DESIRABLE STABLE STATE
Need to design PROCESS based restorations not outcome based restorations.

Late K Configuration

Early K Configuration

Biennials and Short Lived Perennials

Early “Pioneer Species / Annuals”
3. Replacing current static climax community models with dynamic adaptive cycle models

• Set the site on a trajectory towards a desired state
  – Allow for multiple stable states

• Pull the site back to an earlier successional state
  – Stabilize system behavior
• A systems perspective can help restorationists design resilient sustainable systems by:

• 4. Replace current focus on community ecology with a focus ecosystem ecology

• Shift success metrics from species present to ecosystem processes

• Success to be measured by
  – Nutrient cycling and retention
  – Water infiltration and purification
  – Soil retention and building
  – Energy sequestration and transfer
Success of current restorations is measured by species present (FQI)

- Barnyard grass = 1  
  *Echinochloa sp.*

- White fringed orchid = 10  
  *Plantanthera leucophaea*
Success of current restorations is measured by species present (FQI)

Barnyard grass = 1
Sequesters 70% of soil nitrogen
Early successional soil stabilier

White fringed orchid = 10
Current emphasis is placed high FQI values

- Success to be measured by
  - Nutrient cycling and retention
  - Water infiltration and purification
  - Soil retention and building
  - Energy sequestration and transfer

This system receives runoff from a parking lot

Low FQI values
  - Hordeum
  - Puccinellia

High ecosystem service value
High resilient value
Conclusion

If we focus on historic, climax community based ecological, species oriented restorations

Without early successional “memory” species...

Without reference to current & future environmental constraints...

Without consideration of ecosystem service...

then are we restoring a system or a we ...
• creating replicates?
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Field Applications
Constraint to Diverse Mixes

- I believe a major constraint to building diversity into restorations is theoretical which translates to procedural

Example
- You’re a resource manager
- A 20 Acre site
- 2 years site preparation
- Budget: $40,000
- Budget for seed is $20,000
- Erosion, drought, pestilence, wetness and so forth threaten establishment
- Do you bring in a trace (1 gram/acre) of 200 species?
- Or a Kilogram/acre of 30 robust species?
- You have **one** opportunity to make it work
1. Increase Functional Diversity

- Increase demand for “lesser species”
- Develop seed sources
- Construct Functional categories
- Employ multiple reintroductions
Step 2.  Increase Available Propagule Potentials
Increase diversity of available seed

Develop regional seed sources
Step 3. Increase Reintroduction Procedures
Multiple seed reintroductions
Thank you
Stephen Thomforde
References

• Curtis J. T., 1959 *Vegetation of Wisconsin*. University of Wisconsin Press


