Nonlinearities in Assisted Succession to Suppress Reed Canarygrass: a 16-Year Restoration Experiment

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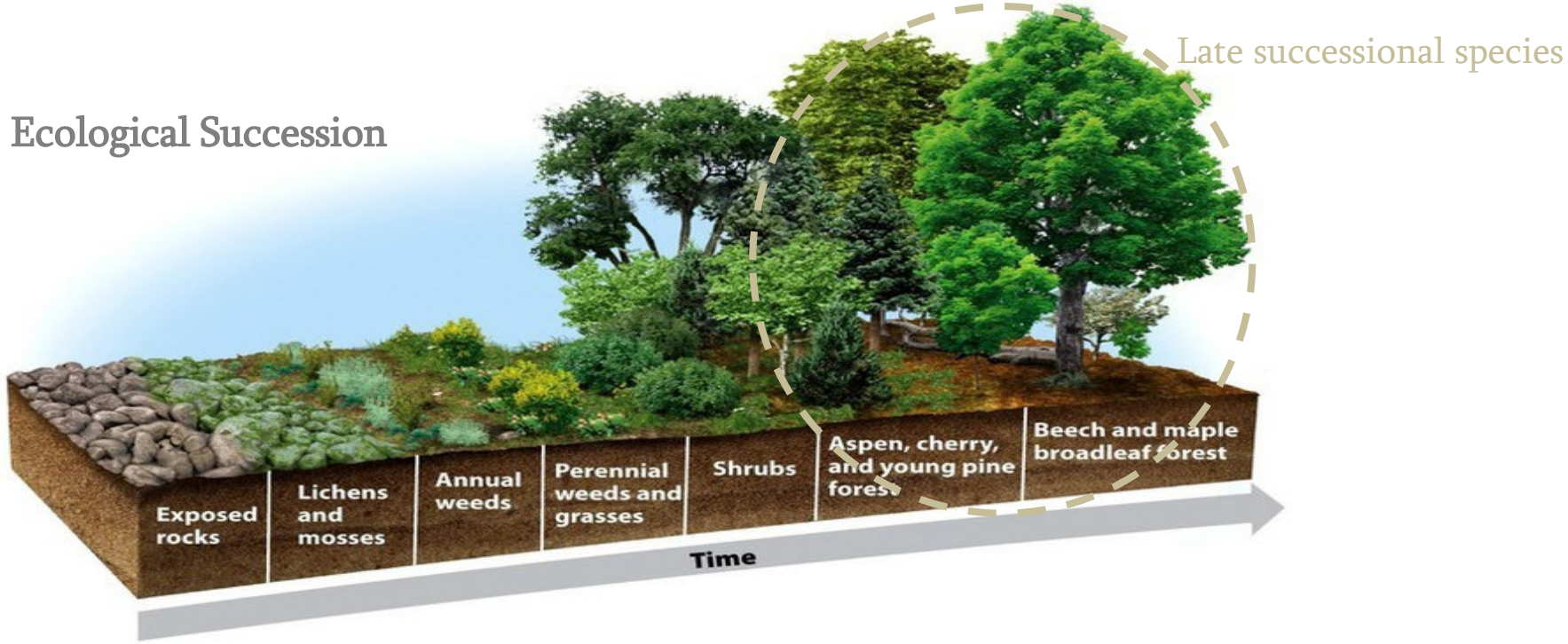
Forthcoming paper in *J Applied Ecology*: Palacio-Lopez et al. in press

Assisted Succession

- Interventions that re-establish a stalled successional trajectory (i.e., arrested succession).
- Entails seeding or planting later-successional species to jump-start their establishment.
- Should be a cost-effective restoration strategy.
- Especially relevant when invader dominance hinders forest regeneration.
  - Particularly when the invader is shade-intolerant.

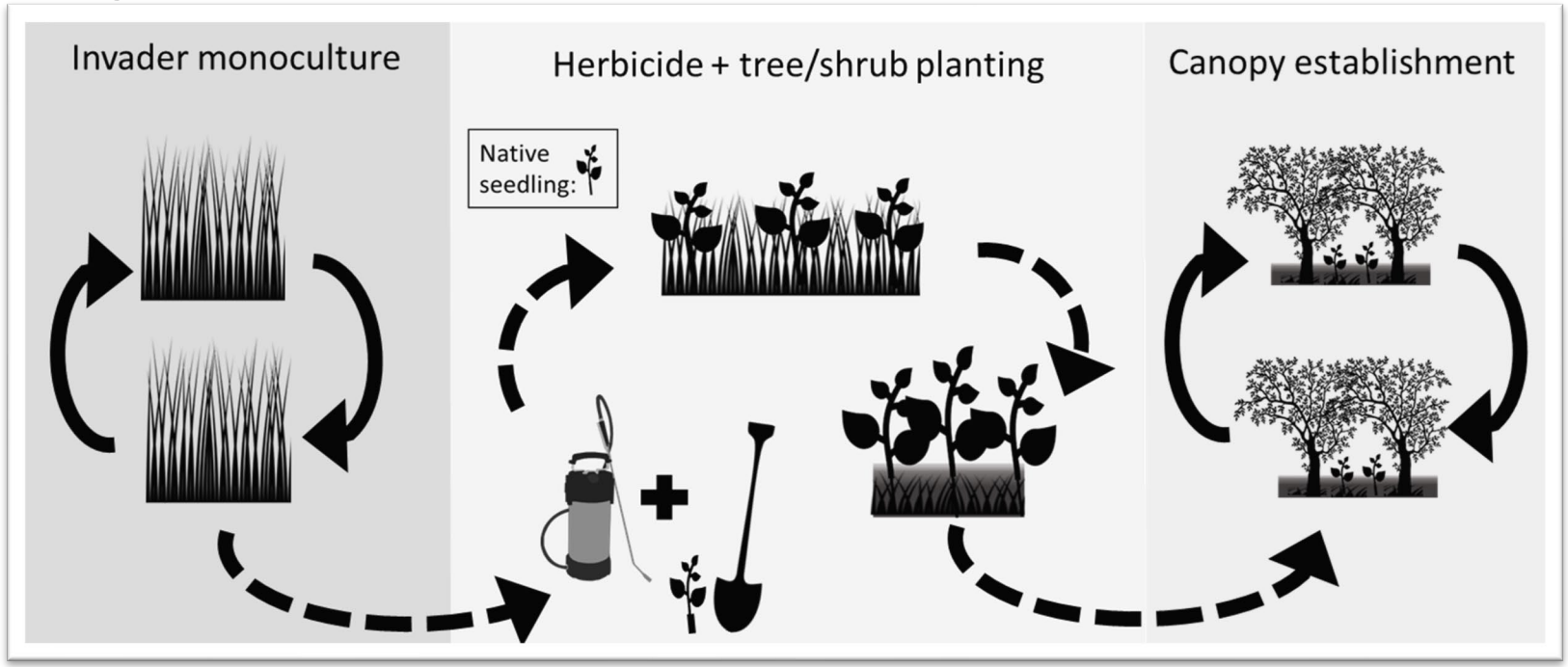


Our system: Swamp forest regeneration suppressed by the wetland invader reed canarygrass (*Phalaris arundinacea*)

Reed canarygrass (RCG)

- Invasive wetland grass.
- Diverse genetically and morphologically.
- Grows in high-density stands.
- Highly competitive.
- Tolerates a wide range of conditions, varying in sedimentation, soil nutrients.
- Does NOT tolerate shade conditions.

Long-term restoration of invaded sites via assisted succession.



Increased tree & shrub cover

↓

Reduction of light availability

→ Suppression of invader abundance

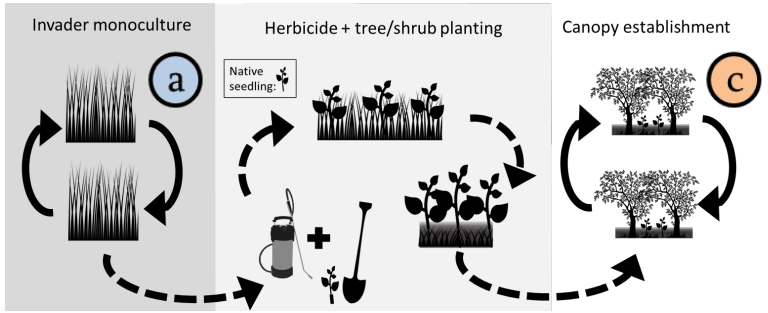
↓

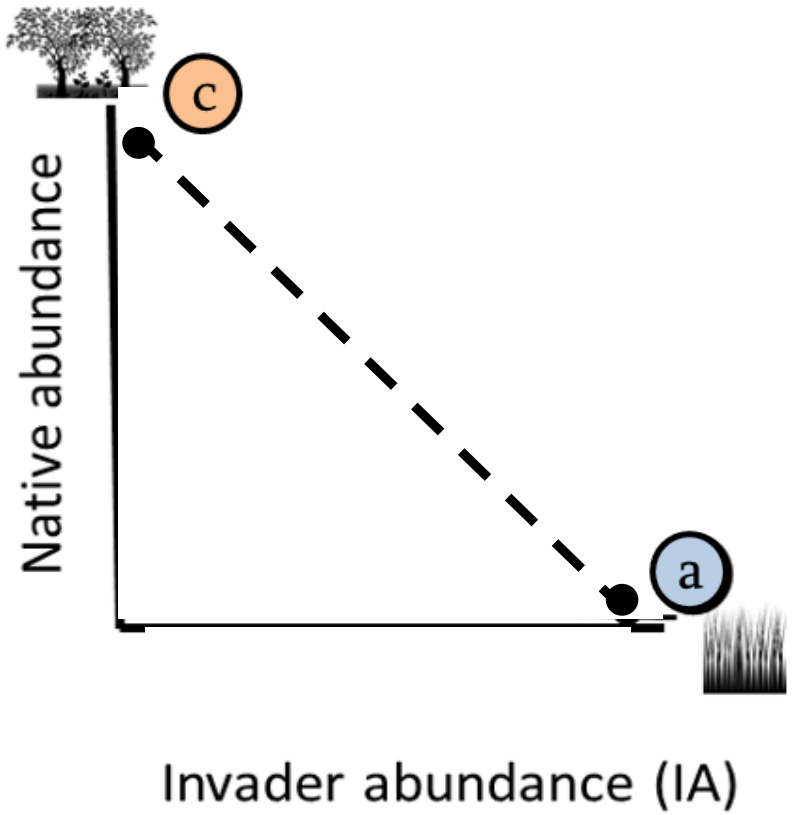
Increase in native abundances

Figure Arrows:

- restoration pathway (heavy dashed arrows).
- "stable" states (heavy solid arrows).

The nature of the relationships between intervention intensity, invader abundance, and invader impacts are important for accurate expectations regarding restoration outcomes.





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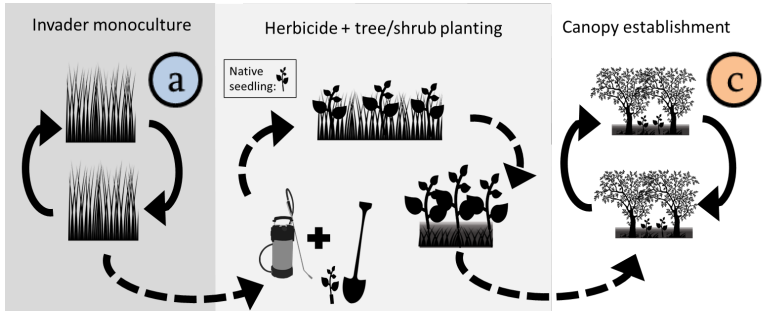

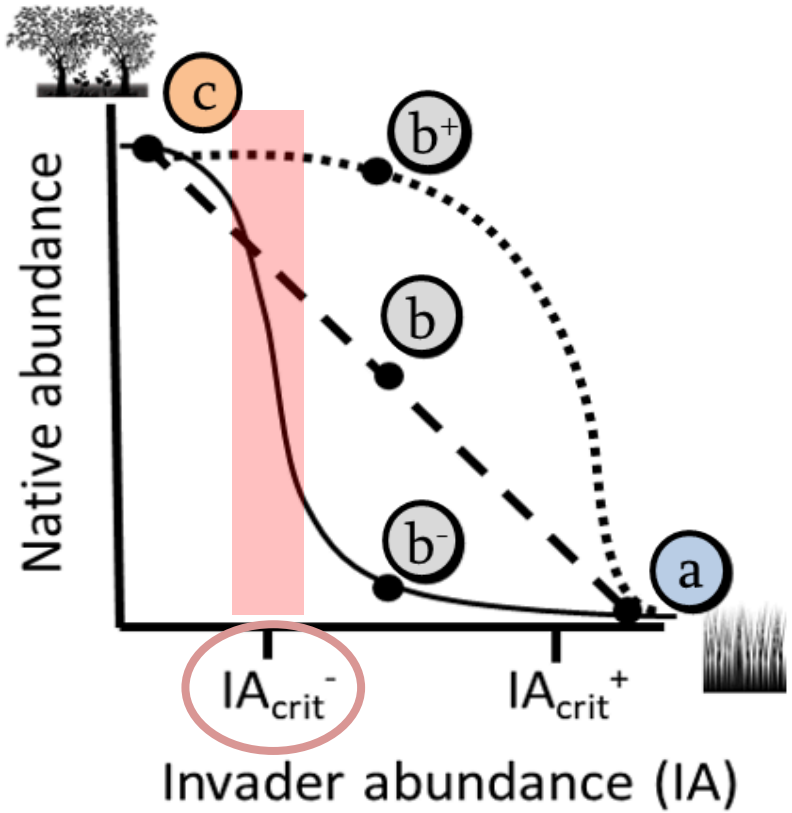

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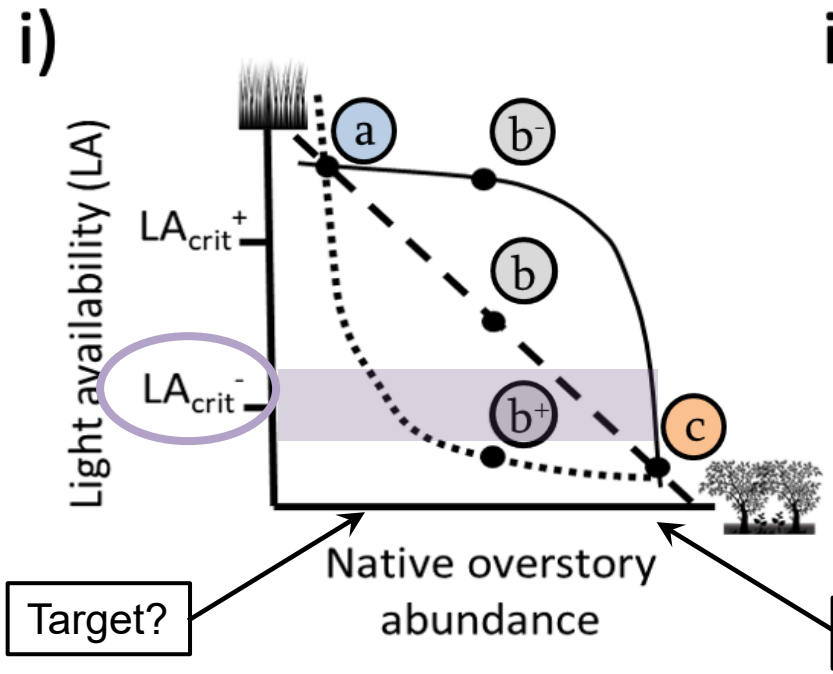
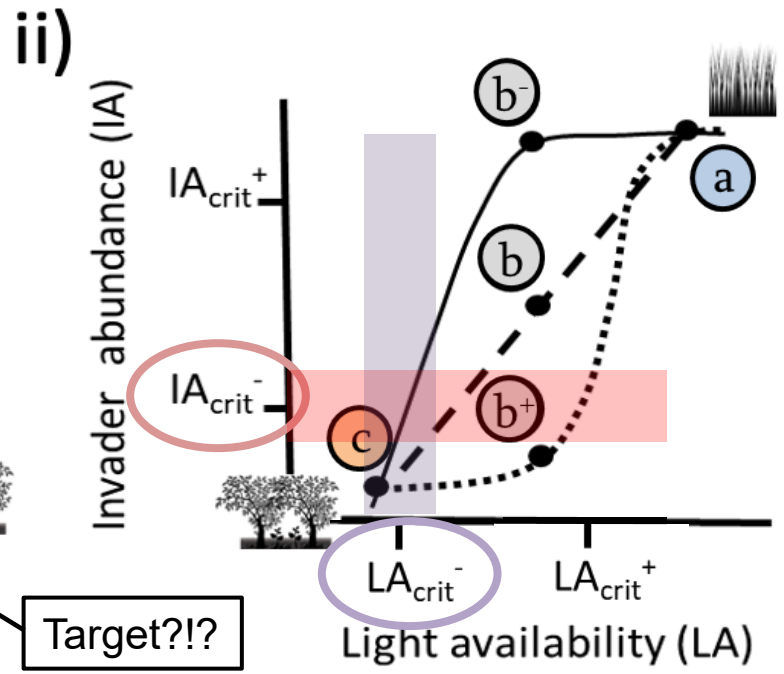
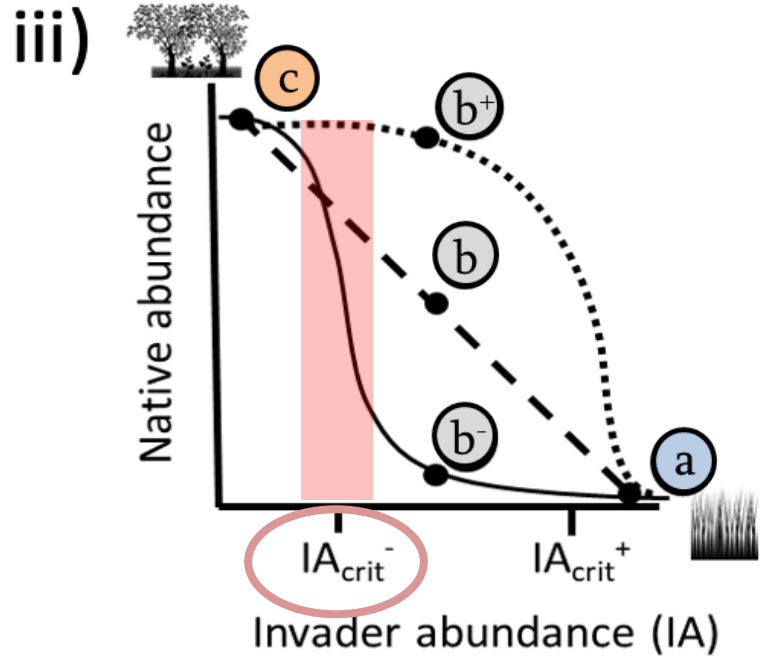
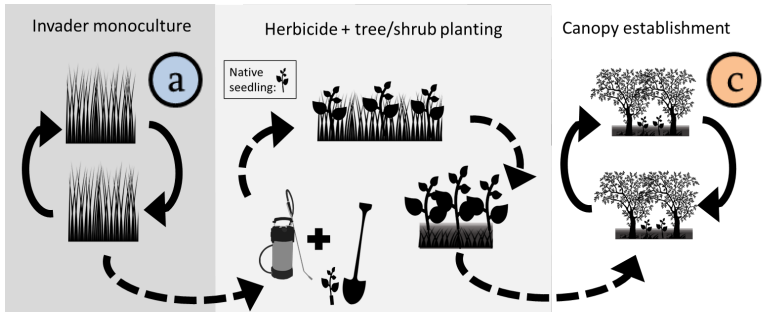








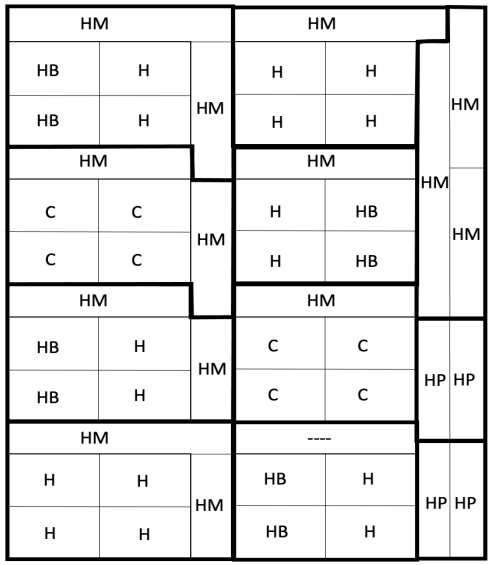
Experimental design:

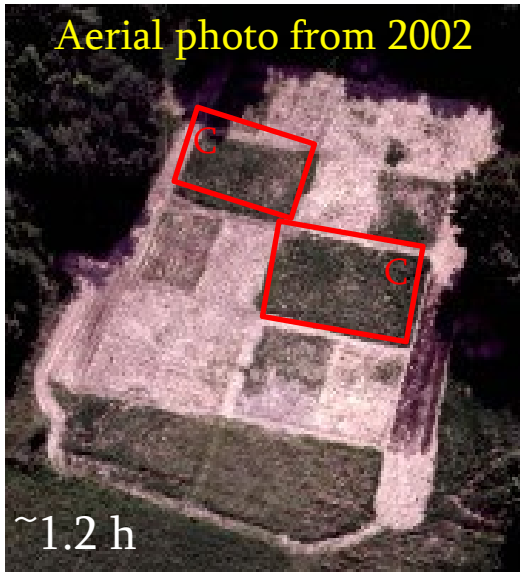
1. Pre-planting treatments:

Field site in SE Wisconsin

50 plots with pre-planting treatments (all herbicide fall 2002):

- (HM) – herbicide + plow
- (HB) – herbicide + burn
- (HM) – mow + herbicide
- (H) – herbicide-only
- (C) – control: untreated *Phalaris*





2. Planting woody species (spring 2003)

23 tree and shrub species planted at high densities (~1 m^{-2}).

3. Field survey 1 year post-planting (summer 2004)

Determine early survival across all woody species.

4. Field survey 16 years post-planting (summer 2019)

Determine tree and shrub abundance (canopy, saplings, seedlings); groundcover; light availability.

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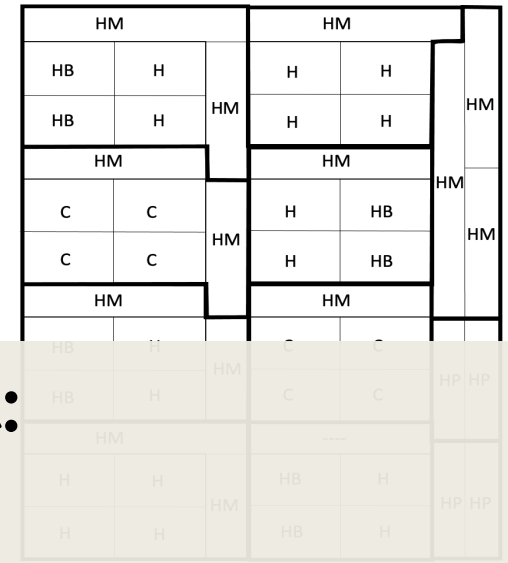


Key questions of interest:

1) **Did it work?**

2) **What are the critical thresholds that might enable/limit restoration success?**

2. Planting woody species (spring 2003)

3. Field survey 1 year post-planting (summer 2004)

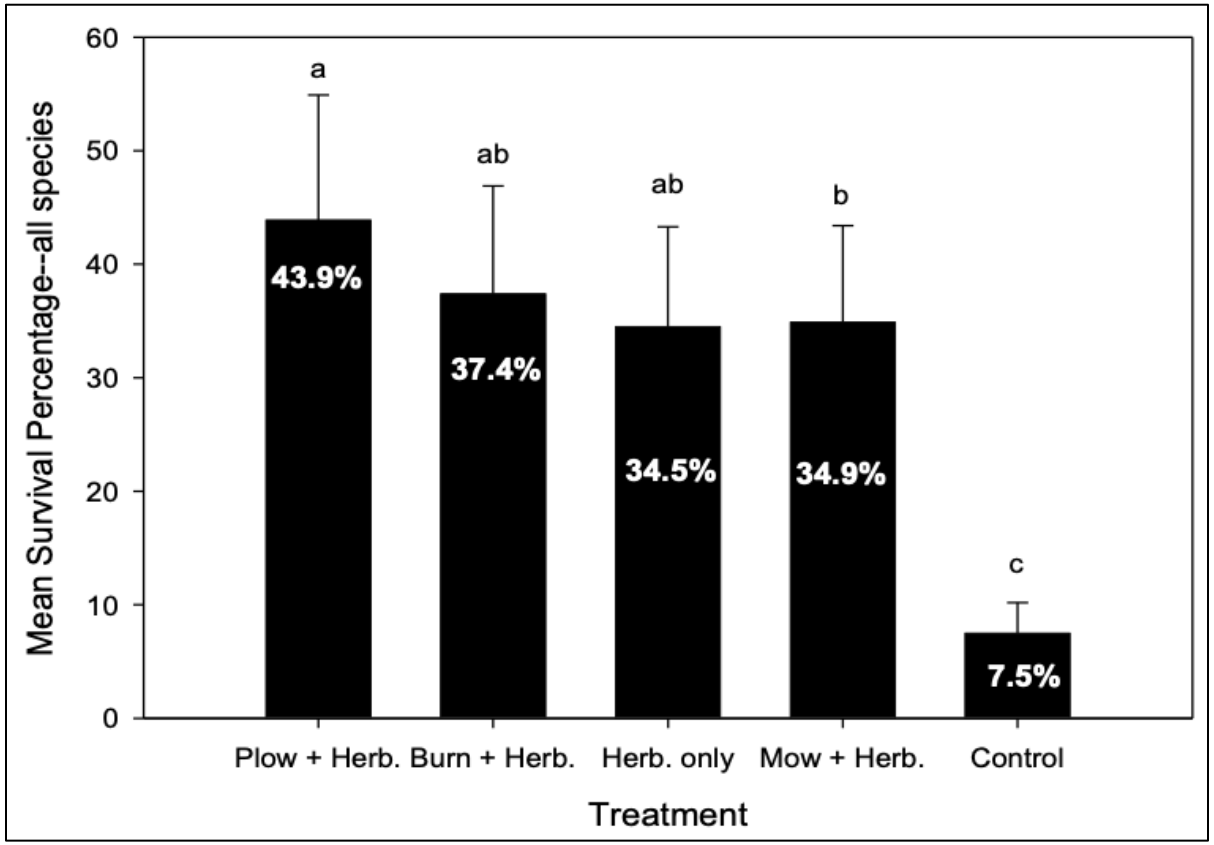
Determine early survival across all woody species.

4. Field survey 16 years post-planting (summer 2019)

Determine tree and shrub abundance (canopy, saplings, seedlings); groundcover; light availability.

Results of field survey 1 year post-planting:

- Low survival in control plots.
- Pre-planting herbicide treatment enabled moderate survival for many species (10 spp. with survival ≥50%).



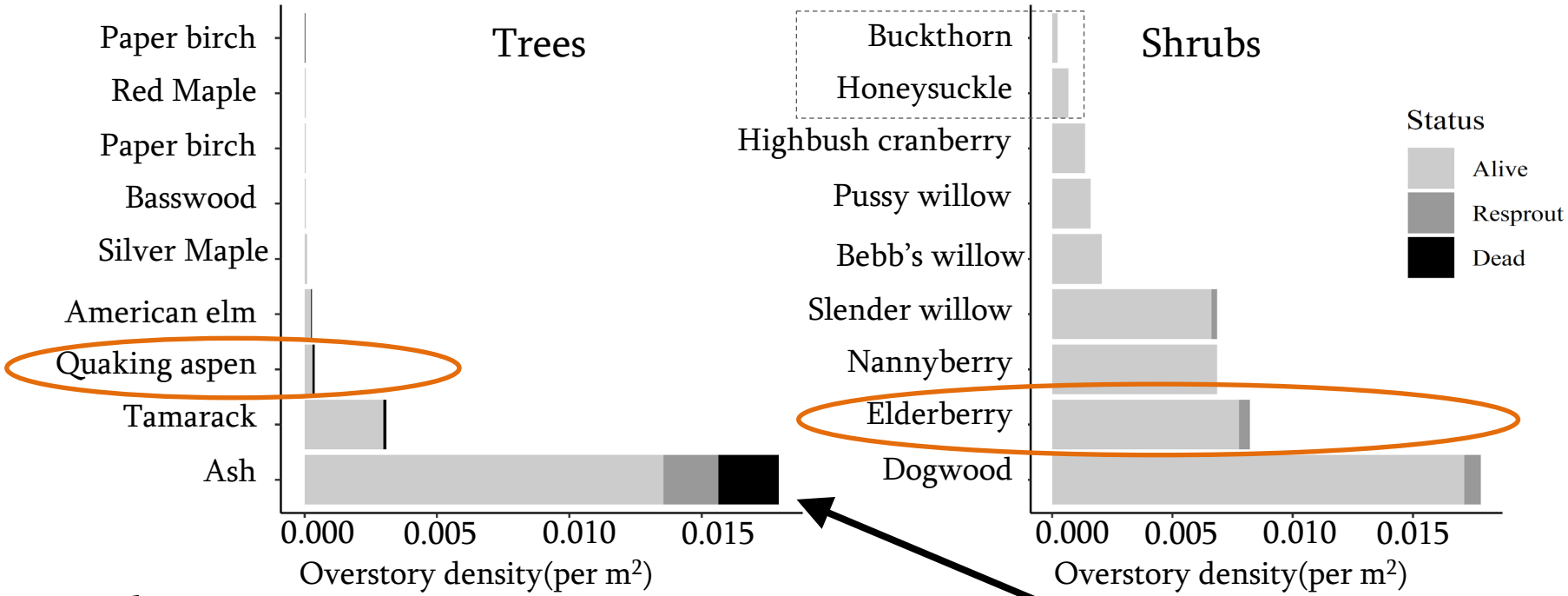
Hovick, S. M., & Reinartz, J. A. (2007). Restoring forest in wetlands dominated by reed canarygrass: The effects of pre-planting treatments on early survival of planted stock. *Wetlands*, *27* (1), 24–39.

Results of field survey 16 years post-planting:

Survival plus Regeneration

- **Overstory**:

  All species surviving in 2004 were found in 2019.



Most dead trees from Emerald ash borer

Regeneration

- **Saplings**:

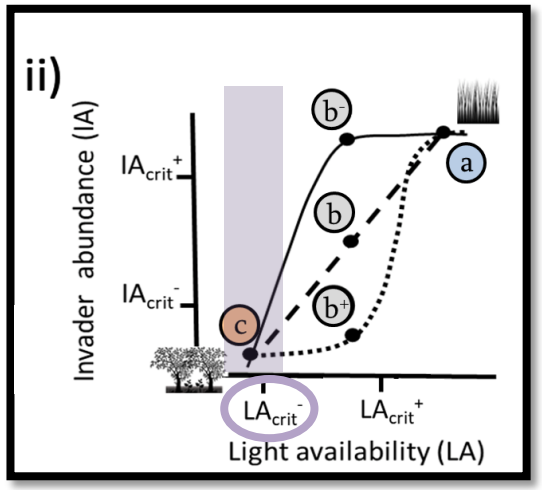
  64% shrubs: Elderberry, Black raspberry, Dogwood
  36% trees: Ash, Aspen, American elm.

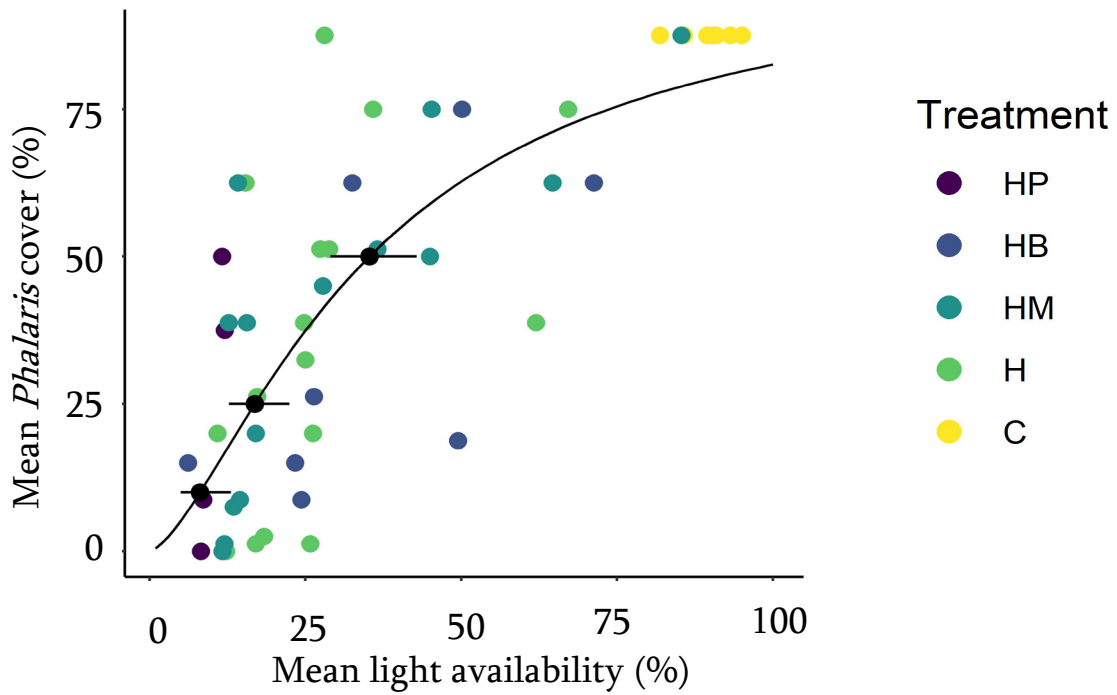
- **Seedlings**:

  50% Ash spp.
  39% Aspen
  11% Maple spp.

Palacio-Lopez et al. in press

A reduction in light availability reduced *Phalaris* cover without differences among the pre-planting treatments.





Our data predict a reduction in light availability of ~35% to achieve 50% *Phalaris* cover
~17% to achieve 25%
~8% to achieve 10%

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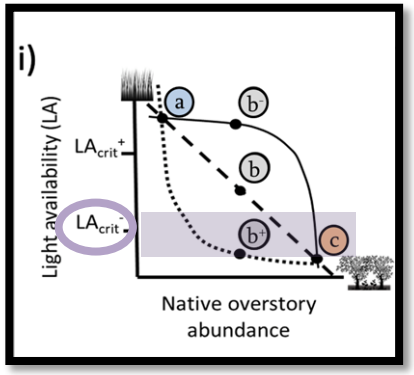
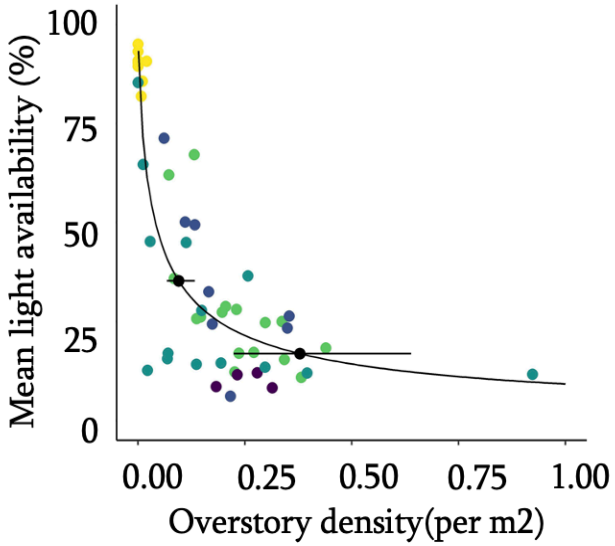
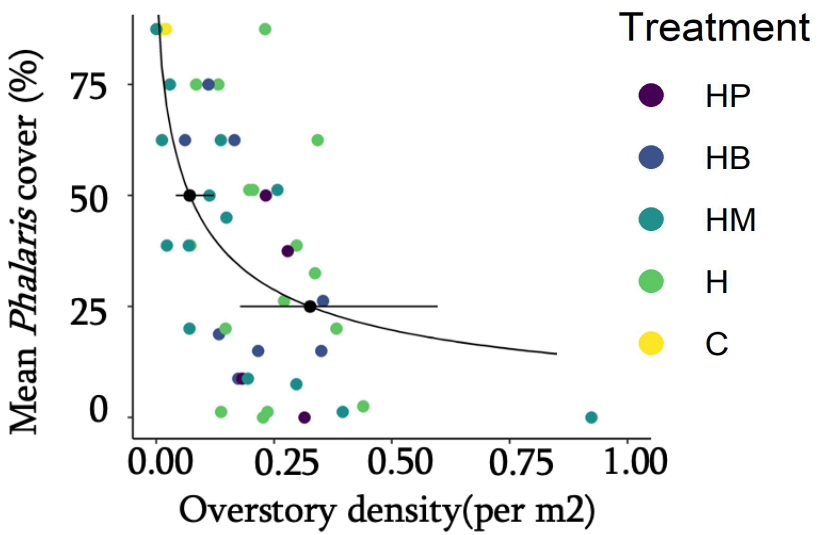
Reduction in *Phalaris* cover occurs via woody overstory establishment (decreasing light availability).







Overstory densities of ~0.07 m^{-2} (~700/ha) needed to achieve 50% *Phalaris* cover, or ~0.33 m^{-2} (3300/ha) to achieve 25% *Phalaris*

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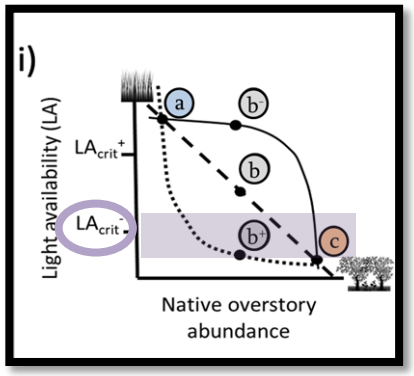

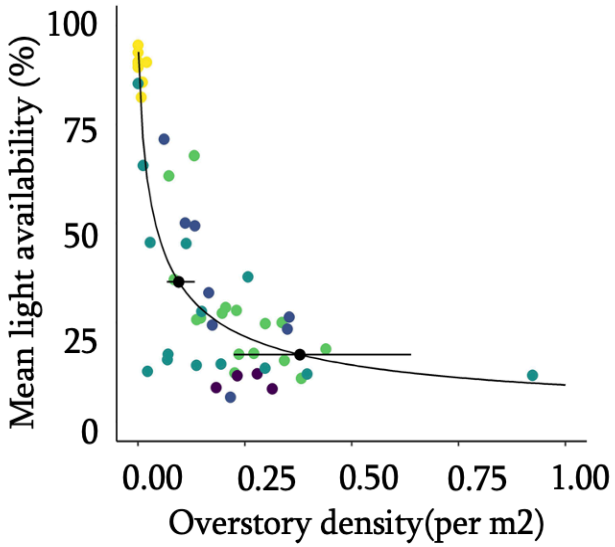

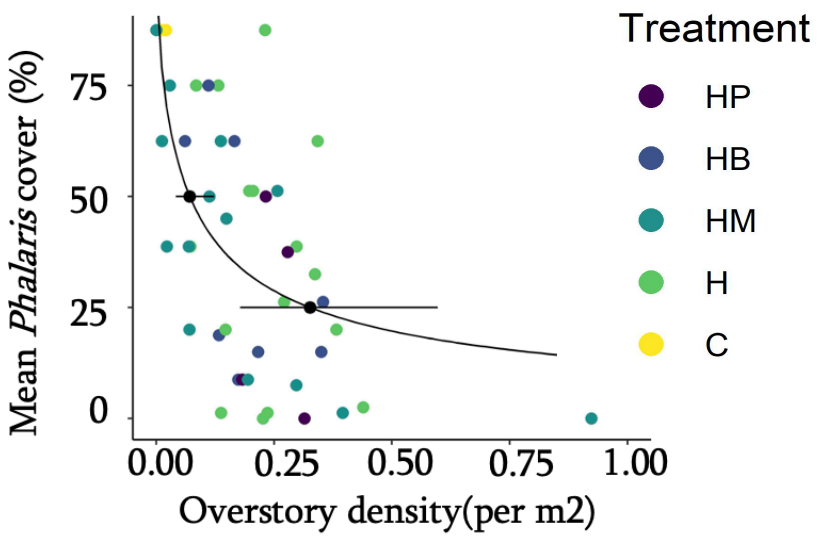

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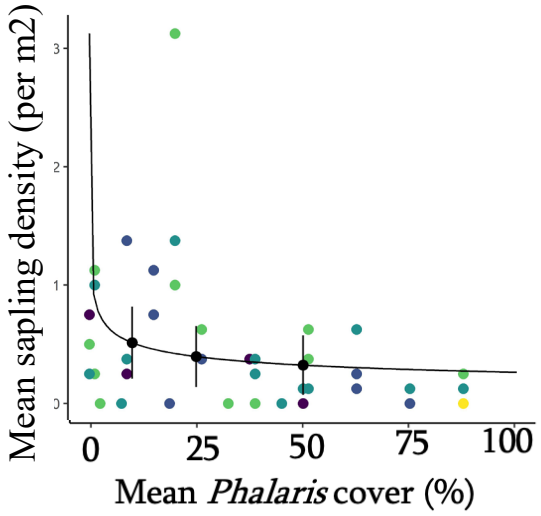
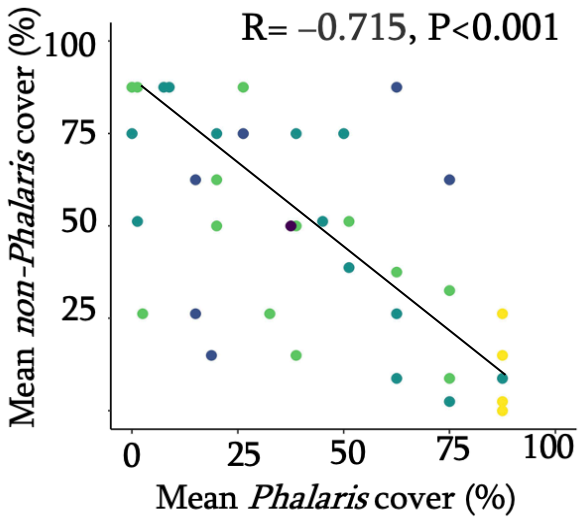
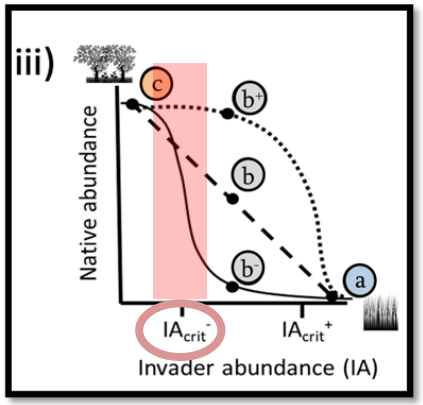
Phalaris cover negatively correlated with non-*Phalaris* cover and sapling densities.

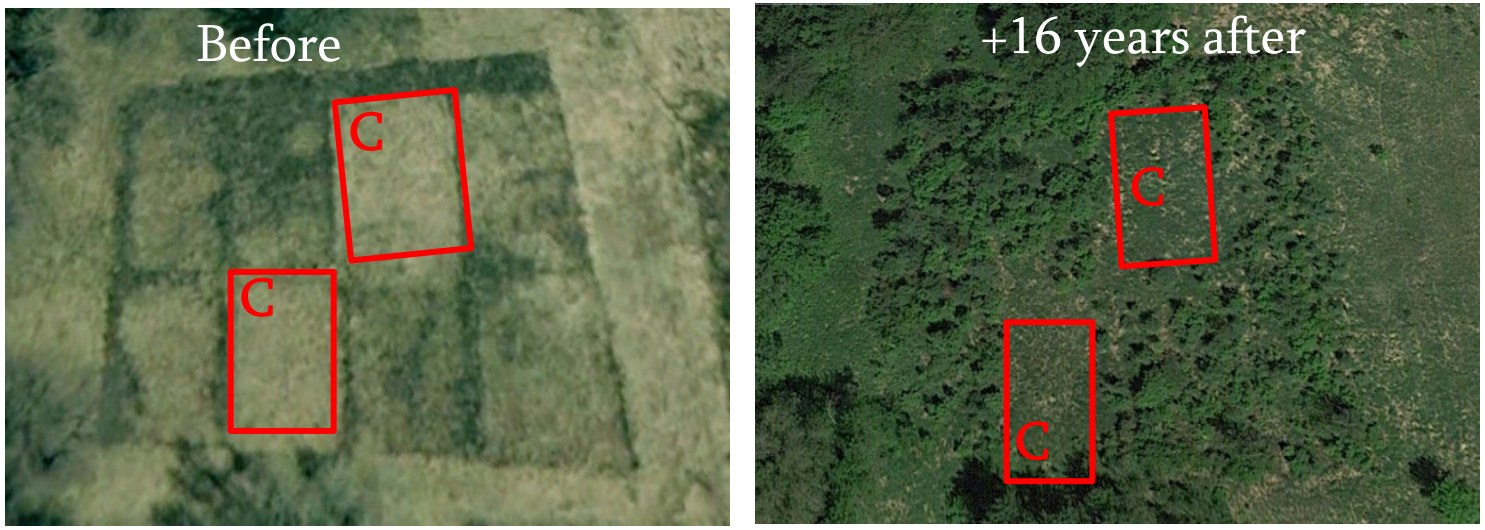






Palacio-Lopez et al. in press

Conclusions



- Establishing a dense canopy of woody species can enable ecosystem recovery, via re-establishment of pre-invasion feedbacks.
  - Late fall herbicide application suppressed *Phalaris* long enough that a dense canopy of native woody species could establish (see also Reinhardt Adams & Galatowitsch 2008).
  - Re-invasion by *Phalaris* in planted areas seems unlikely due to native species regeneration.
- Nonlinearities highlight the need to establish dense canopies and reduce *Phalaris* to low abundances (and probably also other invasive grasses in similar contexts)
- For similar restoration projects, we recommend planting the following species:
  Nannyberry, tamarack, aspen, American elm, Bebb's willow, elderberry, green/black ash.

Thank you!

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Questions?

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