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Local and Landscape Scale Factors Affecting Population Persistence of Rare Long-lived Species

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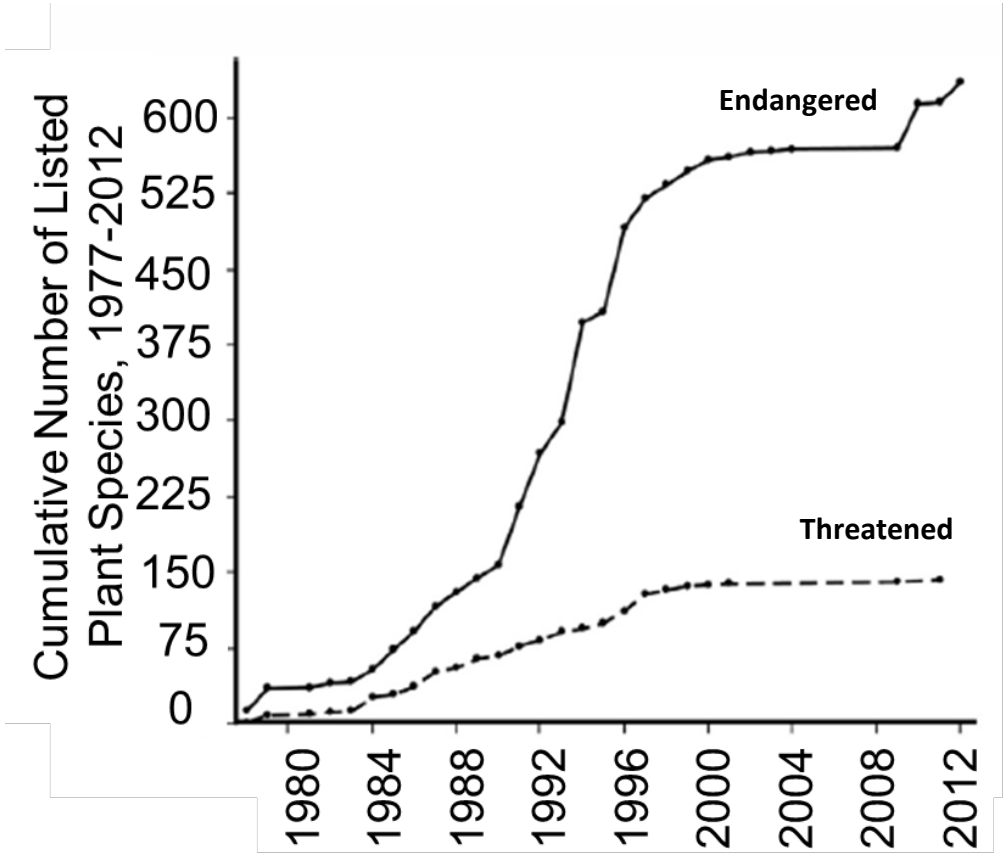
25 YEARS OF ESTCP

2019 | Enhancing DoD's Mission Effectiveness

Approved for public release; Distribution is unlimited

Expect more plant species to become listed as threatened and endangered

- Approximately 31% of the estimated 18,804 native plant species in the US may be at risk of extinction (Negron-Ortiz 2014)
- Recent “mega-petitions” for ESA listing



Negron-Ortiz 2014

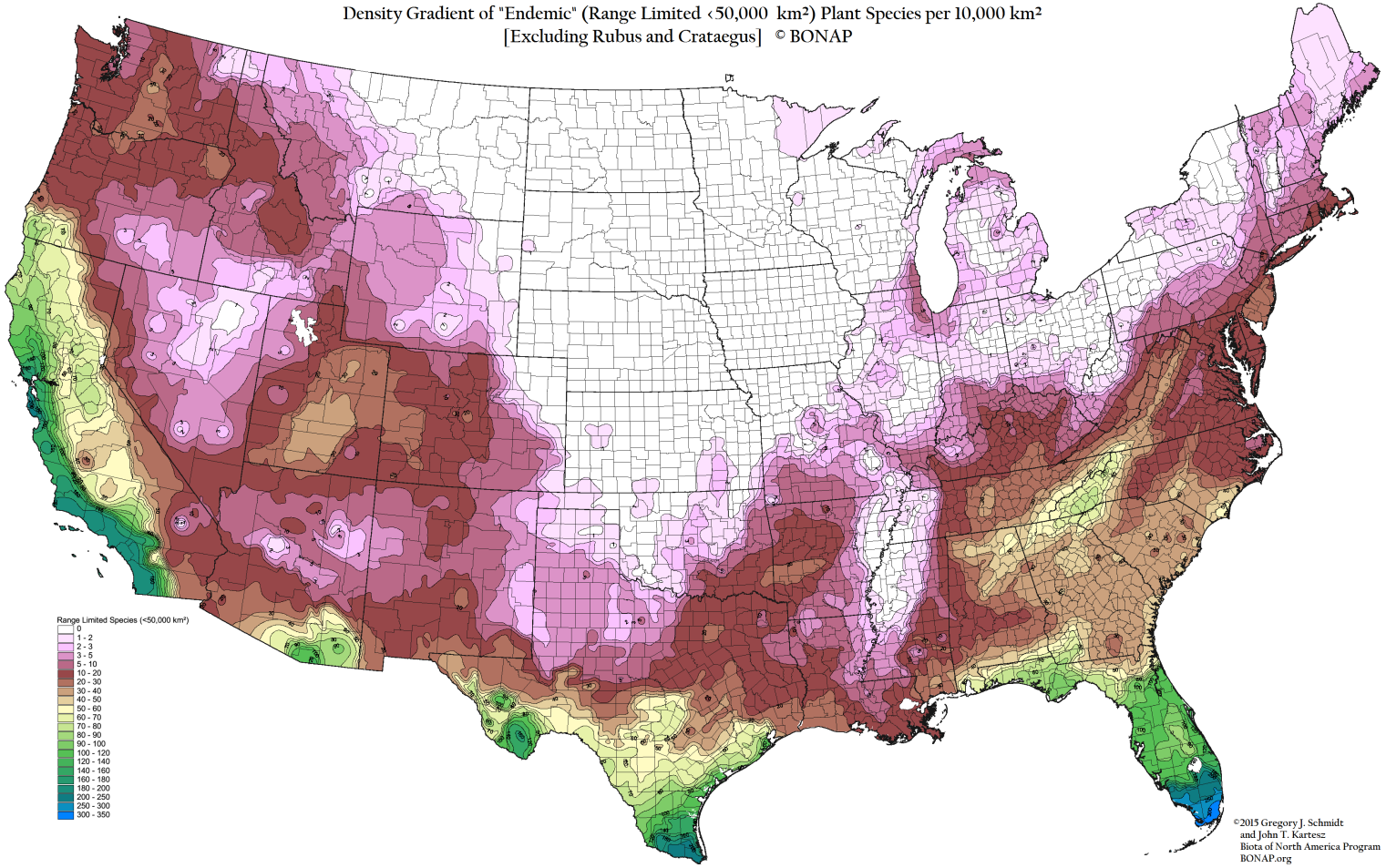
It is important to understand rare plants *before* they become federally protected

-May avert the need to list the species

-May be less costly in terms of future management

-Easier to deconflict training/management

-Prepared if listing occurs



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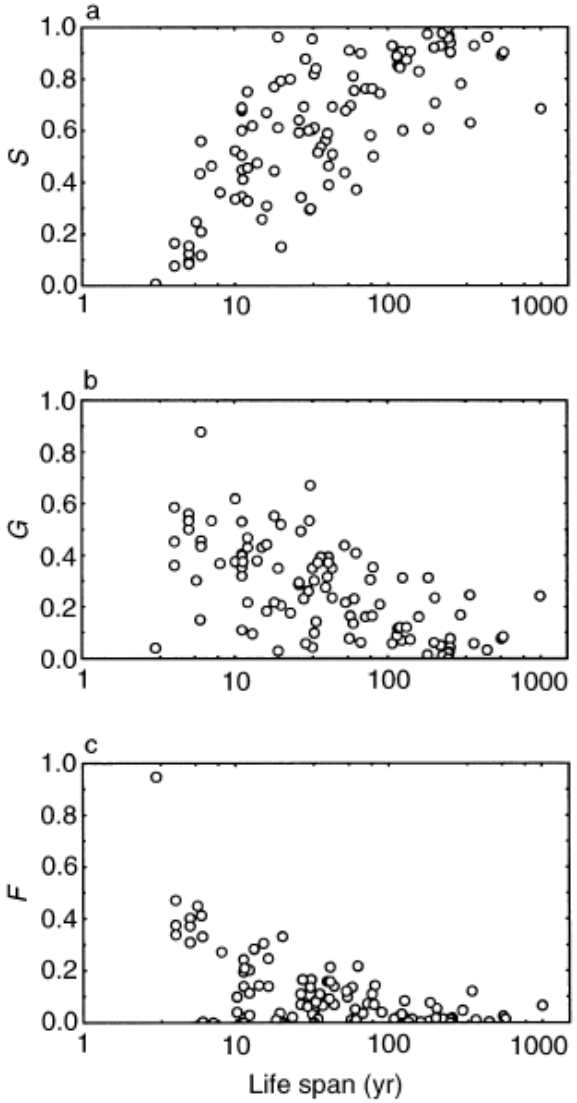
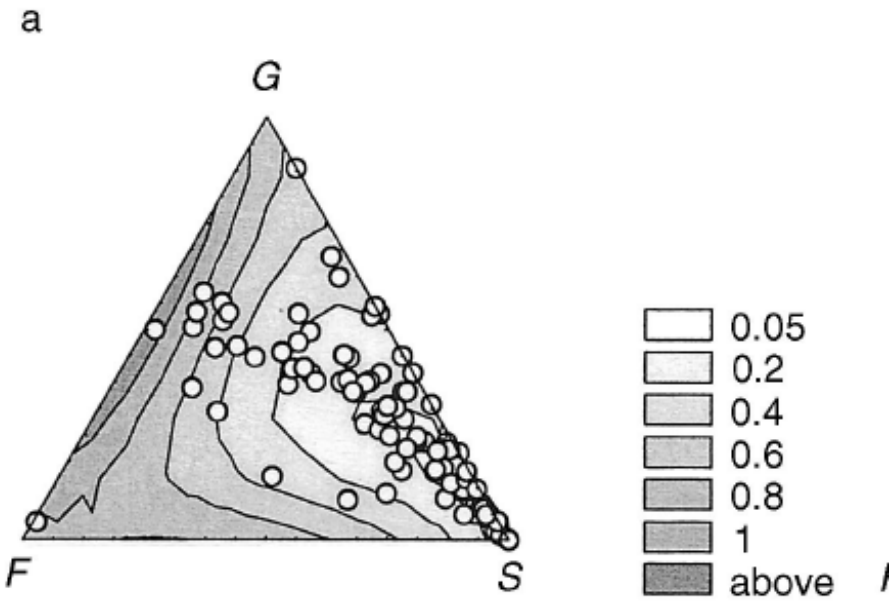
Population dynamics of long-lived plants

- Population growth rates log(λ) for most perennials ~ 0
- Negative relationship between life span and growth, fecundity
- Difficult to assess population trends in 4-5 years





Franco and Silvertown 2004

G growth
F fecundity
S survival

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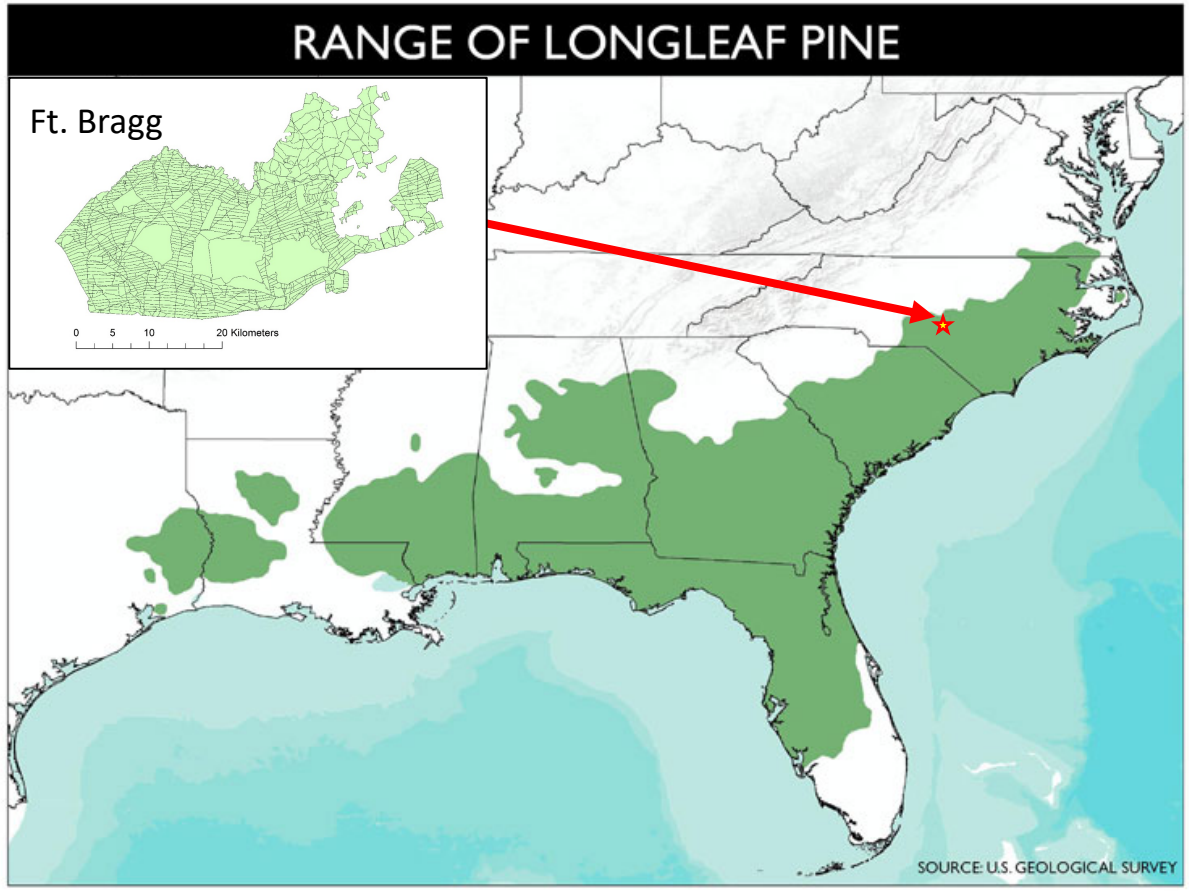
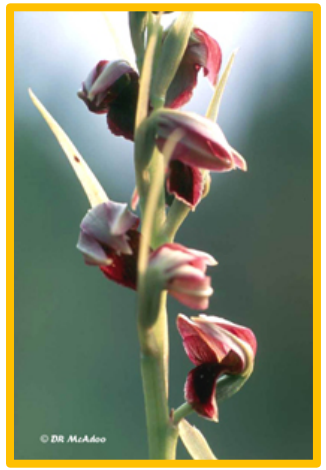
Study system

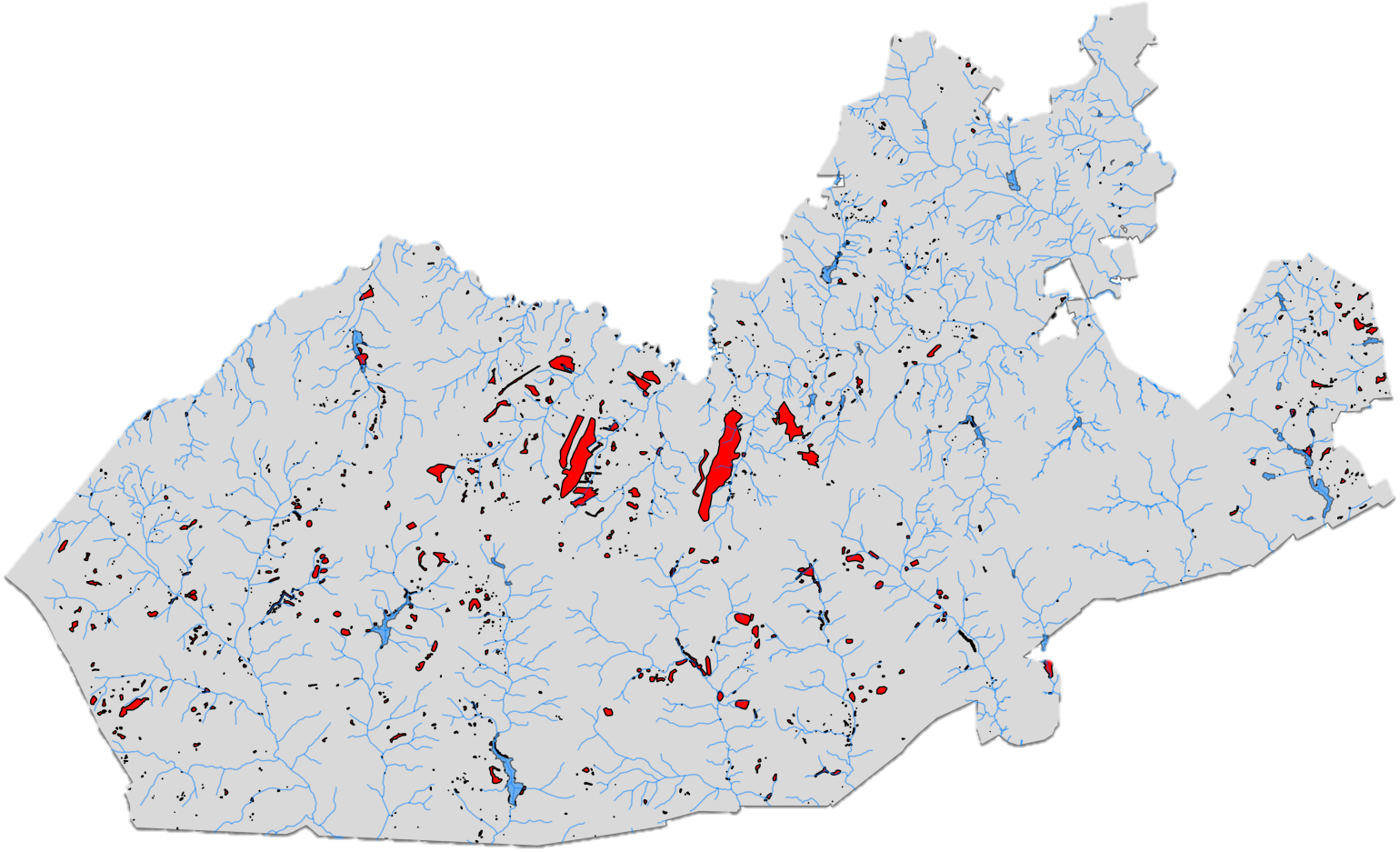


Listed and At-Risk Plant Species

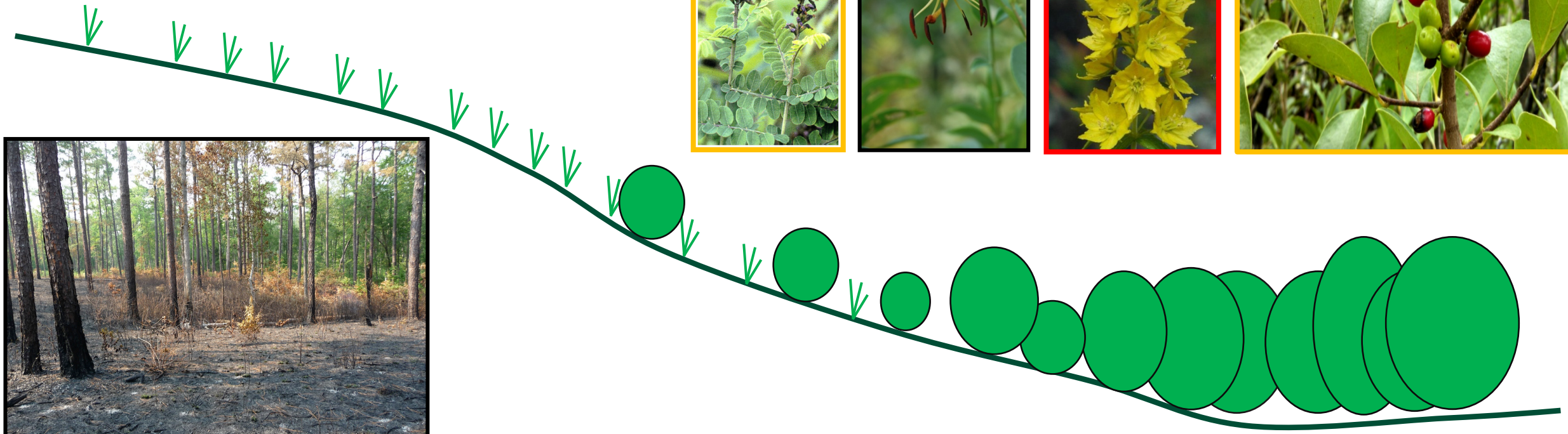


Fort Bragg long-term plant monitoring dataset

- More than 1,500 populations of 56 rare species
  - -3 Federally listed species
  - -6 under listing review
  - -15 Federal species of concern
  - -Remaining are on NC watch list
- Spans 23 years
- 4 surveys (1991,1999, 2006, 2014)



Many of the rare species are in a delicate balance



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Since 1991 great progress has been made to restore historic fire regimes and vegetation structure at Ft. Bragg

Effects of 22 years of habitat management?

Objectives

- What are the effects of fire return interval on the persistence of rare plant populations?
- What are the effects of canopy cover on the persistence of rare plant populations?
- What are the effects of metapopulation structure on the persistence of rare plant populations?
- What are the real-world ramifications of the results?

Mark-recapture approach to analyzing dataset

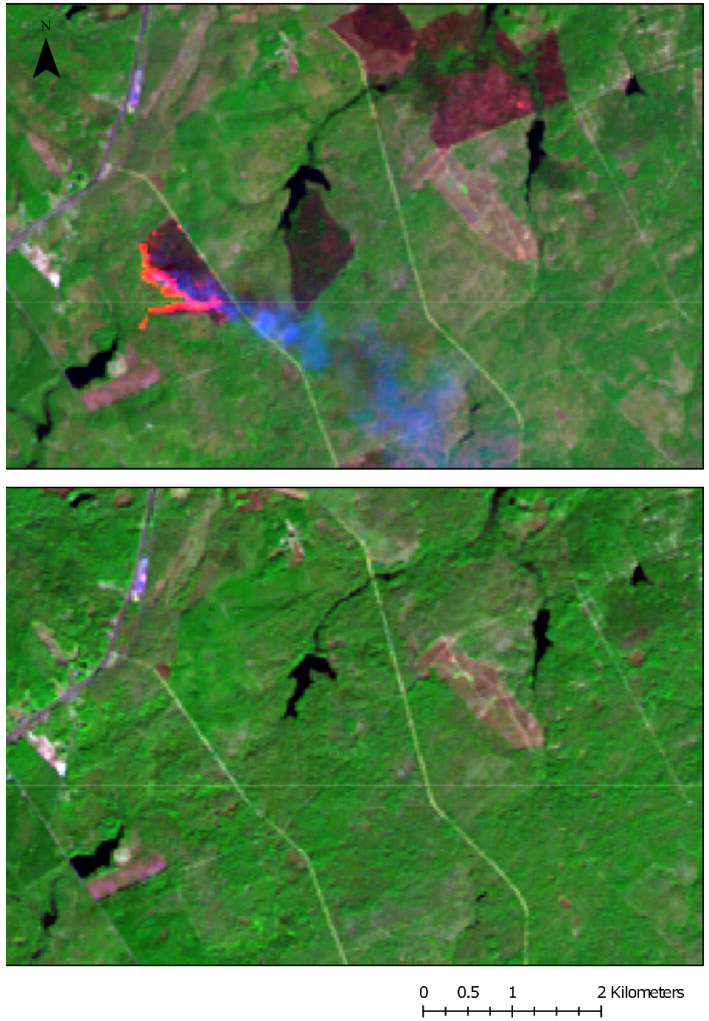
- Allows for estimating survivorship (ϕ) and detection (p) probabilities across time steps
- Dataset meets most assumptions
- Constructed increasingly complex models
- Validated with simulated datasets

$$1 \xrightarrow[p_1]{\phi_1} 0 \xrightarrow[p_2]{\phi_2} 1 \xrightarrow[p_3]{\phi_3} 1 \quad p_4$$

H	*P*(H)
111	$\phi_1 p_2 \phi_2 p_3$
110	$\phi_1 p_2 (1-\phi_2 p_3)$
101	$\phi_1 (1-p_2) \phi_2 p_3$
100	$(1-\phi_1) + \phi_1 (1-p_2)(1-\phi_2 p_3)$

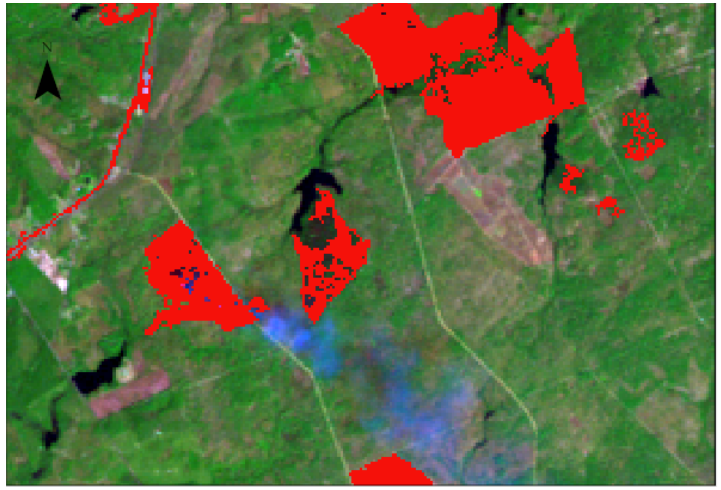
Methods: modeling fire using Landsat imagery

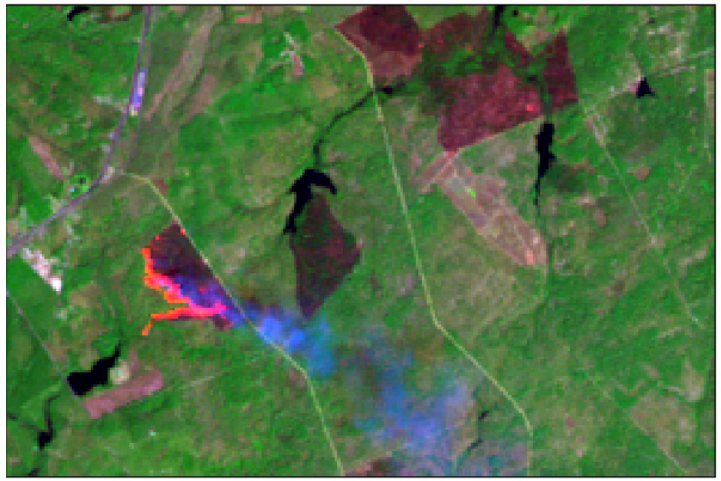
- Can be visualized using Landsat bands 7, 5, and 2
- Burn estimated using mid infrared burn index (MIRBI)
- Combined with imagery and predicted fires using Random Forest machine learning algorithm



Methods: modeling fire using Landsat imagery II

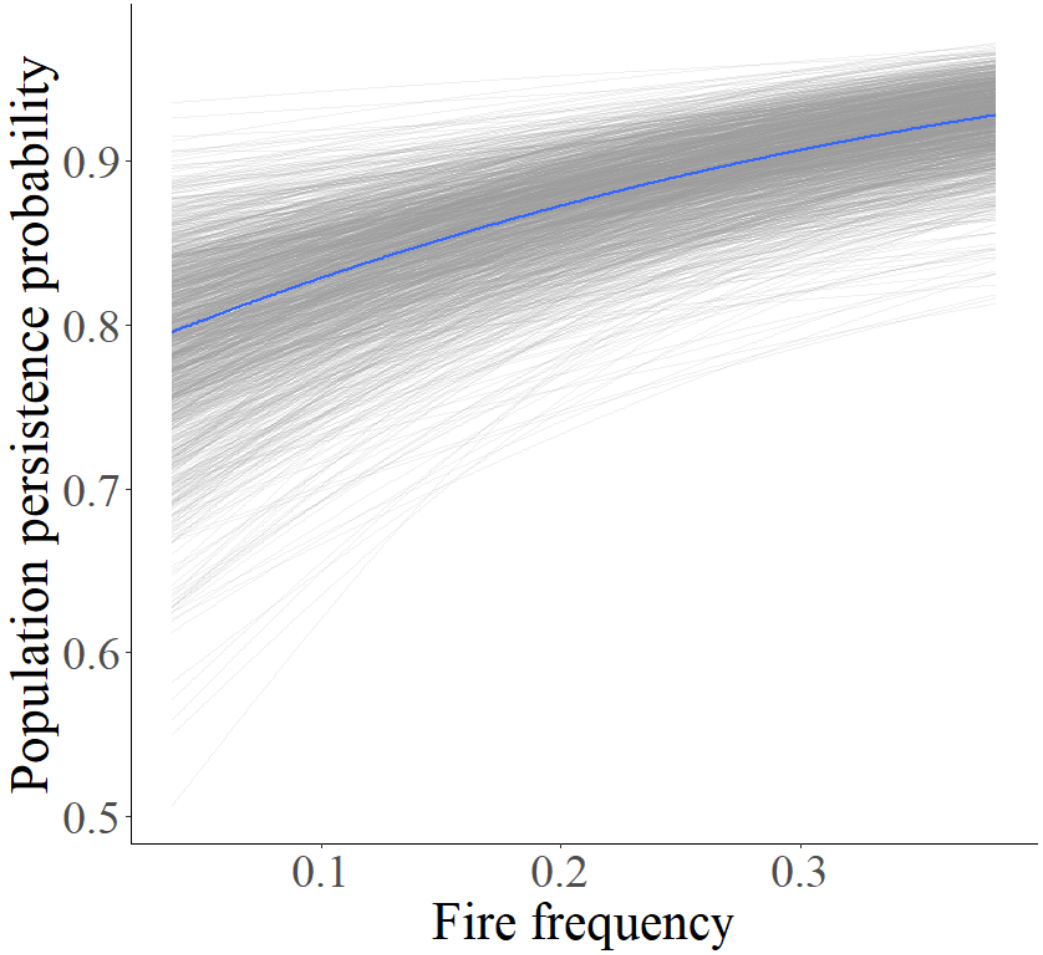
- Successfully identified burned areas
- Was able to differentiate unburned drainages from burned uplands
- Some problems with roads, but not always the case
- Burn “scars” persist across multiple time steps





0 0.5 1 2 Kilometers

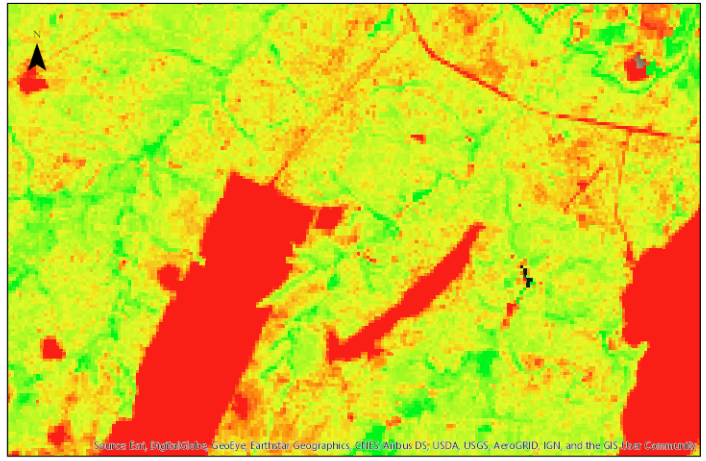
Frequent fire promotes persistence of rare populations



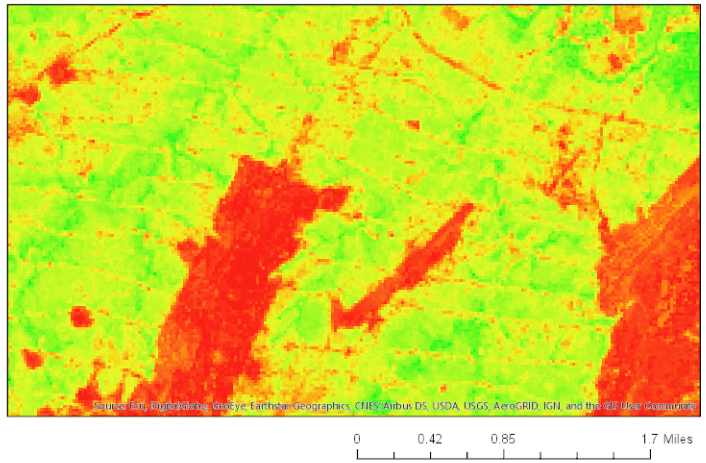
Methods: Modeling canopy cover using Landsat imagery

- Used LiDAR for canopy cover estimation and Landsat bands as predictor variables
- 1991-2014
- Random Forests
- Strong correlation between LiDAR (a) and model estimates (b)

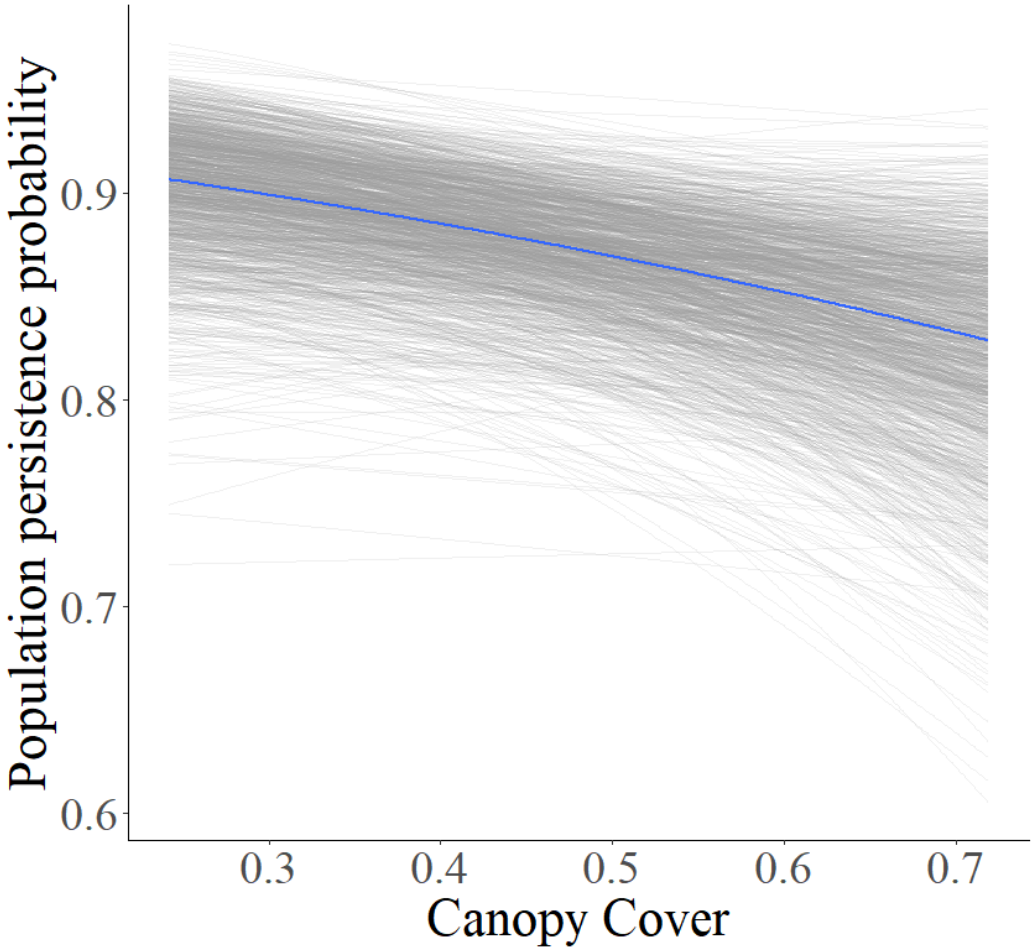
a)



b)



Tree cover has a negative impact on rare plants



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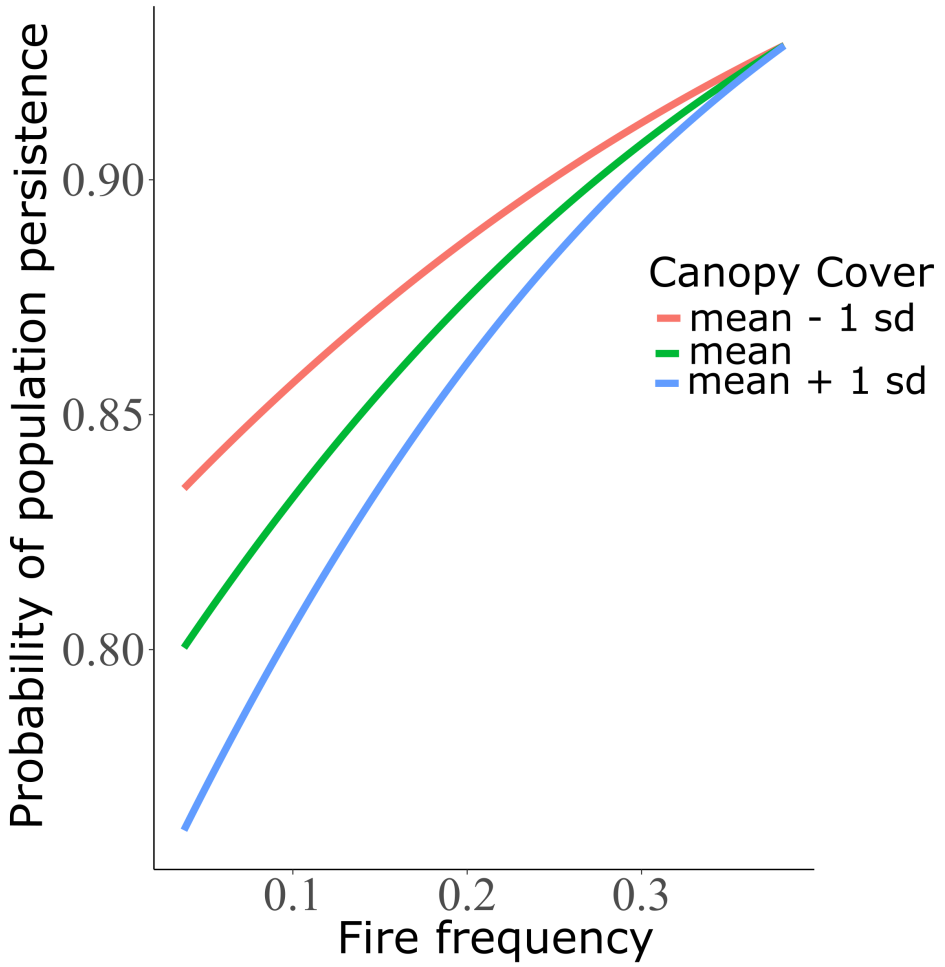
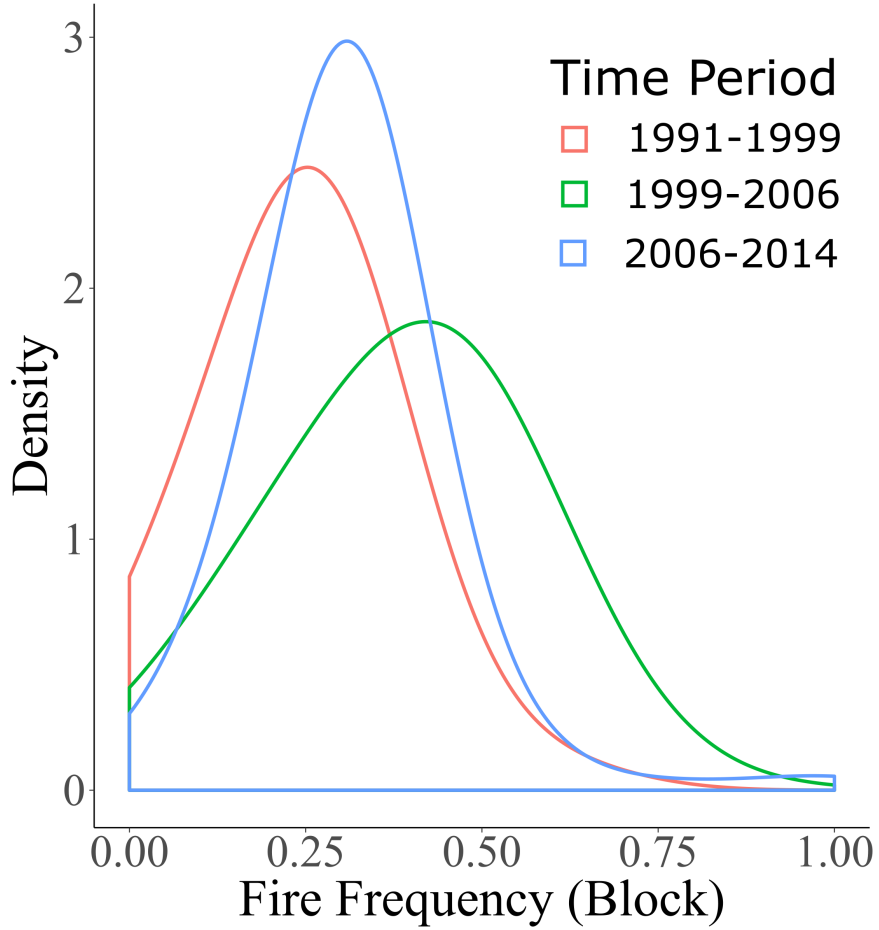
Frequent fire ameliorates effects of canopy cover

- As canopy cover increases, the negative effects of low fire frequency are magnified
- Higher fire frequency is necessary to maintain same probability of population persistence under higher canopy cover

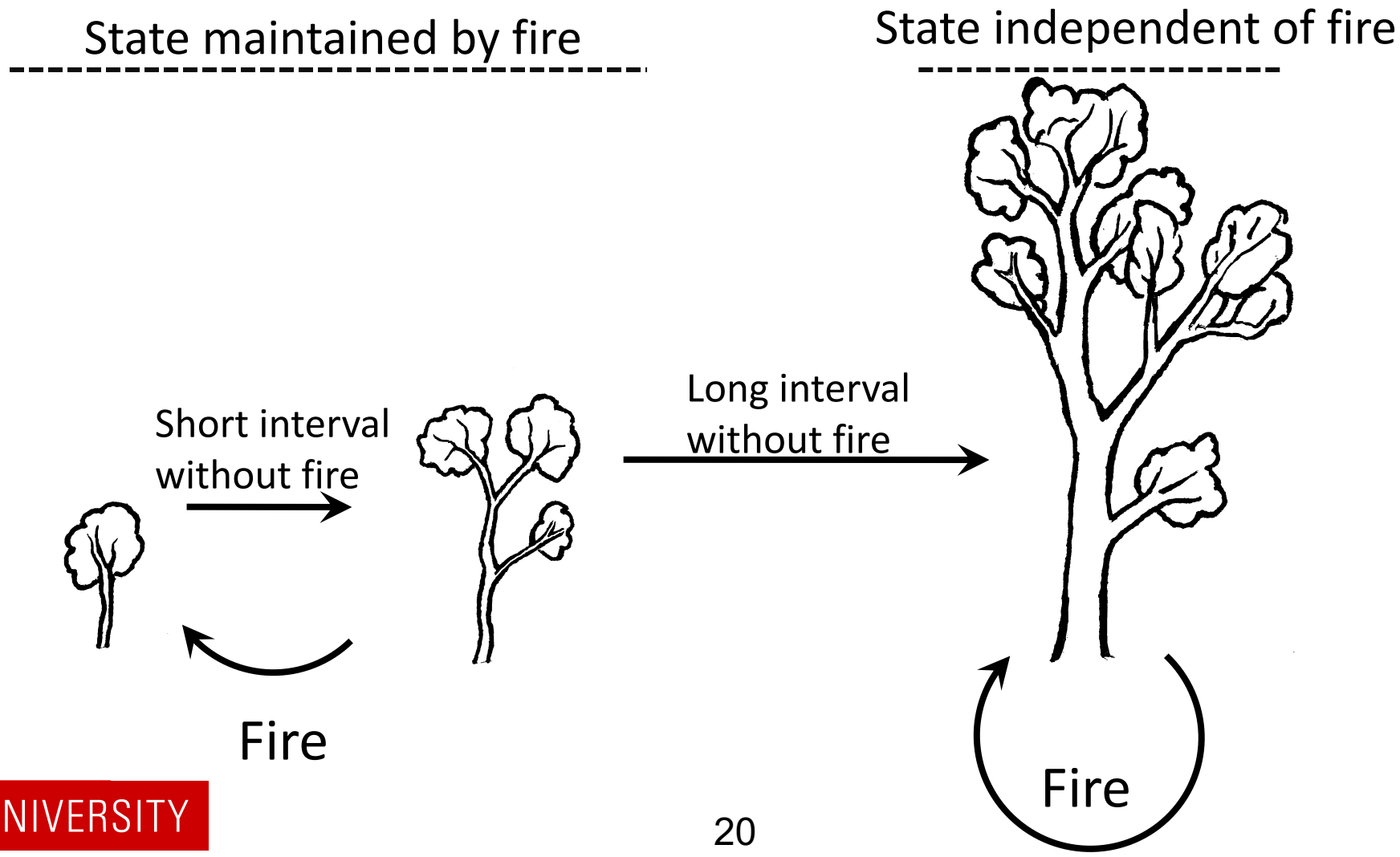


Fire frequency on Fort Bragg 1991-2014

- Fire frequency highest 1999-2006
- Has decreased since 2006

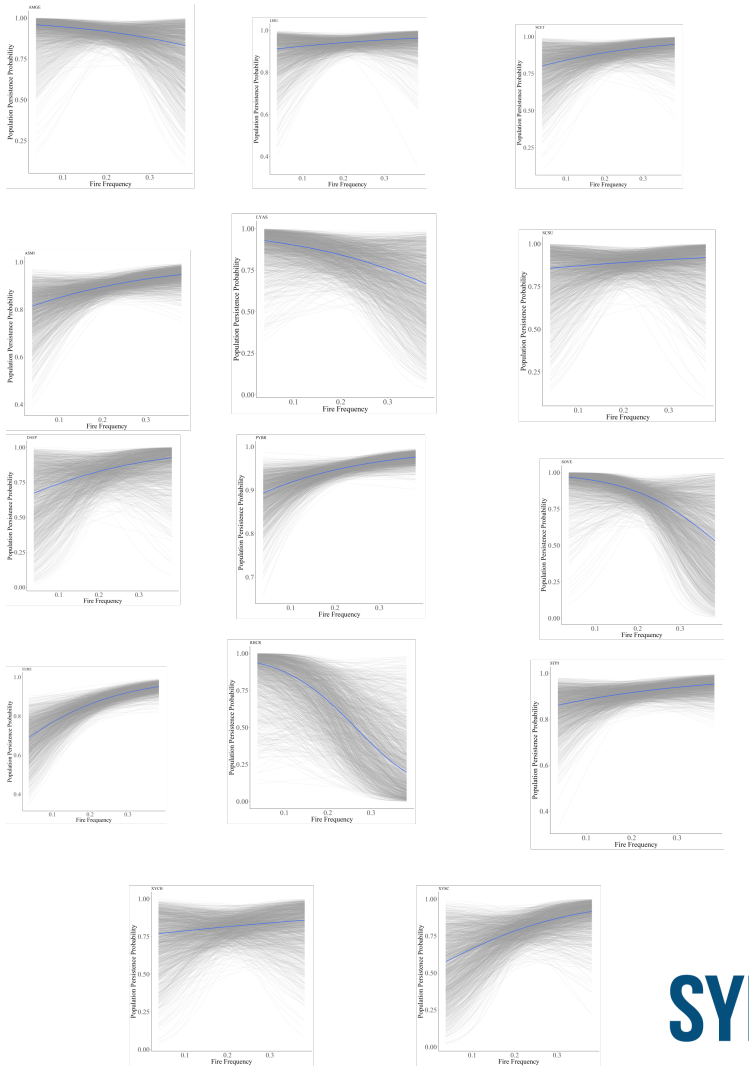


The “fire trap” and alternate stable states



Not all species respond the same to fire

- Variability in response
- Fire can have positive or negative effects on individual vital rates
- Decreased fire frequency can limit available management options



Differences in timing of reproduction

Astragalus michauxii

- Reproduces in summer
- Spring and summer burns cause reproduction failure
- Winter fire enhances reproduction

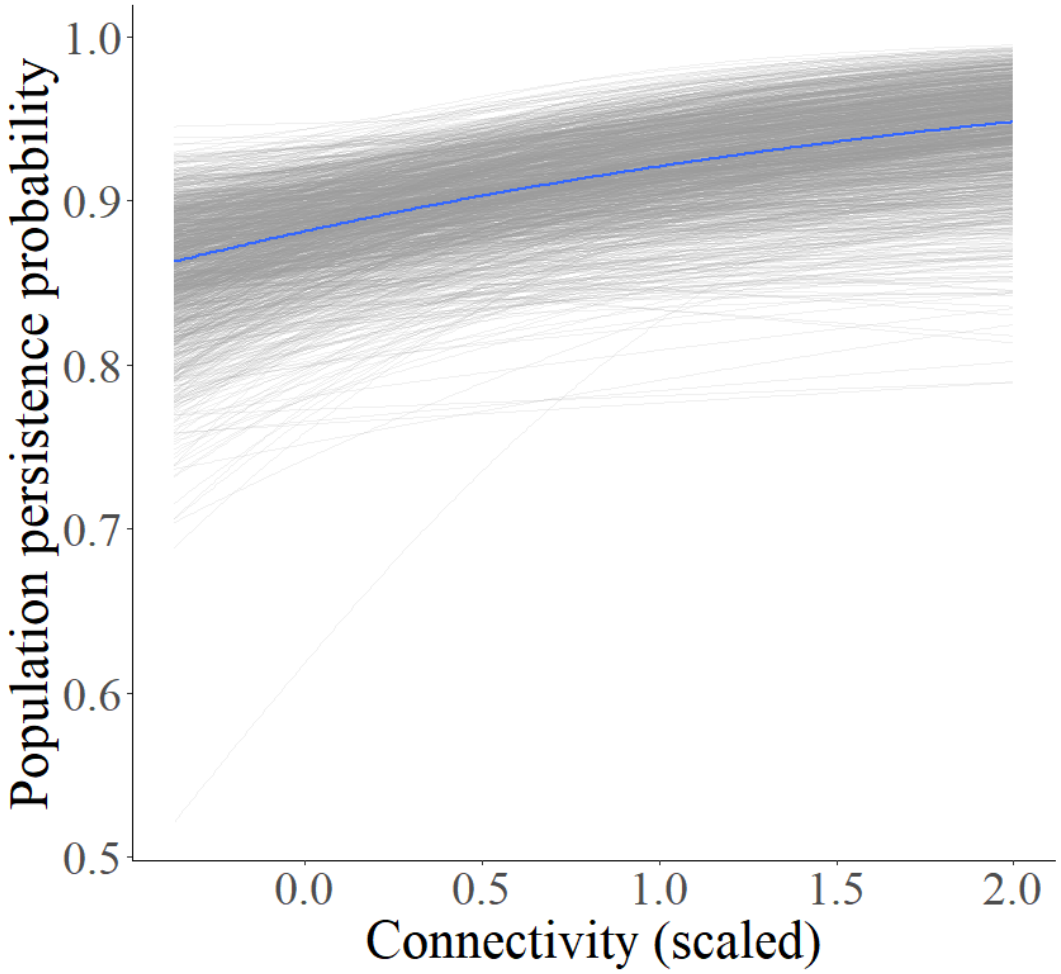
Pyxidanthera brevifolia

- Reproduces in winter
- Winter burns cause reproduction failure
- Seedlings vulnerable to fire for at least one year after germination

Wall, Hoffmann, Wentworth, Gray, Hohmann. 2012. *Plant Ecology* 213:1093-1104.

Spatial isolation correlated with population persistence

- Isolated populations have a lower probability of persistence
- Result of reduced fire frequency/ higher canopy cover?



(SERDP project RC-2707)

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Management Implications

- Maintaining an active fire program is likely the most effective method for managing rare species on Fort Bragg and other SE installations
- Decreased fire frequency has cascading effects such as increased canopy cover and spatial isolation
- But, if you can successfully propagate and outplant new individuals, you might be able to make up for decades of decline

Final Remarks

- It is difficult to detect population decline in long-lived plants
- Current management of fire and vegetation has been effective in slowing the loss of rare plant populations
- More nuanced management will probably be necessary to ensure persistence of many rare species, and detailed understanding of species' biology is necessary to inform this management

Funding

SERDP project RC-2707

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