

## *SERDP & ESTCP Webinar Series*

*Thank you for signing in early*

The webinar will begin promptly at  
12:00 pm ET, 9:00 am PT



# SERDP and ESTCP Webinar Series

***The webinar will begin promptly at 12:00 pm ET,  
9:00 am PT***

- You have two options for accessing the webinar
  1. Listen to the broadcast audio if your computer is equipped with speakers
  2. Call into the conference line: 303-248-0285  
Required conference ID: 6102000
- For any question or issues, please email [serdp-estcp@noblis.org](mailto:serdp-estcp@noblis.org) or call 571-372-6565

## *SERDP & ESTCP Webinar Series*

# Informing Restoration Programs for Threatened and Endangered Plant Species

September 6, 2018



# *SERDP & ESTCP Webinar Series*

## Welcome and Introductions

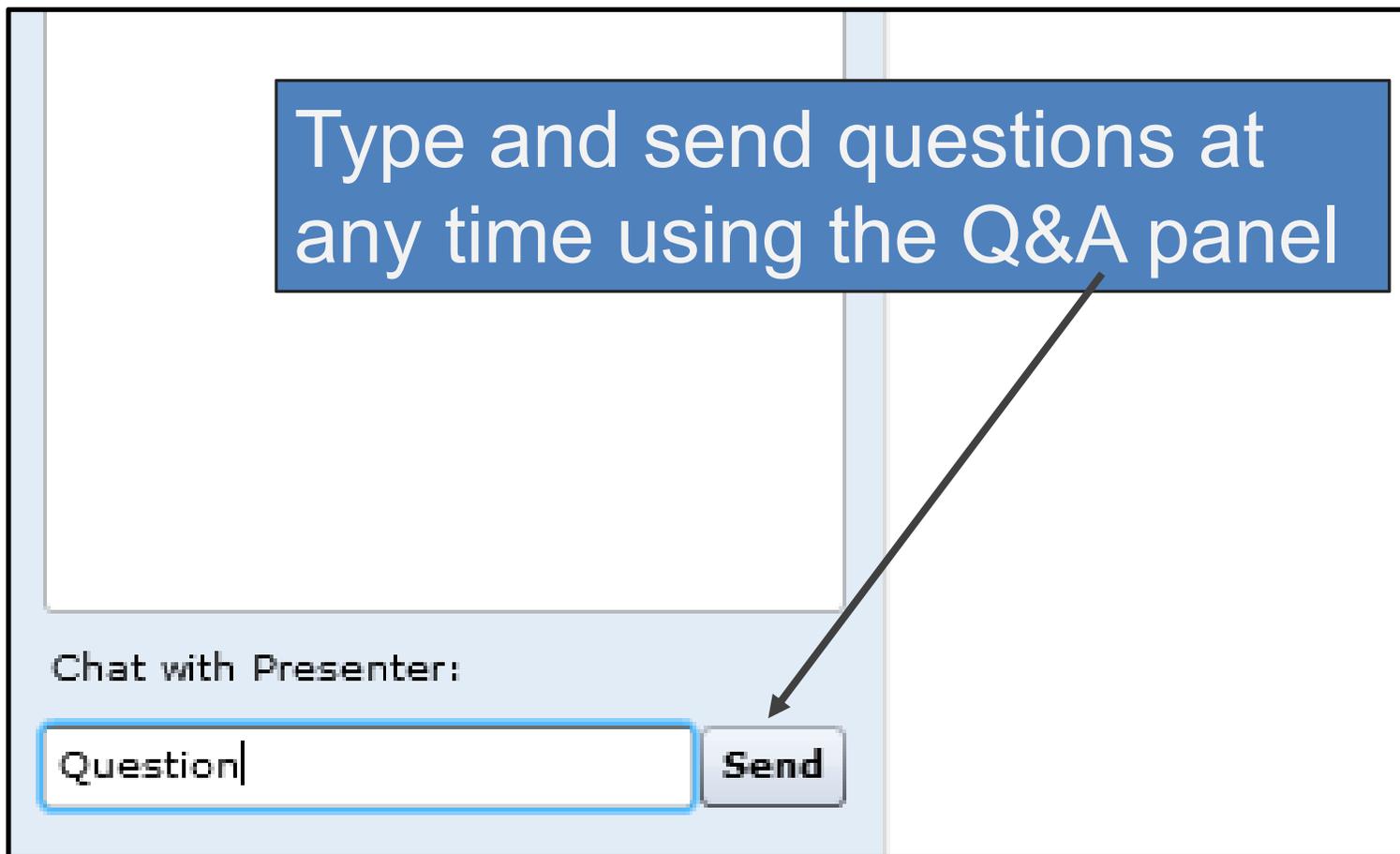
Rula A. Deeb, Ph.D.  
Webinar Coordinator



# Webinar Agenda

- **Webinar Logistics** (5 minutes)  
**Dr. Rula Deeb**, Geosyntec Consultants
- **Overview of SERDP and ESTCP** (5 minutes)  
**Dr. Kurt Preston**, SERDP and ESTCP
- **Habitat Suitability Modeling for Restoration and Reintroduction** (25 minutes + Q&A)  
**Dr. Erin Questad**, California State Polytechnic University, Pomona
- **Operational-Scale Propagation and Reintroduction of Five Endangered and At-Risk Plants** (25 minutes + Q&A)  
**Mr. Matthew Hohmann**, U.S. Army Engineer Research and Development Center
- **Final Q&A session**

# How to Ask Questions



# In Case of Technical Difficulties

- Delays in the broadcast audio
  - Click the mute/connect button
  - Wait 3-5 seconds
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  - If delays continue, call into the conference line
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    - Required conference ID: 6102000
- Submit a question using the chat box

# SERDP and ESTCP Overview

Kurt Preston, Ph.D.  
Resource Conservation and  
Resiliency Program Manager



# SERDP

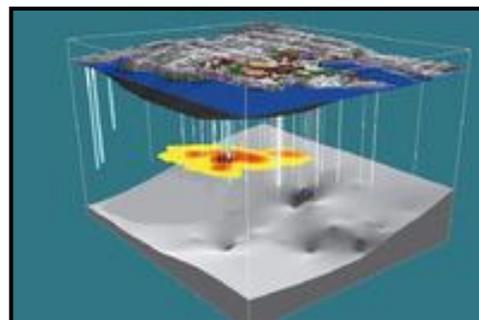
- Strategic Environmental Research and Development Program
- Established by Congress in FY 1991
  - DoD, DOE and EPA partnership
- SERDP is a requirements driven program which identifies high-priority environmental science and technology investment opportunities that address DoD requirements
  - Advanced technology development to address near term needs
  - Fundamental research to impact real world environmental management

# ESTCP

- Environmental Security Technology Certification Program
- Demonstrate innovative cost-effective environmental and energy technologies
  - Capitalize on past investments
  - Transition technology out of the lab
- Promote implementation
  - Facilitate regulatory acceptance

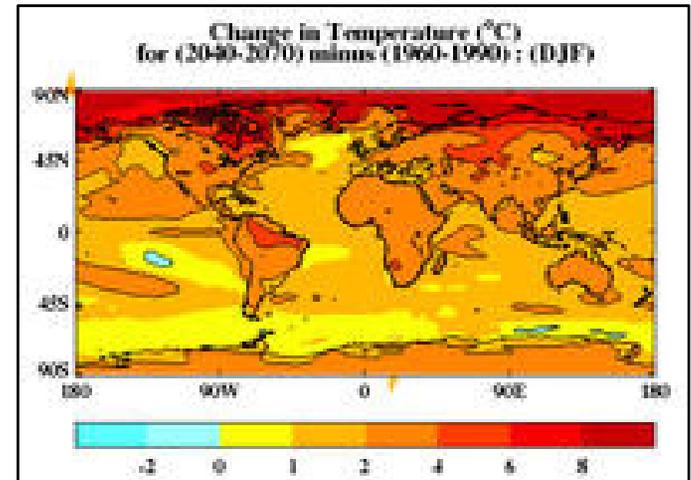
# Program Areas

1. Environmental Restoration
2. Installation Energy and Water
3. Munitions Response
4. Resource Conservation and Resiliency
5. Weapons Systems and Platforms



# Resource Conservation and Resiliency

- **Natural resources**
  - Ecological forestry
  - Arid lands ecology and management
  - Cold regions ecology and management
  - Pacific island ecology and management
  - Coastal and estuarine ecology and management
  - Living marine resources ecology and management
  - Species ecology and management
  - Watershed processes and management
- **Resilience**
  - Vulnerability and impact assessment
  - Adaptation science
  - Land use and carbon management
- **Air quality**
  - Wildland fire dynamics
  - Fugitive dust



# SERDP and ESTCP Webinar Series

Date	Topic
September 20, 2018	Plant Diversity and Biological Nitrogen Fixation in Longleaf Pine Ecosystems at Military Installations
October 4, 2018	Chlorinated Solvents Workshop Overview and Feature Projects
October 18, 2018	Restoration of Chlorinated Solvent Contaminated Groundwater Sites: The Value of Information Challenge
November 1, 2018	Supporting DoD Installation Sustainability Through Informed Stormwater Management
November 15, 2018	Stormwater Impacts on Sediment Recontamination
December 13, 2018	Installation Energy and Water Program Area Webinar

## *SERDP & ESTCP Webinar Series*

**For upcoming webinars, please visit**

<http://serdp-estcp.org/Tools-and-Training/Webinar-Series>



# Save the Date!

SERDP • ESTCP  
**SYMPOSIUM**  
2018 | Enhancing DoD's Mission Effectiveness

A three-day symposium showcasing the latest technologies that enhance DoD's mission through improved environmental and energy performance

November 27-29, 2018  
Washington Hilton Hotel

***Registration is open***

# Habitat Suitability Modeling for Restoration and Reintroduction

Erin Questad, Ph.D.  
California State Polytechnic  
University, Pomona



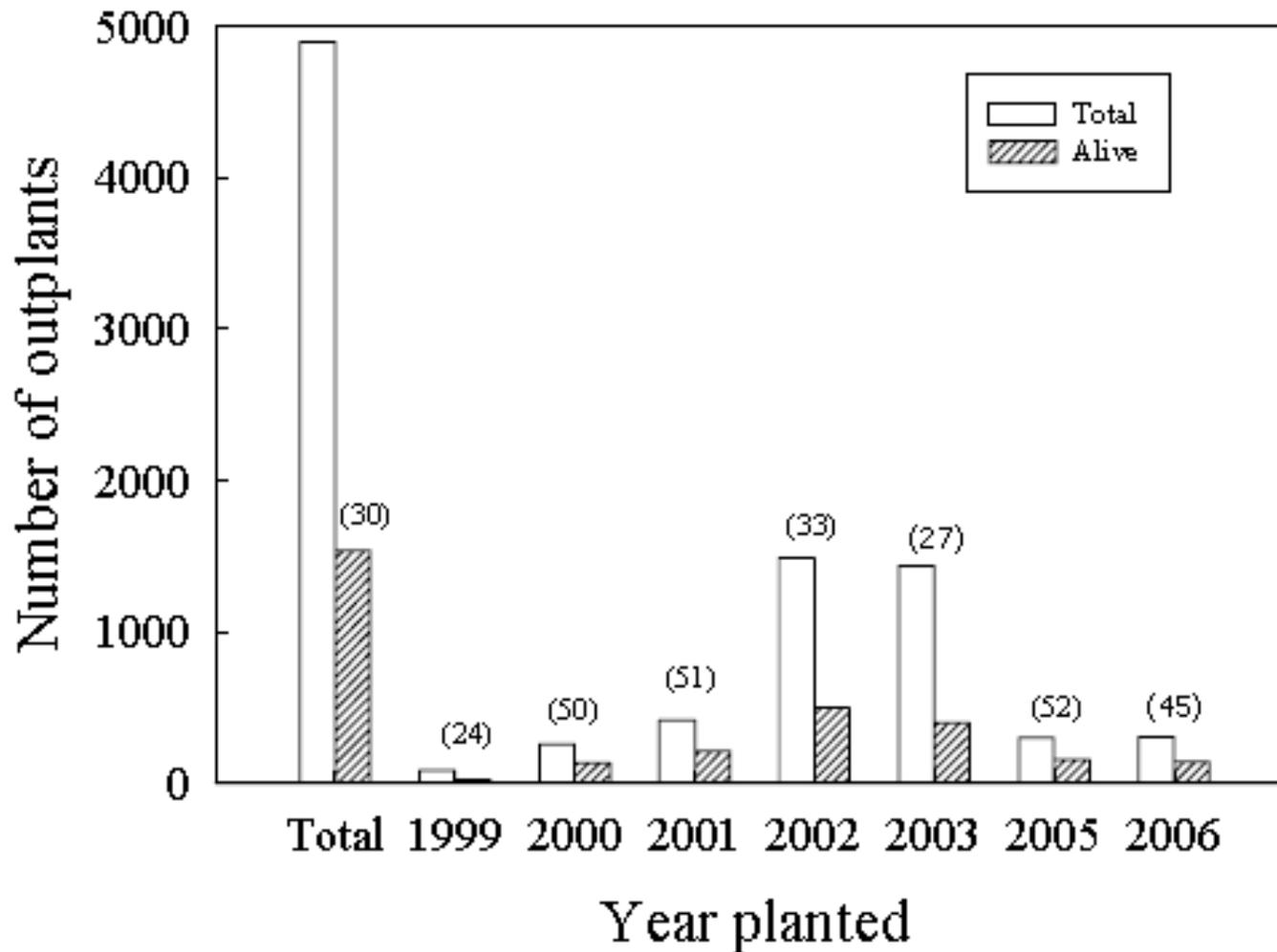
# Agenda

- Challenges to the recovery of threatened species
- Habitat suitability model
- Project results



# Challenges to Recovery

*Survival is low and variable*



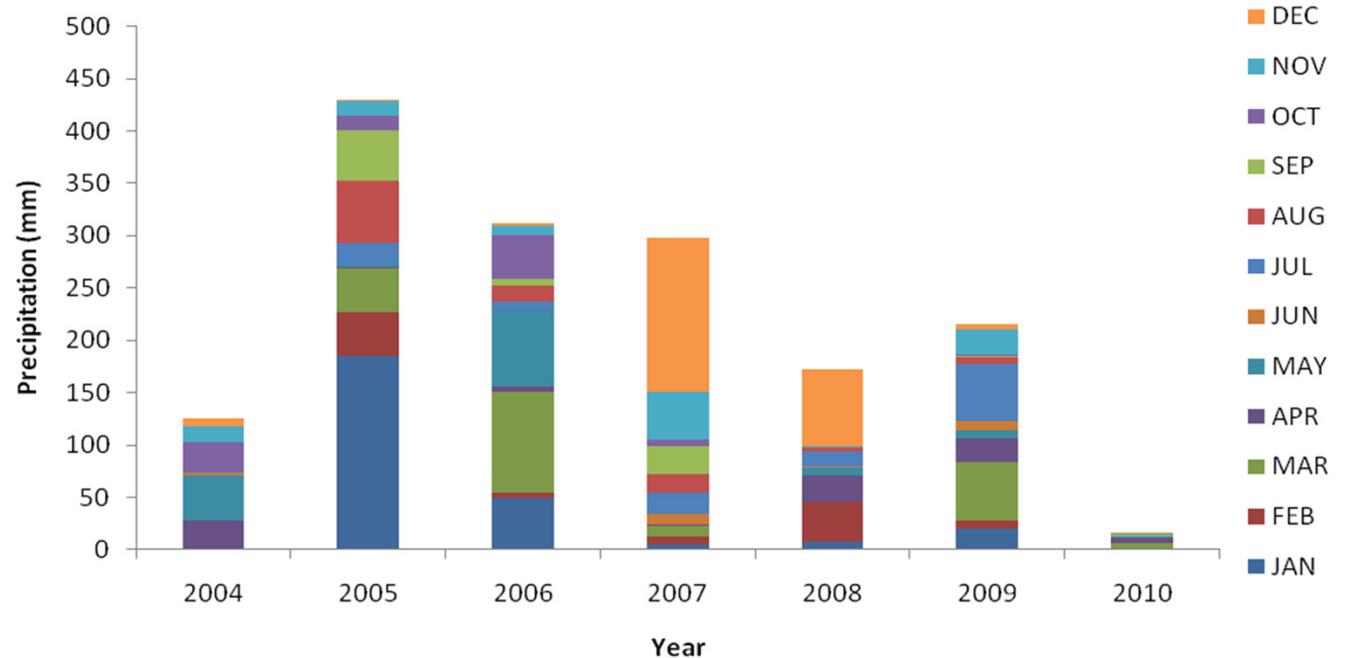
# Challenges to Recovery

## *Extreme environmental conditions*

### Pohakuloa Training Area (PTA)

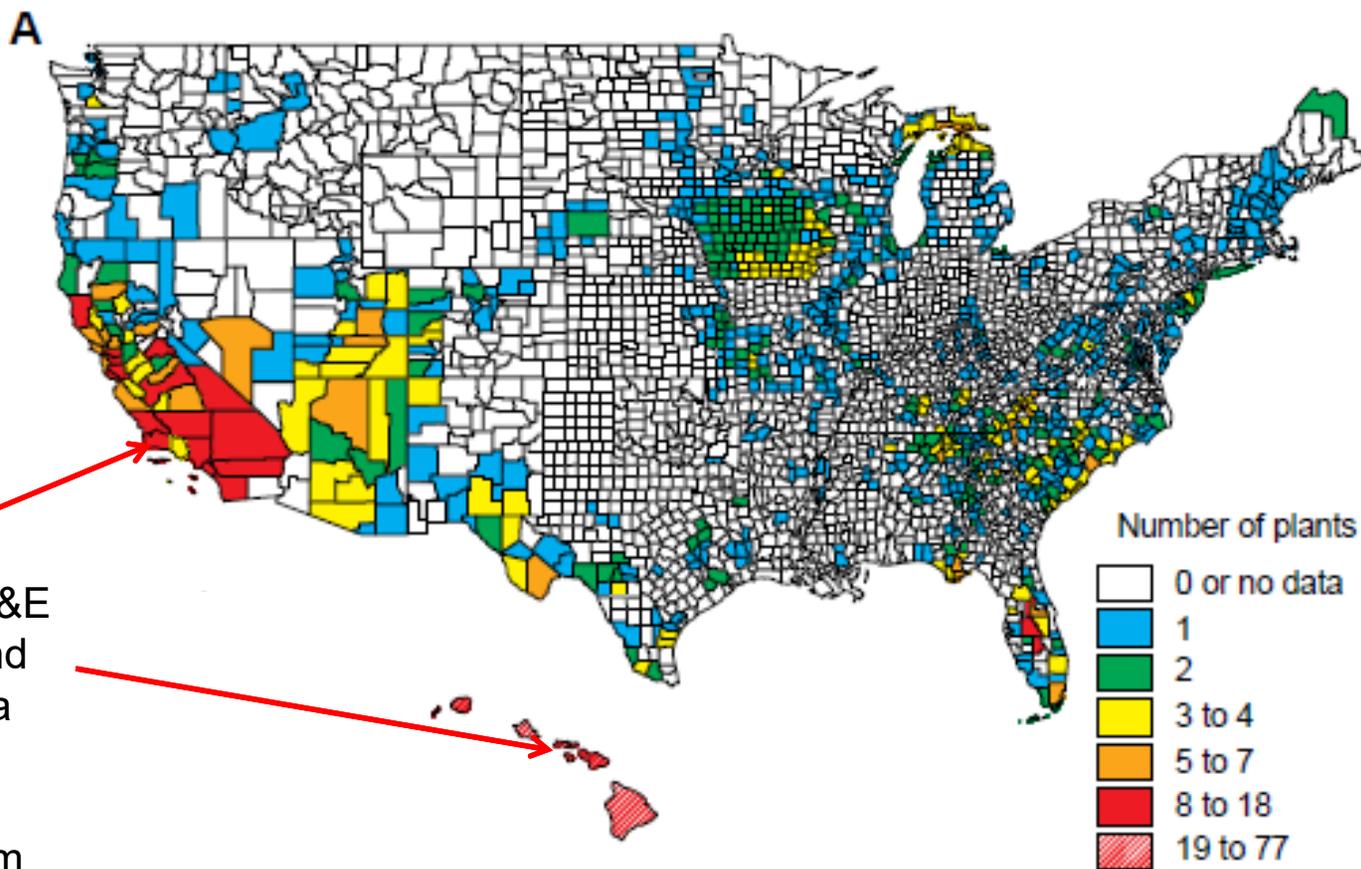
- Mean annual precipitation < 500 mm (19.7")
- Diurnal temperature variation
- Windy
- Wildfires

PTA Range 17 Annual Precipitation



# Challenges to Recovery

## *Seedling desiccation stress*



7 of top 10 DoD installations with T&E plants in Hawaii and Southern California

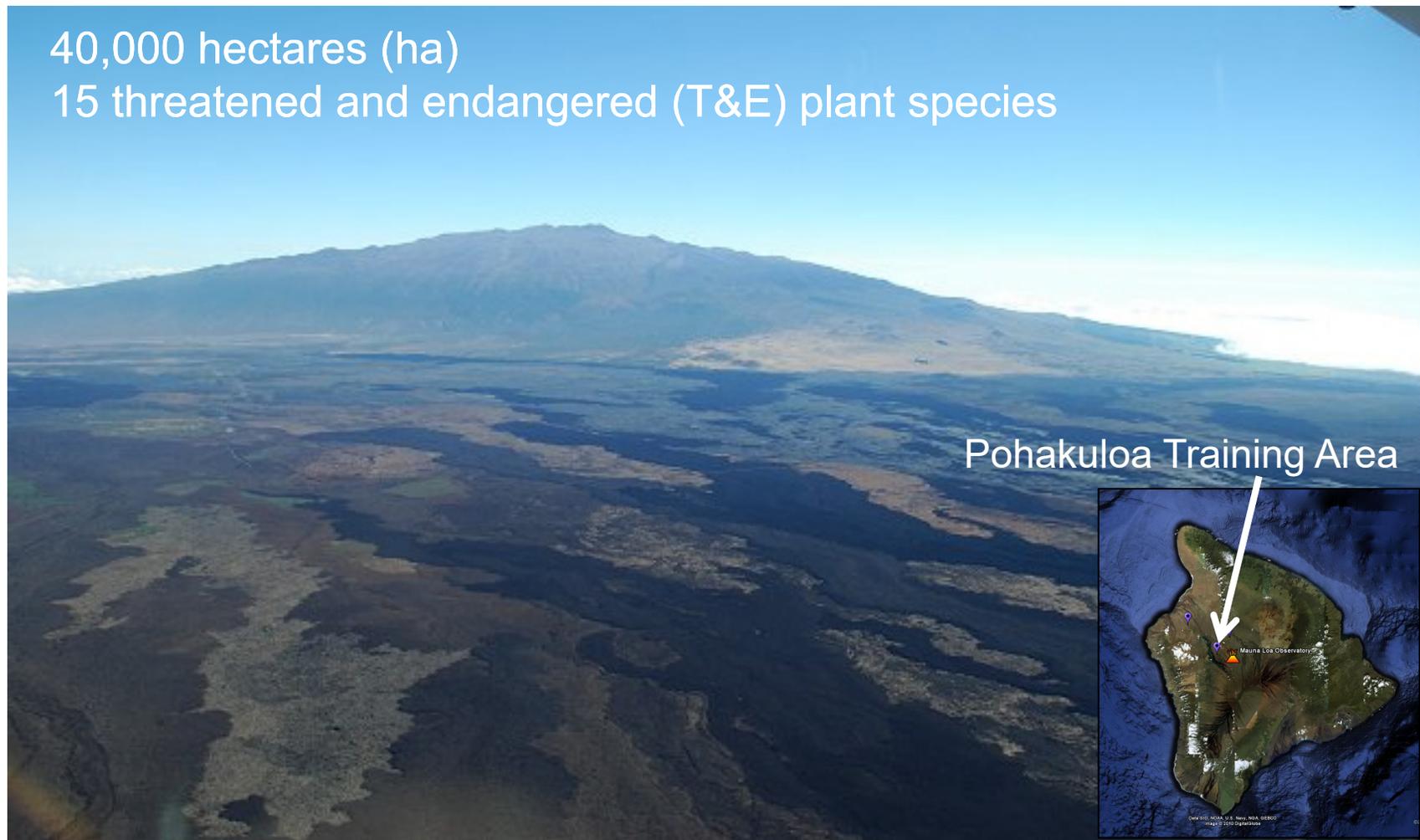
Average annual rainfall 302-762 mm

# Challenges to Recovery

*Large areas with limited access*

40,000 hectares (ha)

15 threatened and endangered (T&E) plant species



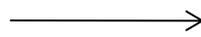
# Challenges to Recovery

*Labor intensive, expensive management plans*

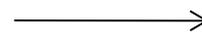
- Approach
  - Reintroduce plants to the highest quality habitats where survival will be highest
  - Identify high quality habitats for restoration with remote sensing

# Habitat Suitability Model

LiDAR



Digital  
Elevation Model



Habitat  
Suitability Model

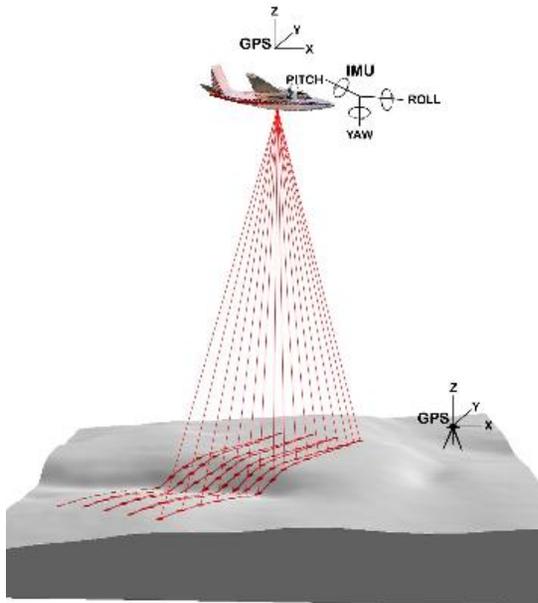
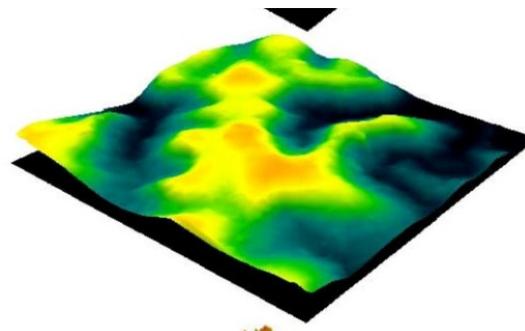
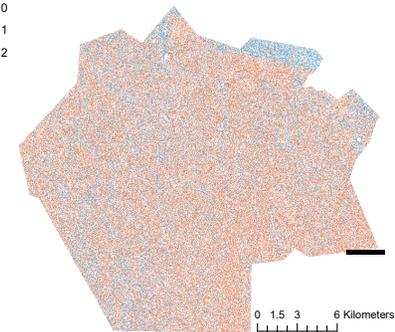


Image from <http://forsys.cfr.washington.edu/>

Pixel size = 2.2 m

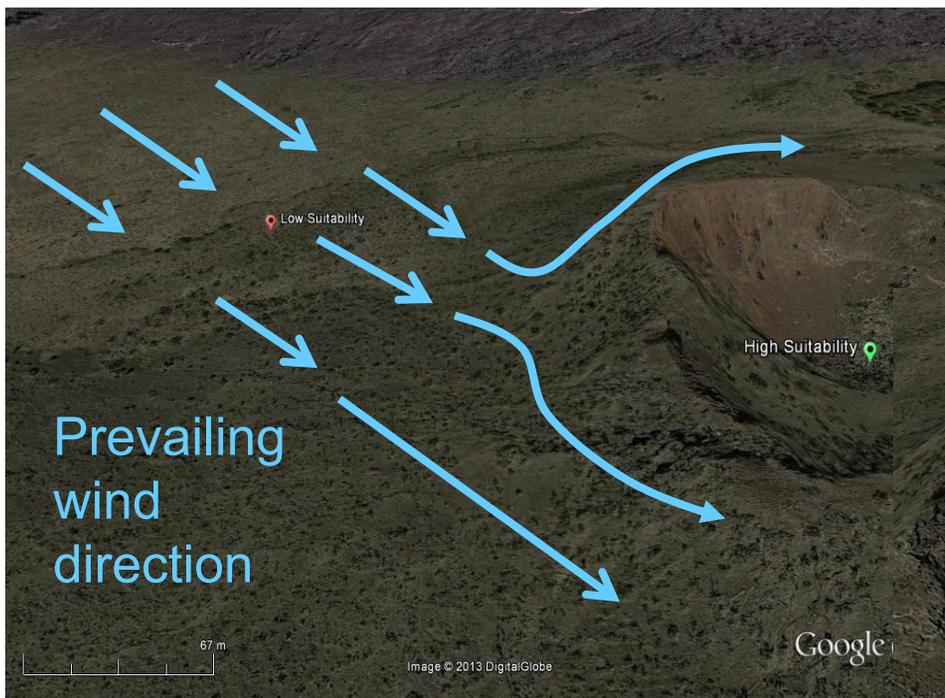


Habitat Suitability Pixel Value

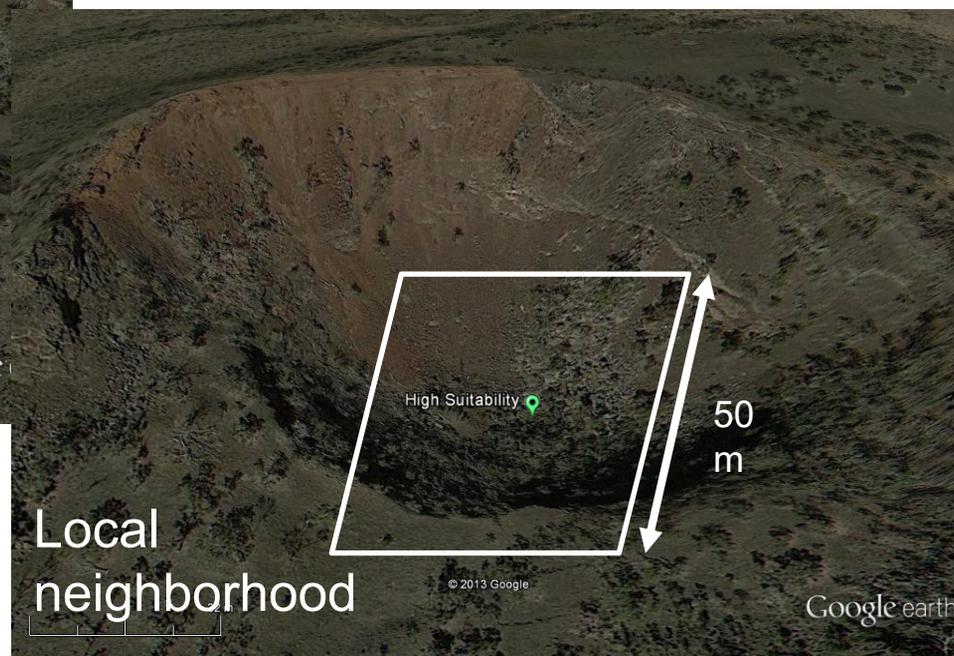


# Habitat Suitability Model

## Leeward criteria variable

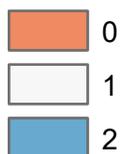


## Descending topography criteria variable

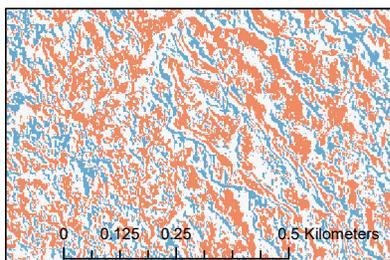
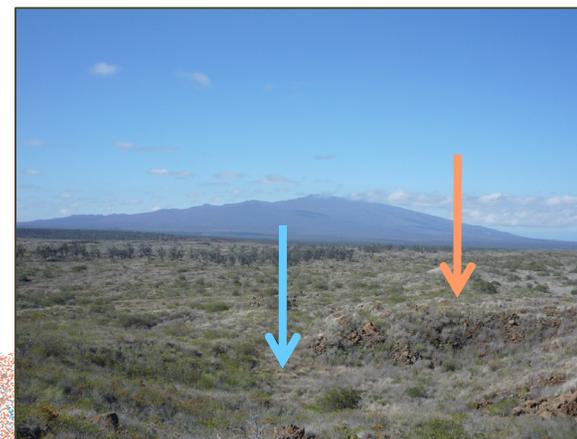
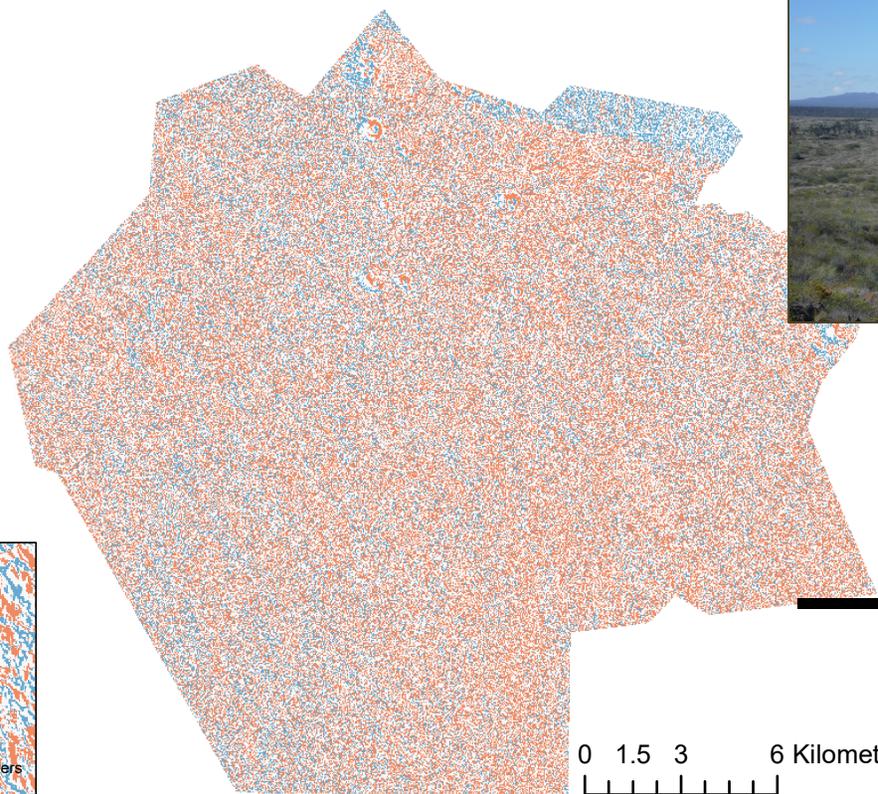
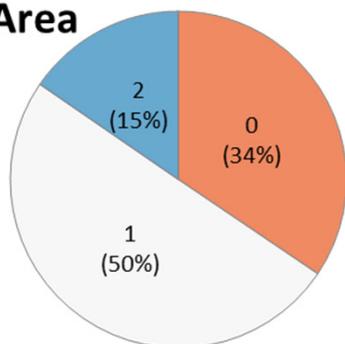


# Habitat Suitability Model

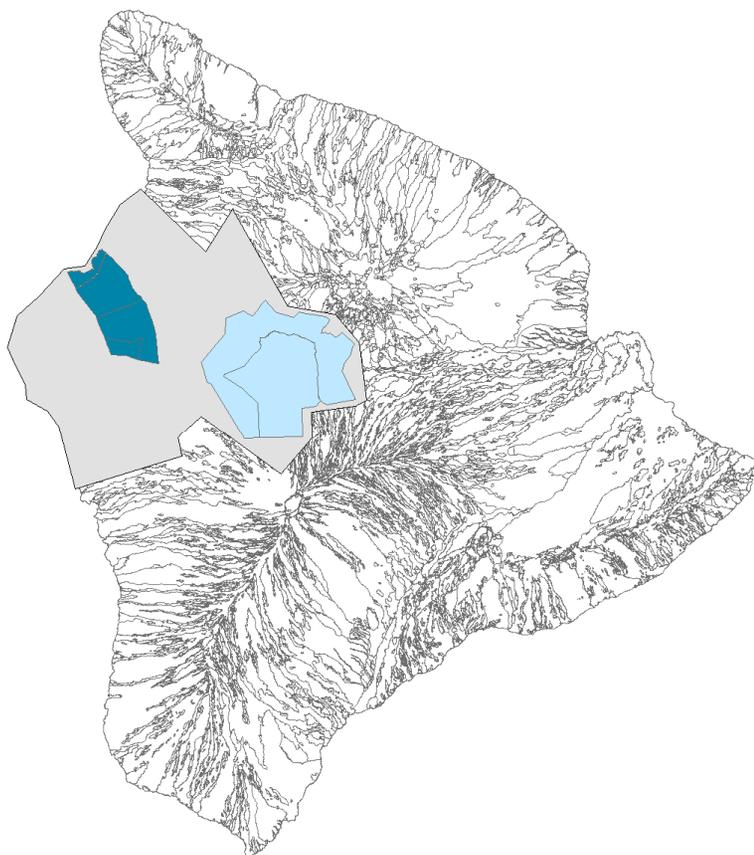
Habitat Suitability Pixel Value



Area



# Habitat Suitability Model



**Pohakuloa Training Area**  
Puu Waawaa

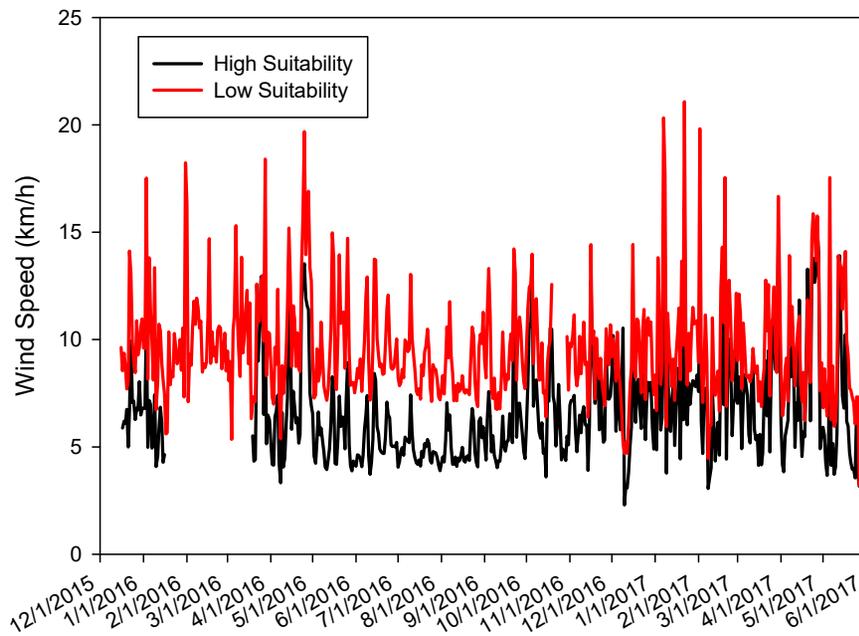


**Vandenberg Air Force Base**  
Santa Monica Mountains

# Results

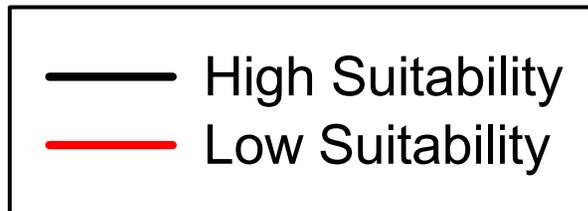
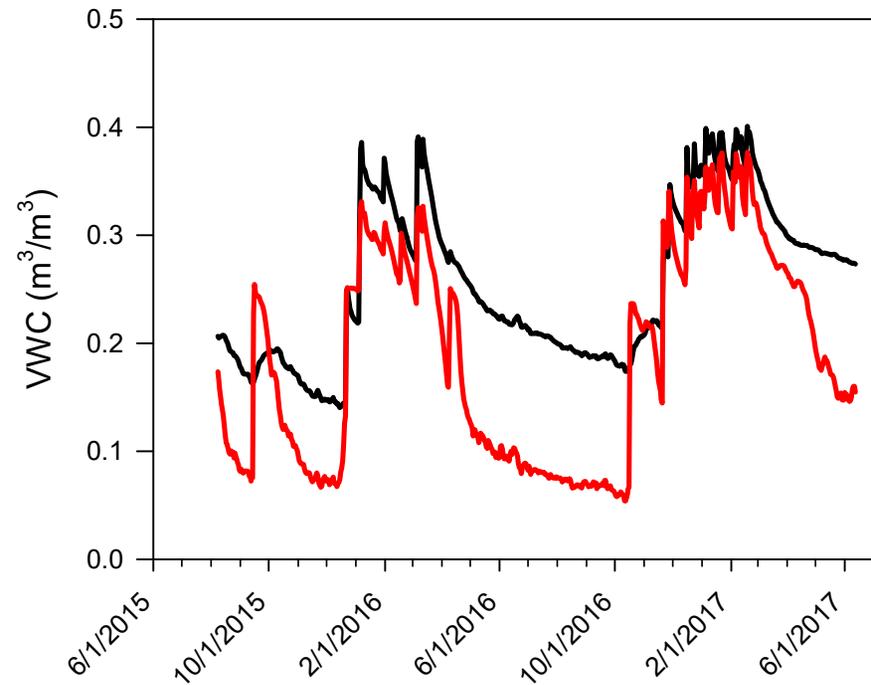
## Wind speed

### Vandenberg Air Force Base



## Soil moisture

### Zuma Ridge, Santa Monica

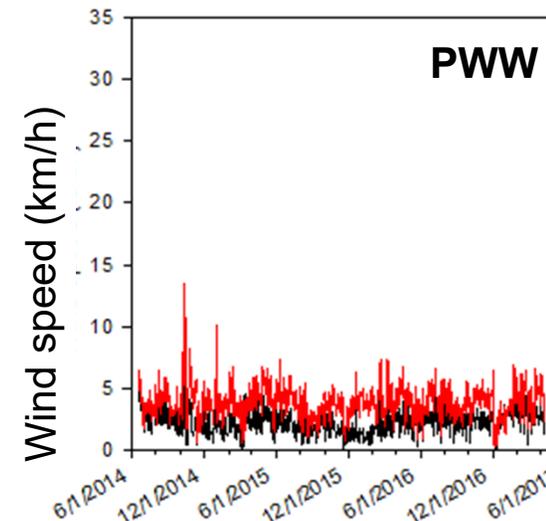
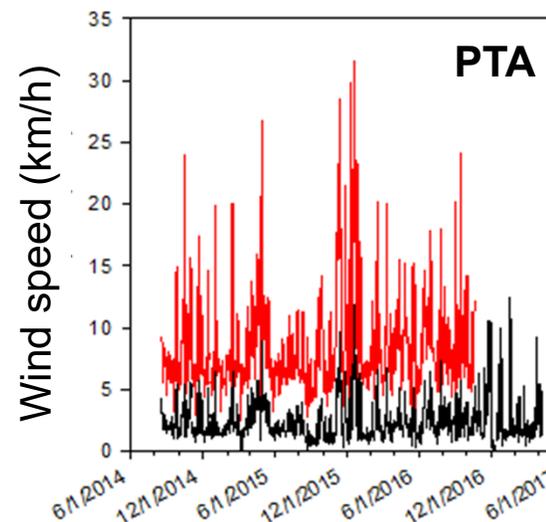
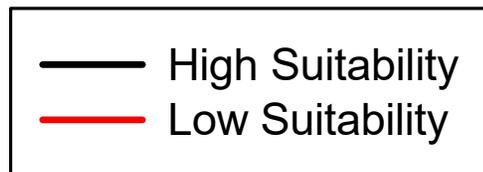


# Results

## *High suitability habitats*

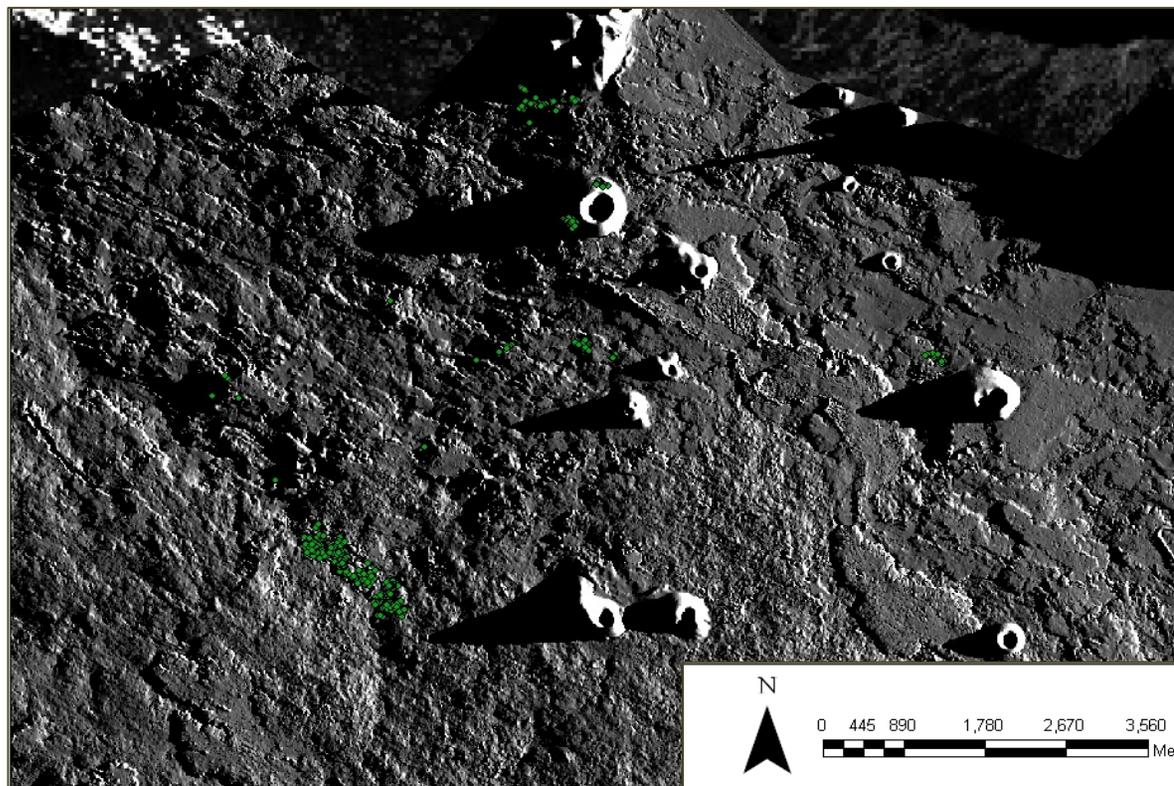
- Greater water availability
- Lower water stress – wind, leaf wetness
- Greater leaf nutrients and plant height

**Difference between high and low suitability is greater in drier, windier sites**



# Results

## *T&E plant species*



**Honohono (*Haplostachys haplostachya*)**

# Results

## *Habitat suitability associations of T&E species*

### **Pohakuloa Training Area**

- Six species higher suitability
- Two species lower suitability
- Three species no association

### **Puu Waawaa**

- Two species higher suitability
- One species lower suitability
- Eight species no association

### **Vandenberg**

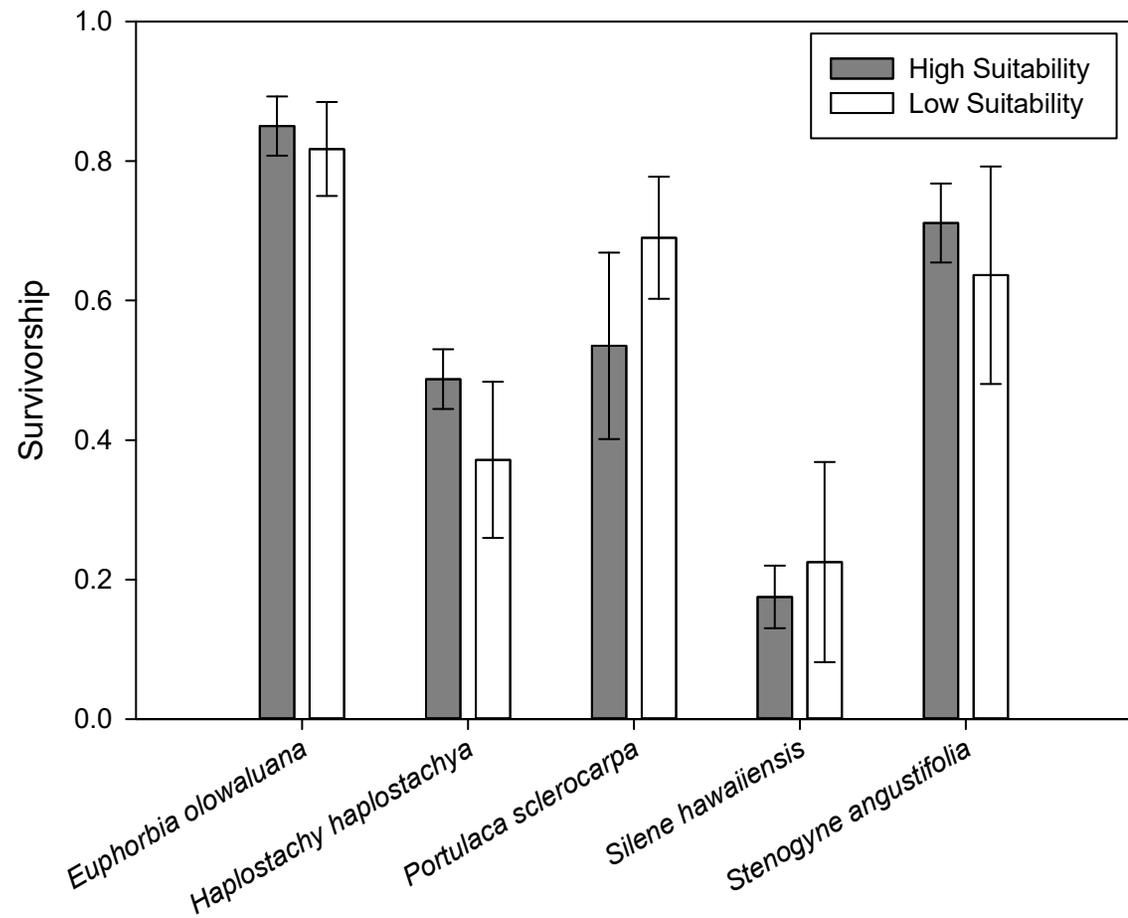
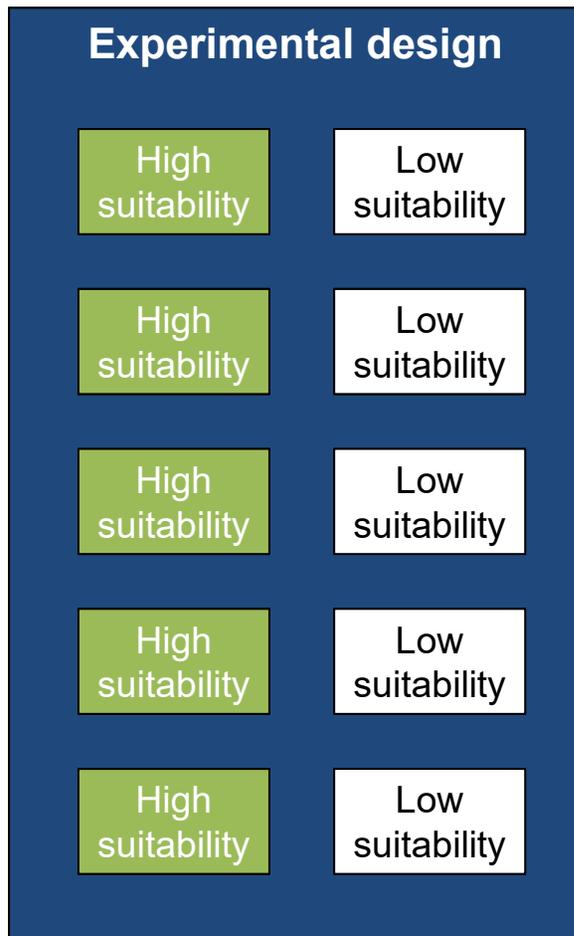
- Two species no association

*Stenogyne angustifolia*



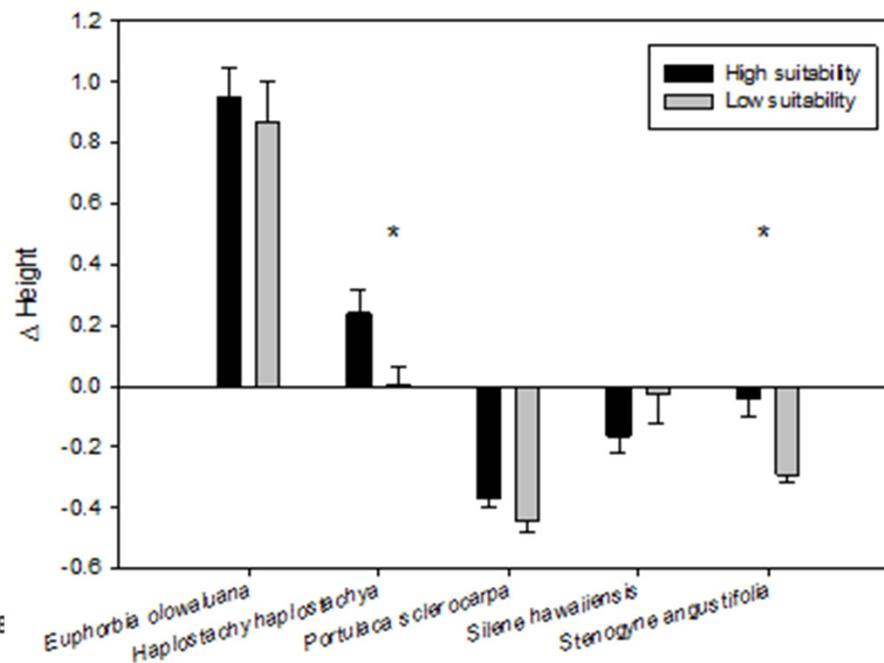
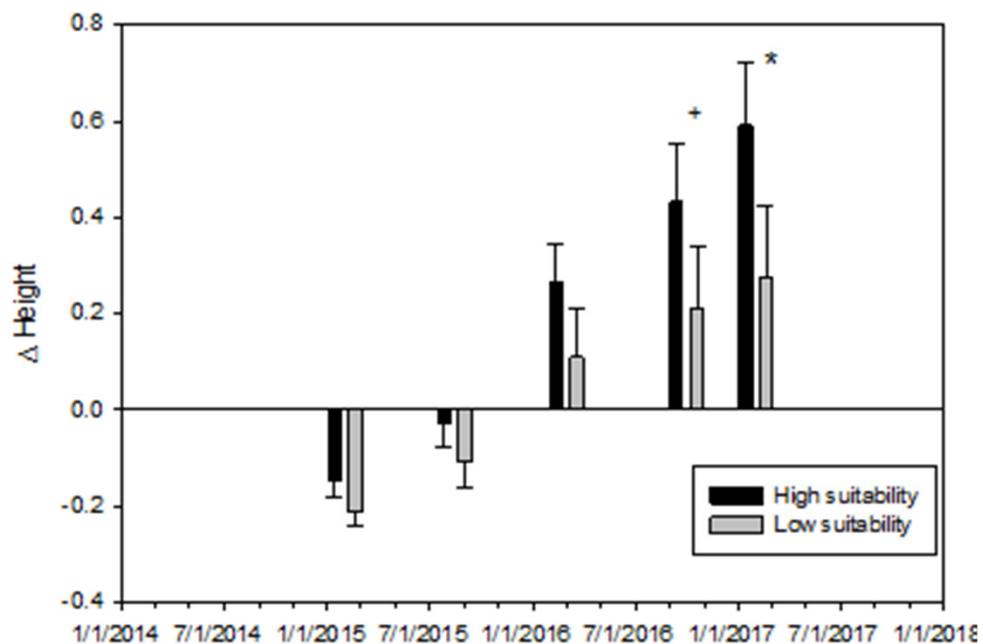
# Results

## *Survival at Pohakuloa Training Area*



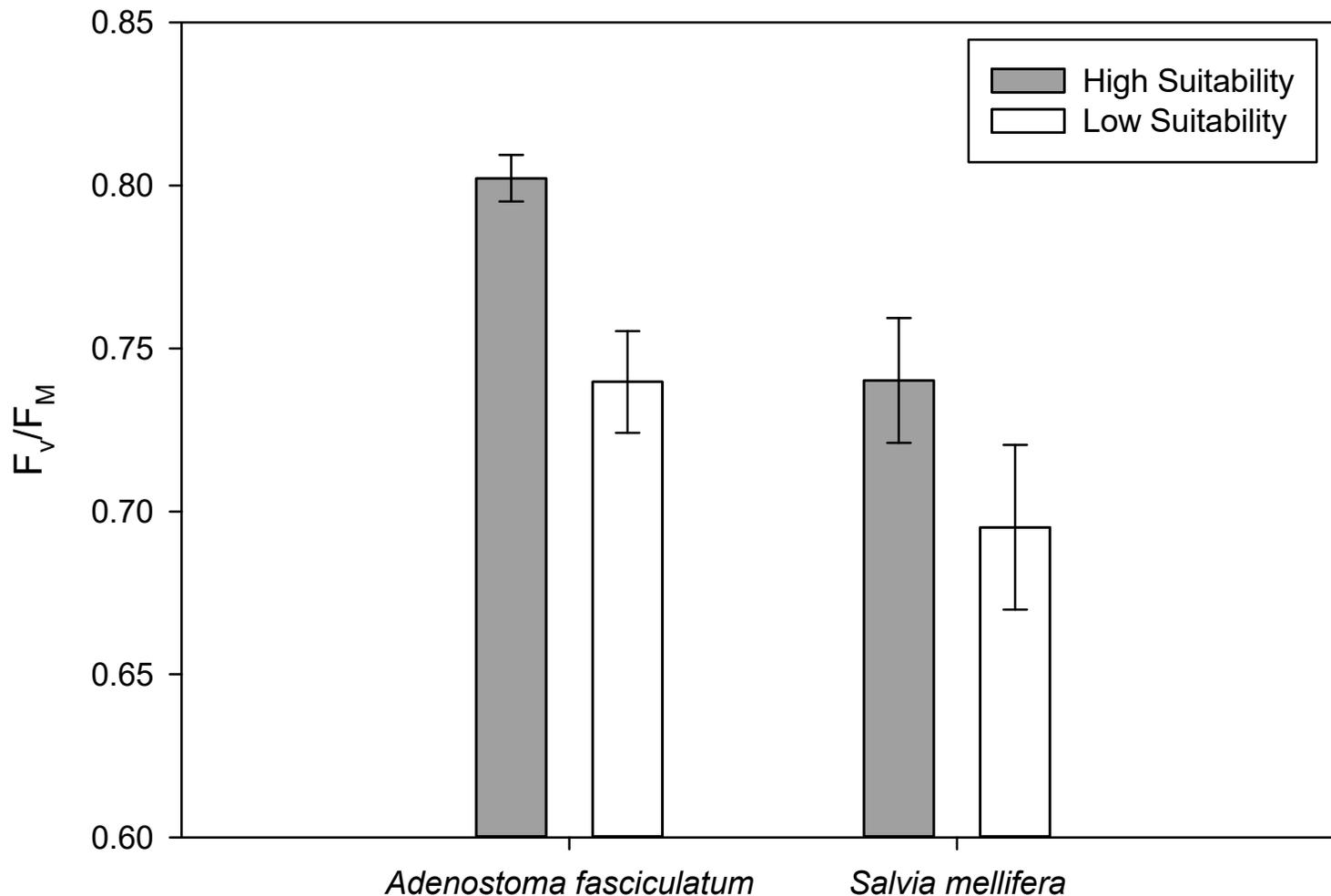
# Results

## *Growth at Pohakuloa Training Area*

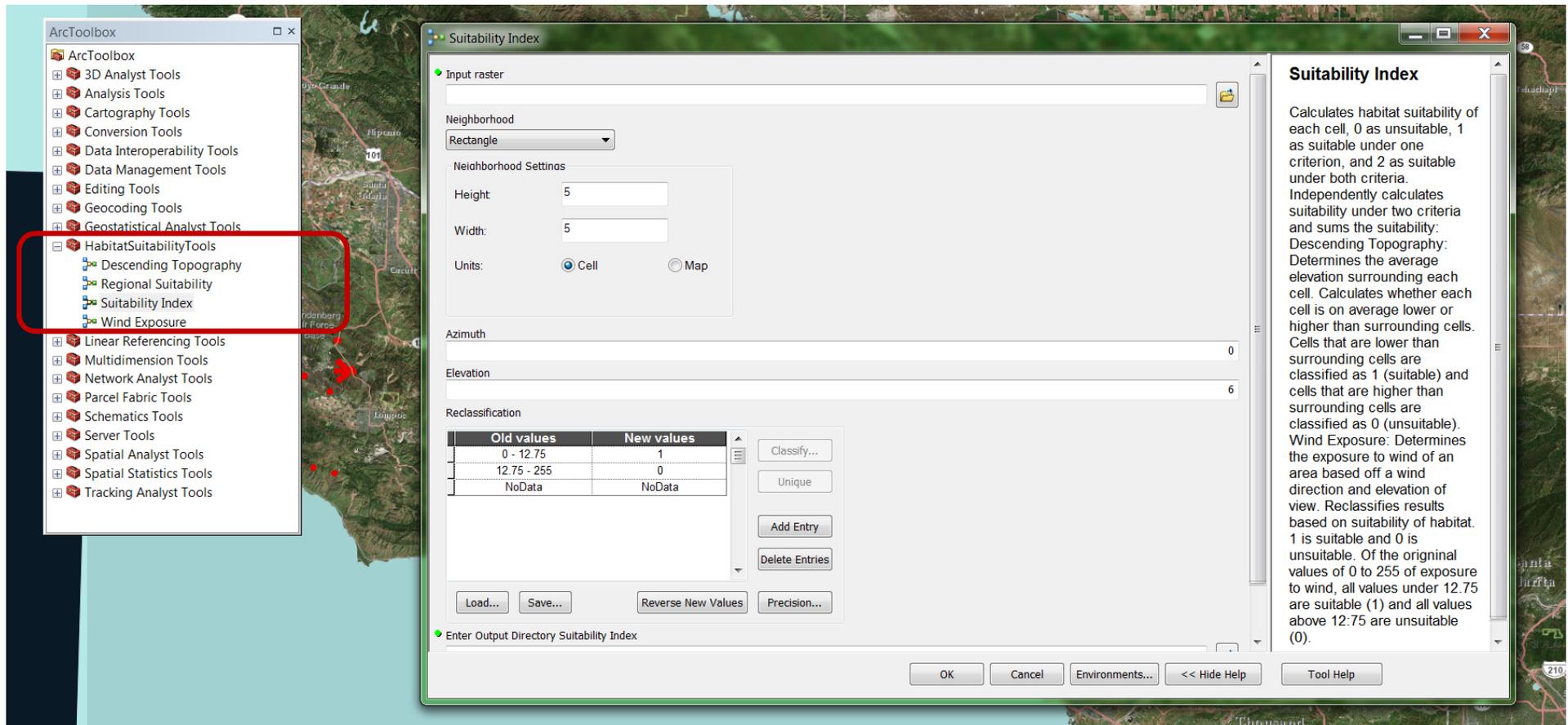


# Results

*Increased physiological performance  
Arroyo Sequit, Santa Monica Mountains*



# Extension *Toolbox for ArcMap*



**Suitability Index**

Calculates habitat suitability of each cell, 0 as unsuitable, 1 as suitable under one criterion, and 2 as suitable under both criteria. Independently calculates suitability under two criteria and sums the suitability. Descending Topography: Determines the average elevation surrounding each cell. Calculates whether each cell is on average lower or higher than surrounding cells. Cells that are lower than surrounding cells are classified as 1 (suitable) and cells that are higher than surrounding cells are classified as 0 (unsuitable). Wind Exposure: Determines the exposure to wind of an area based off a wind direction and elevation of view. Reclassifies results based on suitability of habitat. 1 is suitable and 0 is unsuitable. Of the original values of 0 to 255 of exposure to wind, all values under 12.75 are suitable (1) and all values above 12.75 are unsuitable (0).

**Reclassification**

Old values	New values
0 - 12.75	1
12.75 - 255	0
NoData	NoData

# Conclusions

- Microclimatic differences between high and low suitability were greatest in the driest, windiest sites
- Resource availability and plant physiological performance were higher in high suitability sites, at times
- Plant responses were species-specific

## DoD Benefits

- Areas suitable for planting can be mapped easily to assist conservation/species recovery
- Areas with large amounts of low suitability habitat can be prioritized for other uses
- Greater survival rates can reduce costs of recovery programs, especially at dry, windy installations

# *SERDP & ESTCP Webinar Series*

For additional information, please visit  
<https://www.serdp-estcp.org/Program-Areas/Resource-Conservation-and-Resiliency/Natural-Resources/Species-Ecology-and-Management/RC-201203>

## **Speaker Contact Information**

[ejquestad@cpp.edu](mailto:ejquestad@cpp.edu); 909-869-4206



# *SERDP & ESTCP Webinar Series*

## Q&A Session 1



## *SERDP & ESTCP Webinar Series*

# Operational-Scale Propagation and Reintroduction of Five Endangered and At-Risk Plants

Matthew Hohmann  
United States Army Engineer  
Research and Development Center



# Agenda

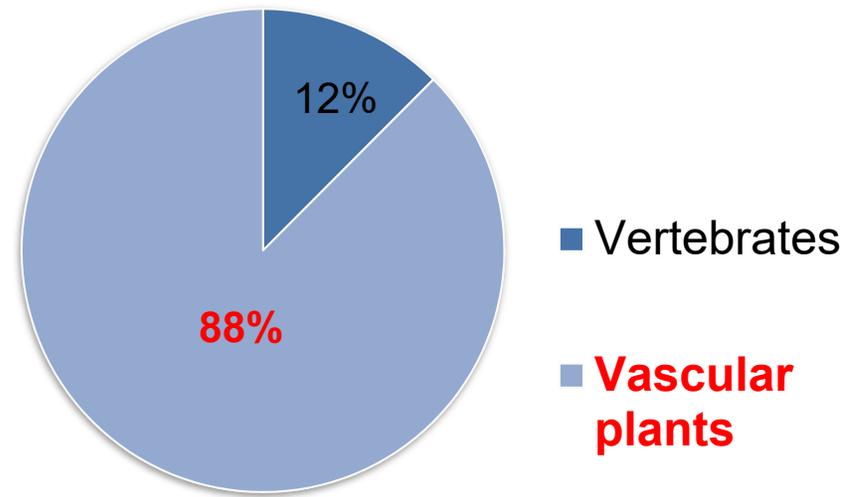
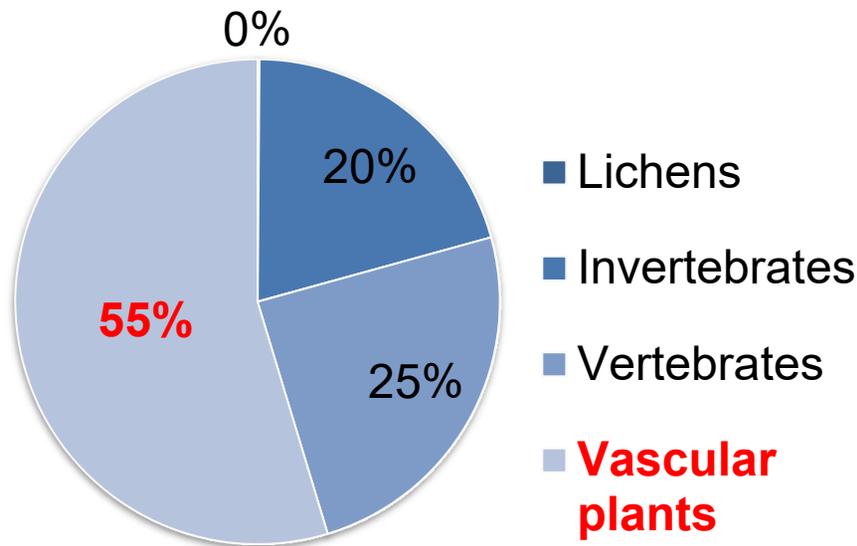
- Background
- Objective
- Approach
- Results
- Conclusions
- Acknowledgements



# Background

## *ESA Status and Imperiled Species on Federal Lands*

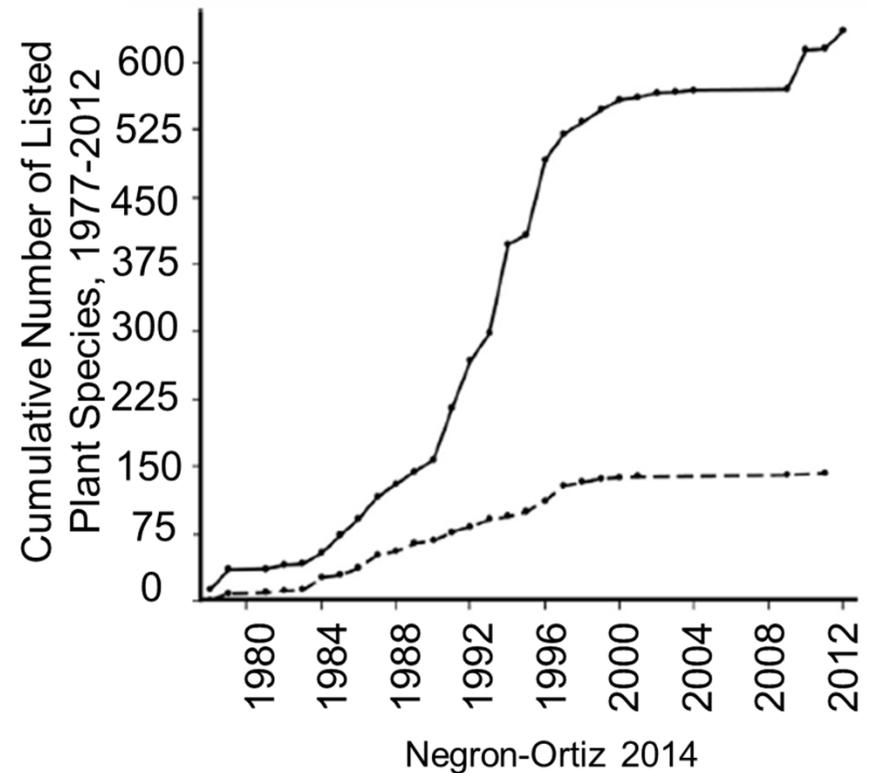
- Taxonomic representation of 1,520 ESA status species (Stein et al., 2008)
- Taxonomic representation of 3,069 imperiled species



# Background

## *ESA Listing Backlog*

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



# Background

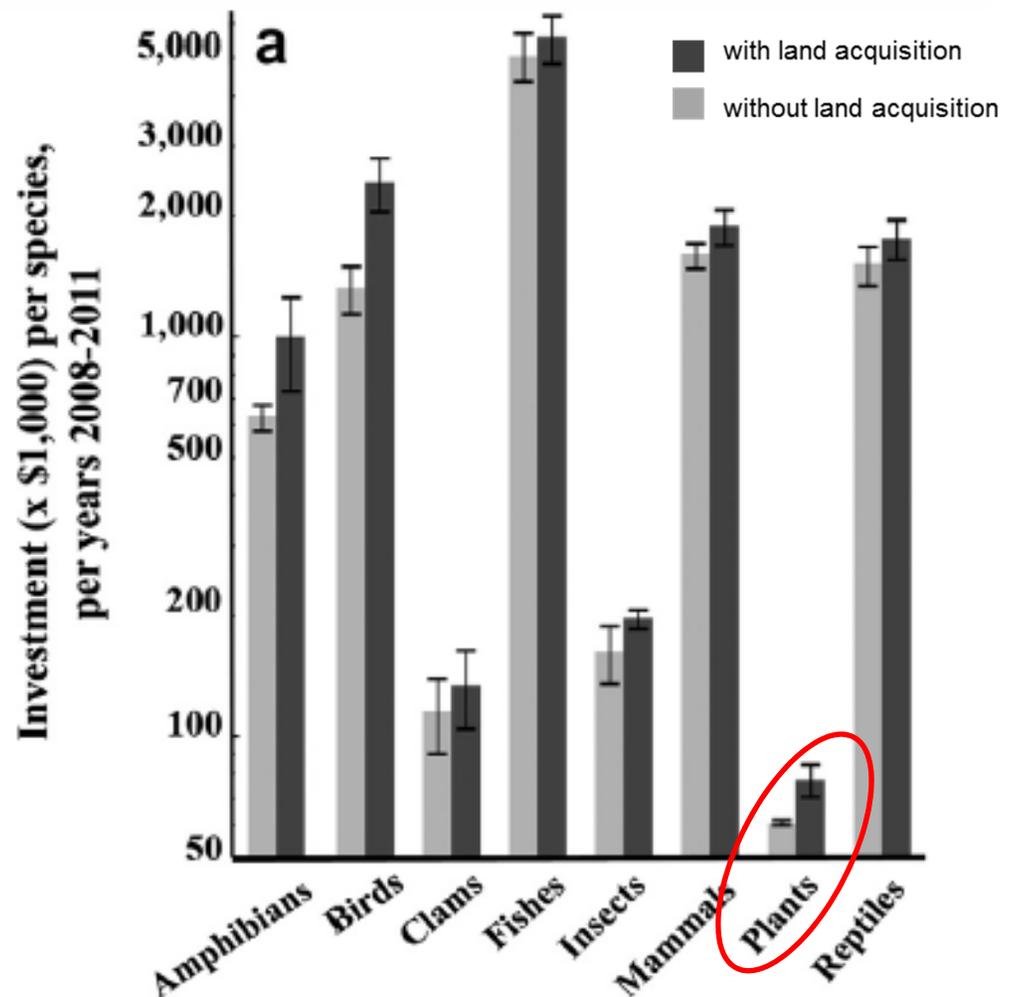
## *Conservation Benefits of Federal Listing?*

- Listed plant conservation responsibility falls on federal land managers
  - Limited ESA protections for plants on non-Federal lands
  - Few state endangered species laws include plants
    - Those that do rarely offset ESA limitations

# Background

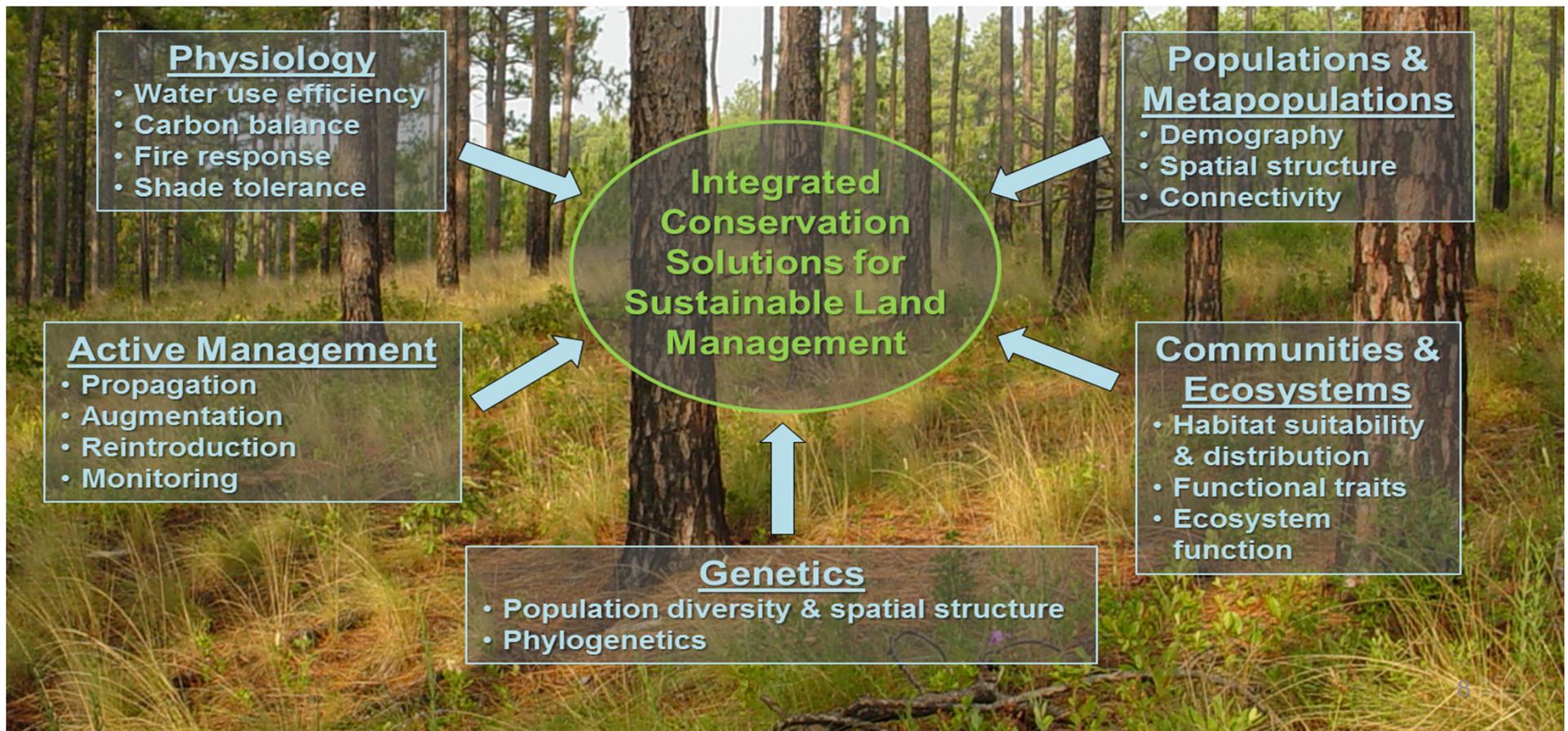
## *Conservation Benefits of Federal Listing?*

- Plants receive the lowest investment in recovery
  - <5% of federal and state recovery funding to plants
- Recovery cost estimates substantially lower for plants than animals



# Proactive Management and Recovery Research

## *Integrated Conservation of Listed and At-Risk Plants*



# Background

## *Payoffs of Propagation and Reintroduction?*

- Listed species recovery or down-listing
- Preclude the need to list at-risk species
- Expanded conservation partnering opportunities
- Improved reintroduction success and cost efficiency



*The Tennessee purple coneflower (Echinacea tennesseensis) was listed as Endangered in 1979, and Recovered in 2011*

# Background

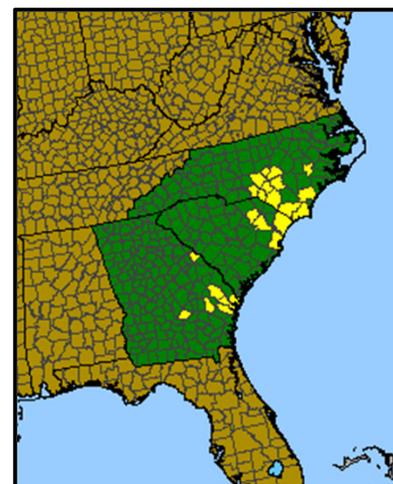
- When is propagation and reintroduction the right strategy?
  - Feasible
  - Contributes to an established conservation goal
  - Overcomes a limiting factor that is contributing to species rarity and decline

# Background

- Limitations on propagation and reintroduction as a conservation strategy
  - Insufficient scientific knowledge
  - Insufficient funding
  - No regulator support
    - No recovery goals/criteria in species recovery plan to support
  - Lack of suitable habitat
  - Lack of will

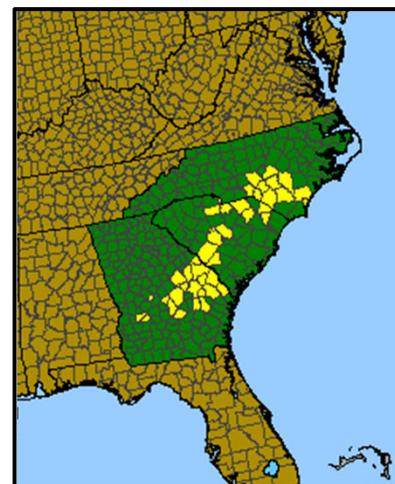
# Background

- *Amorpha georgiana* (Georgia leadplant)
  - Woody subshrub
  - Under review for ESA listing; Endangered in North Carolina and Georgia
  - Occurs in wet and mesic pine flatwoods on ancient terraces and swamp margins associated with longleaf pine savannas
  - Produces abundance of seeds on multiple racemes per plant



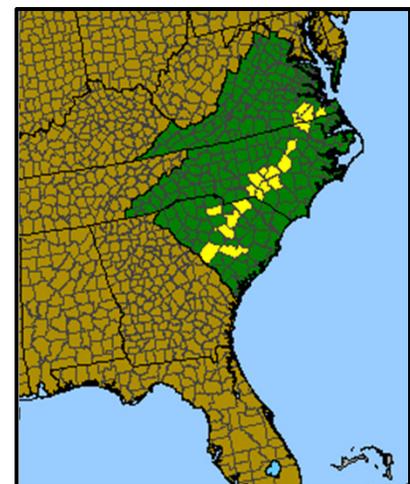
# Background

- *Astragalus michauxii* (Sandhills milkvetch)
  - Herbaceous perennial
  - Threatened in Georgia; Special Concern in North Carolina
  - Xeric sandhill scrub and pine-scrub oak sandhill communities
  - Found in small topographic depressions
    - High loam content
    - High nutrients and moisture
  - Variable seed production



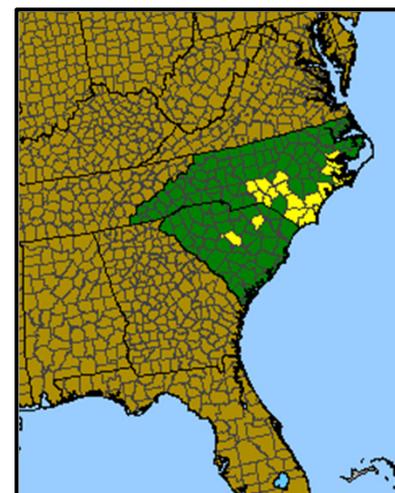
# Background

- *Lilium pyrophilum* (Sandhills lily)
  - Herbaceous perennial
  - Endangered in North Carolina
  - Edaphic specialist, restricted to:
    - Sandhill seeps
    - Streamhead pocosin ecotones
    - Small stream swamps (rare)
  - Slow to mature
  - Presumably long-lived
  - Variable seed production
  - Vegetative dormancy



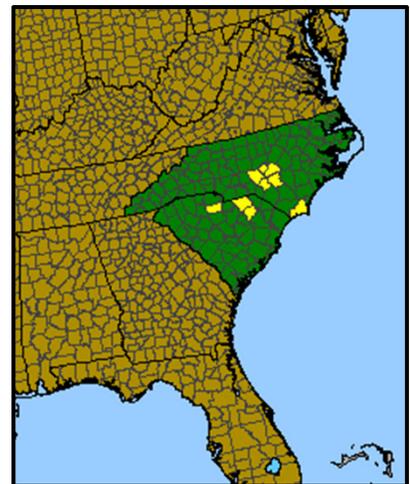
# Background

- *Lysimachia asperulifolia*  
(Rough-leaved loosestrife)
  - Rhizomatous pseudoannual
  - Federally listed as Endangered
  - Occurs in:
    - Wet pine flatwoods
    - Pine savanna
    - Streamhead pocosin
    - Sandhill seep
    - Low pocosin
    - High pocosin
  - Seeds rare



# Background

- *Pyxidantha brevifolia*  
(Sandhills pyxiemoss)
  - Woody cushion plant
  - No state or federal protections
  - Xeric sandhill scrub communities
  - Many small seeds per year

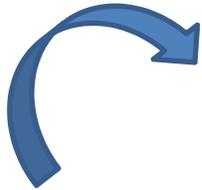


# Objectives

- Implement production-scale propagation and operational-scale reintroduction
- Evaluate reintroduction success using comparative demography
- Optimize cost for establishment of self-sustaining populations

# Approach

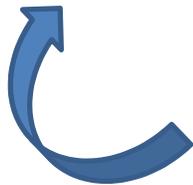
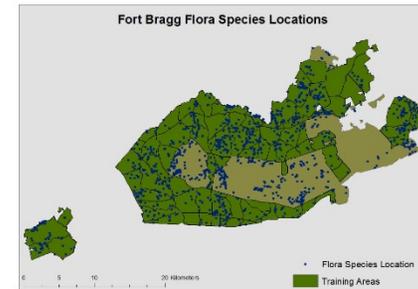
Cost assessment and technology transfer



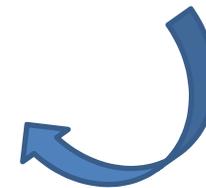
Propagation



Reintroduction



Comparative demographic monitoring and analysis



# Additional Tests and Treatments

- Seed-addition plots
  - *A. georgiana* and *L. pyrophilum*
- Supplemental irrigation
  - *A. georgiana* seed-addition plots and outplants
  - *A. michauxii* outplants
- Site maintenance
  - *L. pyrophilum* outplants



## Results - *Amorpha*

- $\lambda_{\text{reintro}} (0.80) < \lambda_{\text{nat}} (1.06)$
- 1<sup>st</sup> year survival was 90% for individuals > 20 cm
- No seeds recruited into irrigated or non-irrigated seed-addition plots
  - Outplanting more efficient than seeding
- Survivorship of irrigated plants (79%) marginally greater than non-irrigated plants (70%),  $p < 0.05$ 
  - At cost of ~\$20/individual, supplemental irrigation not recommended
- 22% of 3,065 outplants became established

## Results - *Astragalus*

- $\lambda_{\text{reintro}} (0.75) < \lambda_{\text{nat}} (0.97)$
- 1<sup>st</sup> year survival was 90% for individuals  $> 20$  cm
- Supplemental irrigation did not enhance outplant growth or survival ( $p > 0.05$ )
- 13.4% of 1,914 outplants became established



## Results - *Lilium*

- $\lambda_{\text{reintro}} (0.98) = \lambda_{\text{nat}} (1.02)$
- 1<sup>st</sup> year survival
  - Bulbs < 2 cm at outplanting had ~50% survival
  - Largest individuals had ~25% survival
- No *L. pyrophilum* seedlings recruited into seed-addition plots
  - Outplanting more efficient than seeding
- Vegetation removal doubled first-year survival
  - Site maintained = 0.38 vs. not removed = 0.18;  $p = 1.23 \text{ e-}08$
  - Little effect on growth ( $F = 0.245$ ,  $p = 0.63$ )
- At a cost of ~\$4/individual for vegetation removal and extended propagation time, recommend vegetation removal within reintroduction sites
- 24.0% of 670 outplants became established

## Results - *Lysimachia*

- $\lambda$  could not be estimated
- 1<sup>st</sup> year survivorship (~35%) not strongly influenced by rhizome length
- Proportion of stems exhibiting vegetative recruitment ~0.00 - 0.17 over four years
- 24.2% of 710 outplants became established
- Outplanted rhizomes of ~8 cm in length cost \$13.49
  - Using survivorship estimates for rhizomes of this length (0.35), establishment cost ~\$39.00 per individual

## Results - *Pyxidantha*

- Propagation challenges
- Exceptionally high transplant mortality
- *P. brevifolia* abandoned as a demonstration species

# Results - Establishment Costs

Species	Cohort	Propagation and reintroduction cost per individual (\$)	Mean survivorship (Standard Deviation)	Establishment costs per individual (\$)
<i>A. georgiana</i>	8 mo	8.48	0.681 (0.128)	12.45
	6 mo	7.62	0.561 (0.066)	13.59
	3 mo	6.52	0.544 (0.023)	11.99
<i>A. michauxii</i>	8 mo	12.83	0.527 (0.122)	24.34
	6 mo	11.08	0.485 (0.105)	22.85
	3 mo	8.26	0.451 (0.088)	18.32
<i>L. pyrophilum</i>	4 yr	29.12	0.610 (0.120)	47.73
	3 yr	22.43	0.523 (0.109)	42.89
	2 yr	13.52	0.412 (0.115)	32.82

# Results - Cost Optimization

Species	Cohort	Number needed	Propagation and reintroduction cost per individual (\$)	Estimated cost (\$)
<i>A. georgiana</i>	8 mo	396	8.48	3,358.08
	6 mo	545	7.62	4,152.90
	3 mo	574	6.52	3,742.48
<i>A. michauxii</i>	8 mo	905	12.83	11,611.15
	6 mo	1,080	11.08	11,966.40
	3 mo	1,184	8.26	9,779.84

# Conclusions

- Propagation and reintroduction are viable conservation tools for 4 of 5 target species, potentially supporting recovery, downlisting, or mitigation
- Populations of 100 individuals can be established five years post-outplanting at below threshold cost (\$10K) for all species except *Pyxidantha*
- Propagation and reintroduction should not be a substitute for active conservation of the remaining natural populations of the five species

## Benefits to DoD

- Expanded conservation and mitigation strategies
- New opportunities to share conservation responsibility with partner agencies and organizations
- Potential recovery and/or down-listing
- Potential reduced likelihood that at-risk species will be listed

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# *SERDP & ESTCP Webinar Series*

## Q&A Session 2



## *SERDP & ESTCP Webinar Series*

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*Plant Diversity and Biological Nitrogen  
Fixation in Longleaf Pine Ecosystems at  
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# *SERDP & ESTCP Webinar Series*

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