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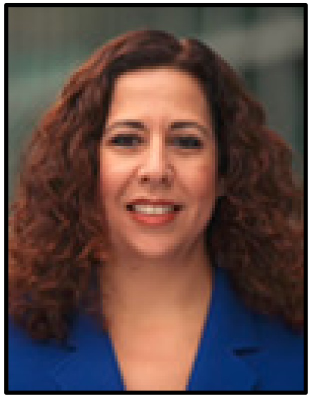
Long-Term Ecological Studies: Evaluating Responses to Ecosystem Restoration and Optimizing Recovery of Plant Communities

March 26, 2020

SERDP DOD • EPA • DOE | ESTCP

Welcome and Introductions

Rula A. Deeb, Ph.D.
Webinar Coordinator



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Webinar Agenda

- **Webinar Logistics** (5 minutes)
  Dr. Rula Deeb, Geosyntec Consultants
- **Overview of SERDP and ESTCP** (5 minutes)
  Dr. Kurt Preston, SERDP and ESTCP
- **Evaluating Long-Term Ecological Responses to Instream Restoration** (25 minutes + Q&A)
  Dr. Natalie Griffiths, Oak Ridge National Laboratory
- **Using Long-Term Data to Optimize Recovery of Understory Plant Communities in Longleaf Pine Ecosystems** (25 minutes + Q&A)
  Dr. John Orrock, University of Wisconsin-Madison
- **Final Q&A session**

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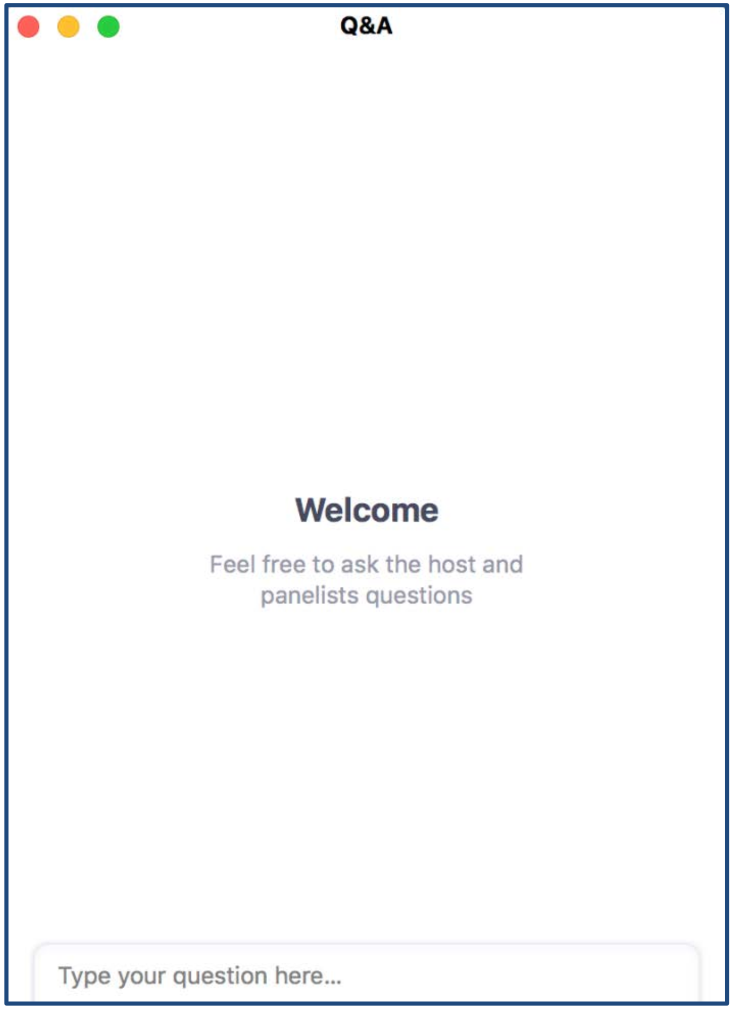


SERDP and ESTCP Overview

Kurt Preston, Ph.D.
SERDP and ESTCP

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

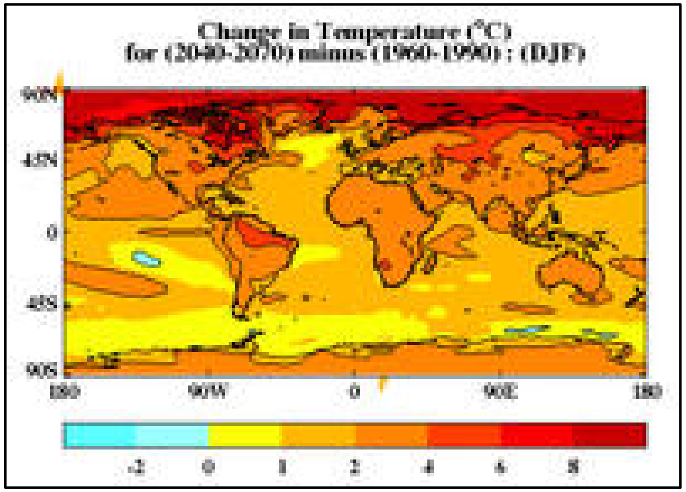
- Environmental Security Technology Certification Program
- Demonstrate innovative cost-effective environmental and energy technologies
  - Capitalize on past investments
  - Transition technology out of the lab
- Promote implementation
  - Facilitate regulatory acceptance

Program Areas

- Environmental Restoration
- Installation Energy and Water
- Munitions Response
- Resource Conservation and Resiliency
- 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
April 9, 2020	Ecological Risk Assessment Approaches at PFAS-Impacted Sites
April 23, 2020	Munitions Response Webinar: Project of the Year Award Winners
May 7, 2020	Innovative Technologies for PFAS Destruction in Investigation Derived Wastes
May 21, 2020	Analysis of Defense Related Ecosystem Services
June 4, 2020	Waste Reduction and Treatment in Armed Forces Vessel Environments
June 18, 2020	Predicting PFAS Fate and Transport in Subsurface Environments, and Treatment

For upcoming webinars, please visit

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Evaluating Long-Term Ecological Responses to Instream Restoration

Natalie A. Griffiths, Ph.D.
Oak Ridge National Laboratory

SERDP
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ESTCP

Agenda

- Background on stream restoration
- Ecological restoration at Ft. Benning
- Project objective
- Field measurements
- Key findings
- Conclusions and benefits to DoD
- References

Stream Restoration

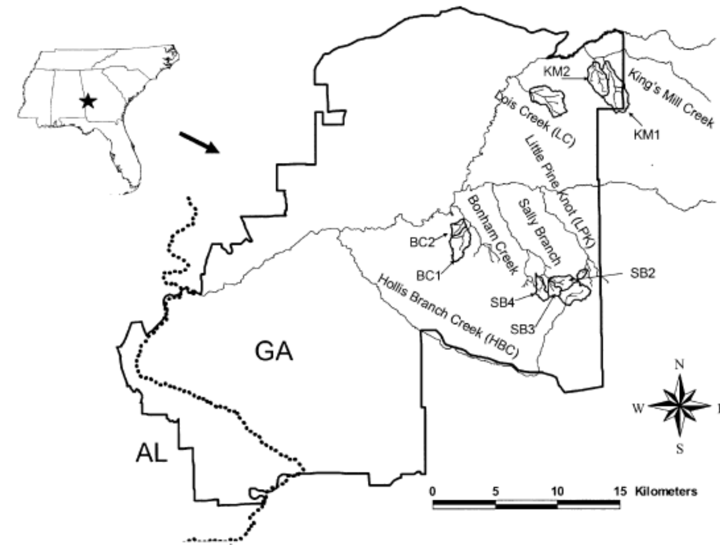
- Defined as returning stream structure and function to pre-disturbance conditions
- >65% U.S. streams in poor or fair condition
- $1 billion/year spent on stream restoration
- ~10% restorations monitored; very few for long periods of time

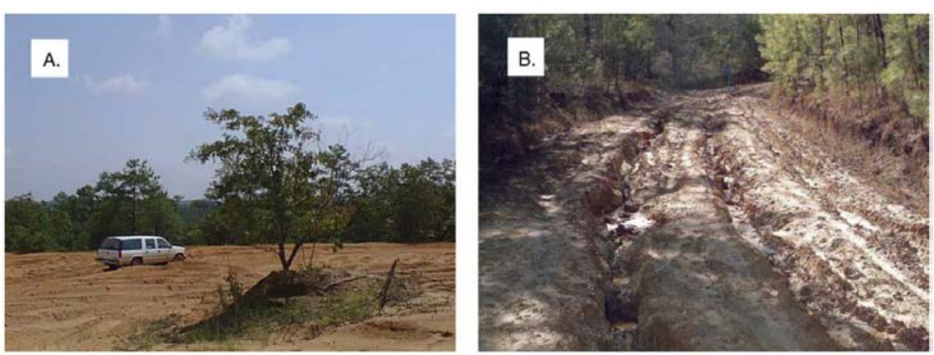
Types of Restoration (NRC, 1992)
Bank stabilization
Channel modification
Fish reintroduction
Flow augmentation
Organic matter addition
Revegetation of banks
Land use regulation
Soil stabilization
Water quality improvements
Water temperature alteration

__Citations__: NRC, 1992; U.S. EPA, 2006; Bernhardt et al., 2005

Fort Benning Military Installation

- Established in 1918
- Pine forests, upland sandy soils
- Military training can lead to soil erosion and sediment loading to streams





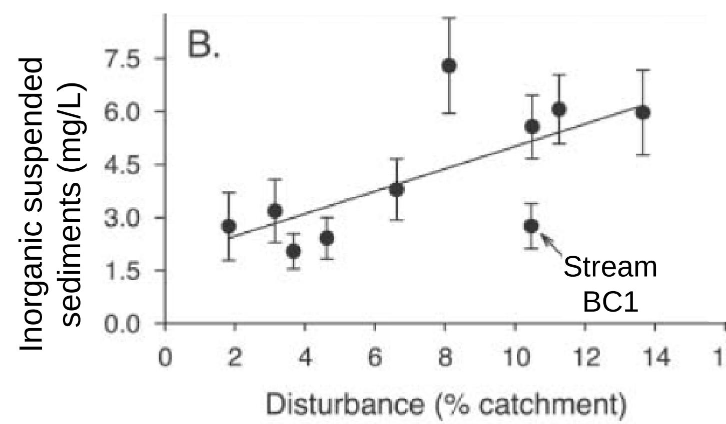
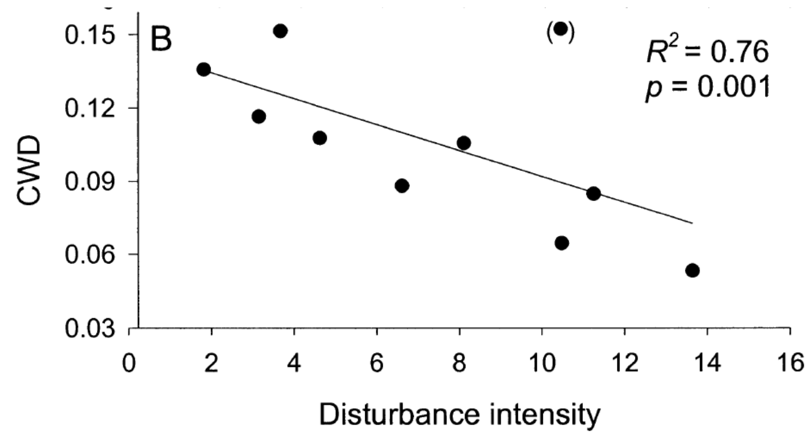


***Image sources**: Houser et al., 2006*

Stream Restoration Study

- Motivation
  - Lower coarse woody debris (CWD) in streams with greater watershed disturbance



- 4 unrestored streams, 4 restored streams

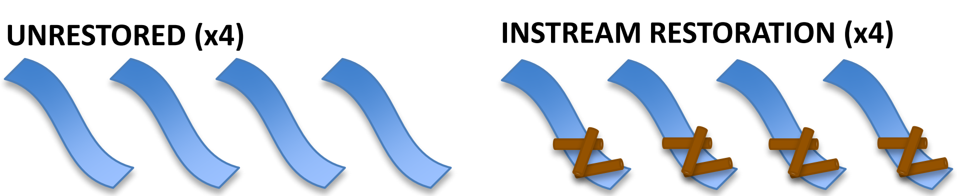
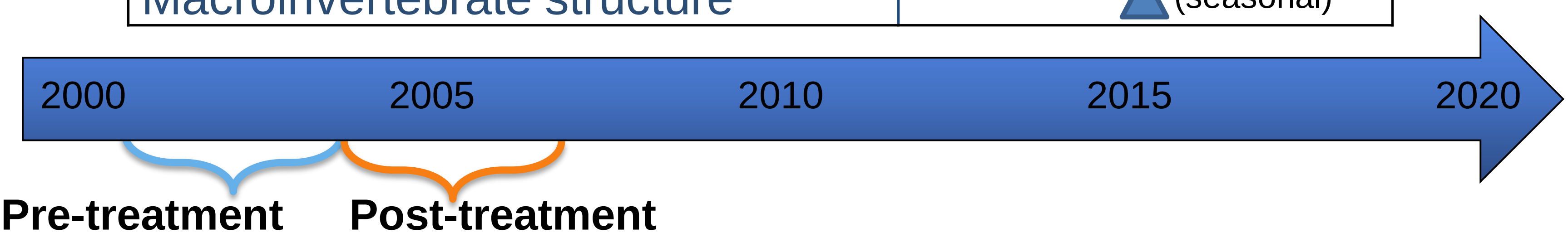


Image source: *CWD figure from Houser et al., 2005*

Stream Restoration Study

- “Short-term” evaluation: 3 years post-treatment

Indicator	Initial response
Water quality metrics	↔
Gross primary production	↑ then ↔
Ecosystem respiration	↑
Ammonium uptake rate	↑
Benthic particulate organic matter	↑
Macroinvertebrate density	↑ (seasonal)
Macroinvertebrate richness	↑ (seasonal)
Macroinvertebrate structure	△ (seasonal)

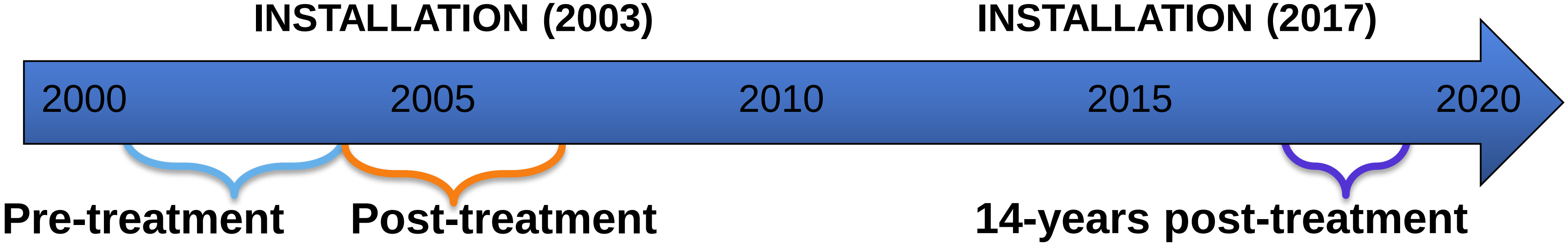


Project Objective

- Evaluate long-term effects of restoration on stream ecosystem processes

CWD DAM IMMEDIATELY AFTER INSTALLATION (2003)

CWD DAM 14 YEARS AFTER INSTALLATION (2017)



Field Measurements

- Used similar methods to measure in-stream responses 14 years after restoration
- Compared to findings from original project

WATER QUALITY

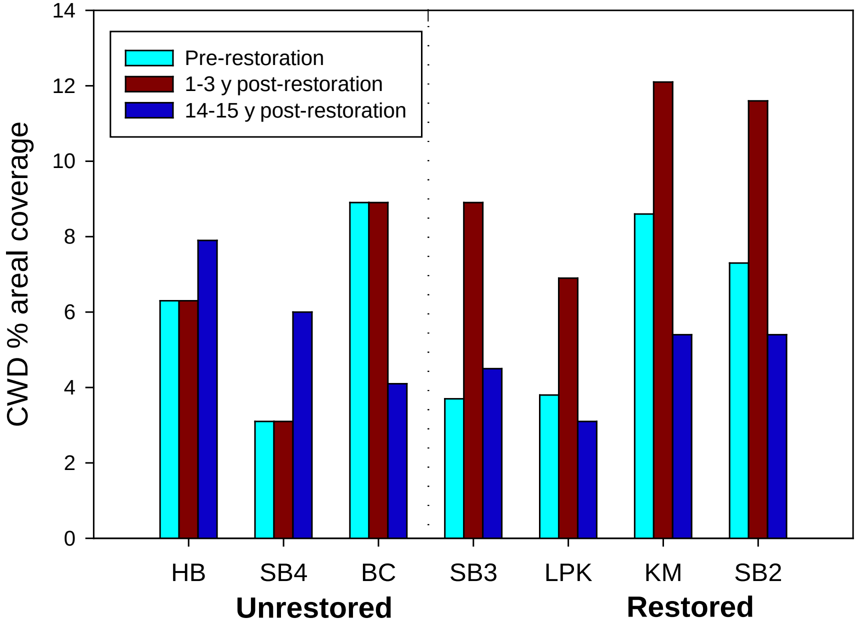
NUTRIENT & CARBON CYCLING

COARSE WOODY DEBRIS & BENTHIC ORGANIC MATTER

MACRO-INVERTEBRATES

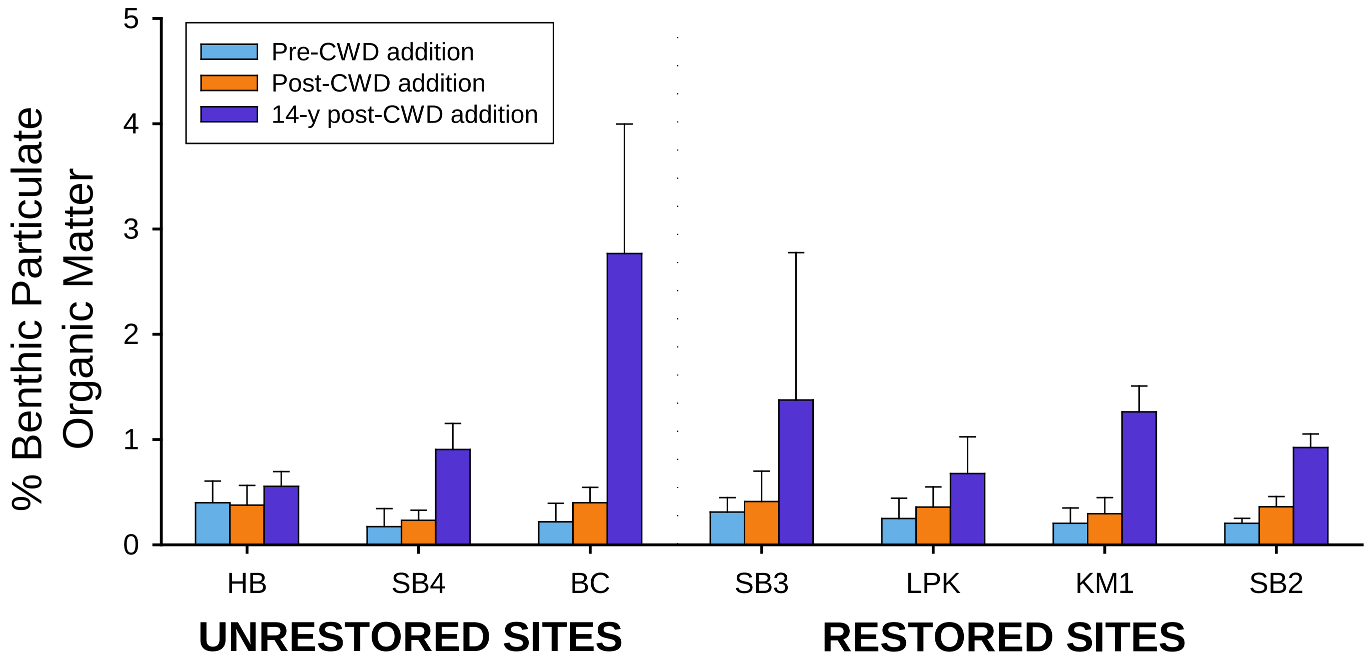
Debris Dams Still Intact

- Debris dams found in all restored streams
- But, debris dam abundance now similar in restored and unrestored streams



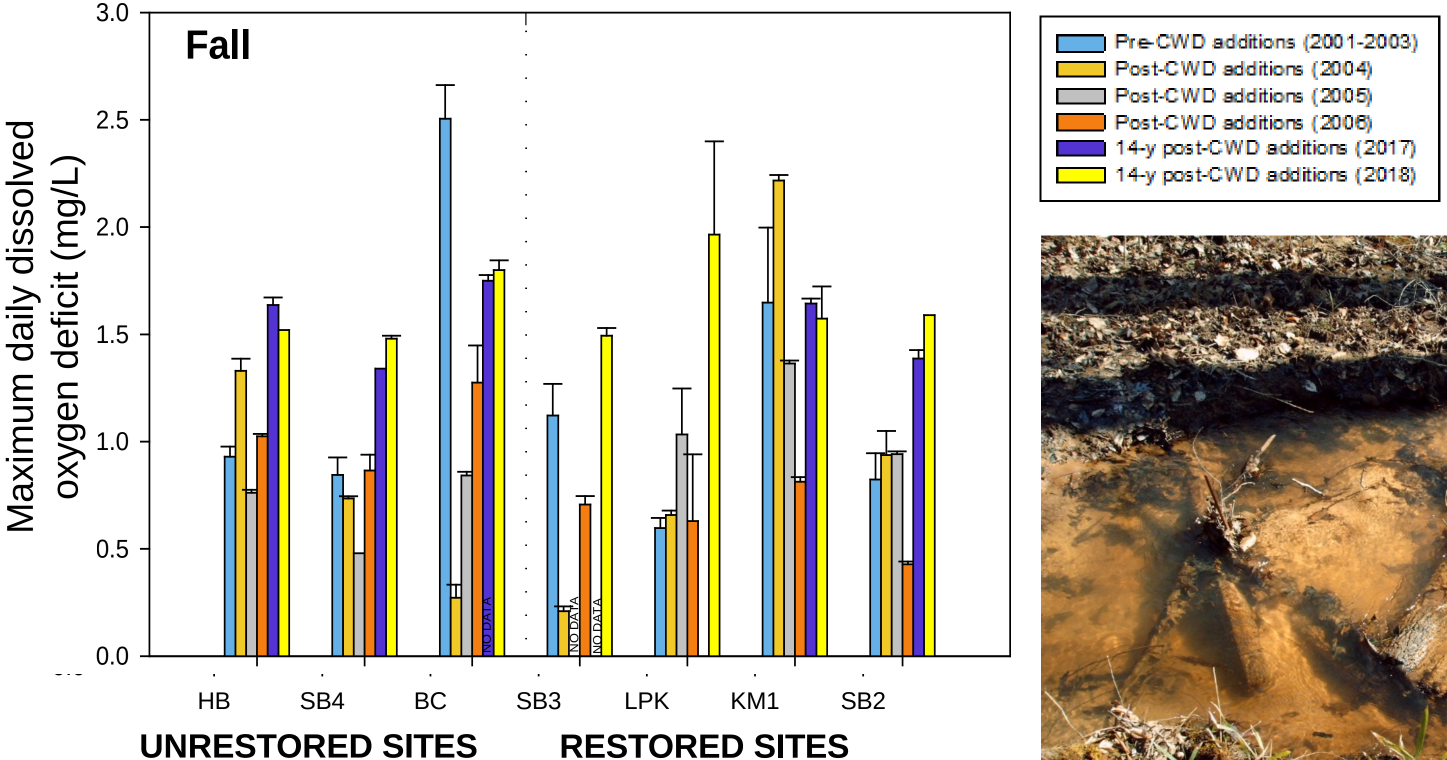
Benthic Organic Matter

- No effect of restoration on organic matter accumulation, but greater storage across all streams



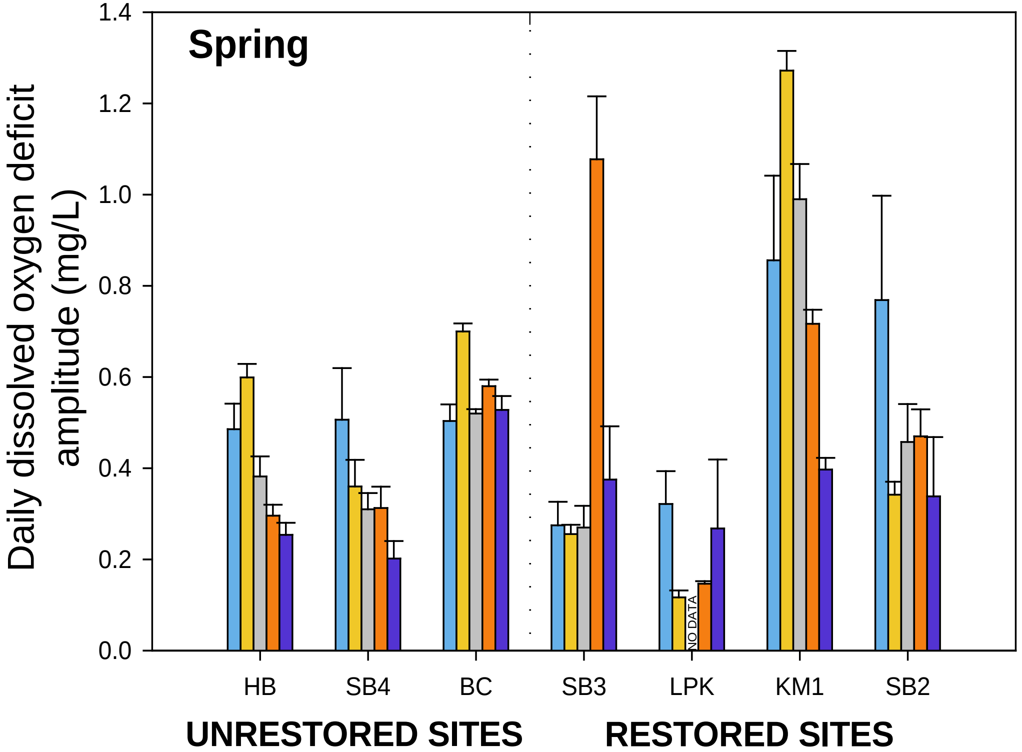
Whole-Stream Metabolism

- Ecosystem respiration indicator showed no change over the long term



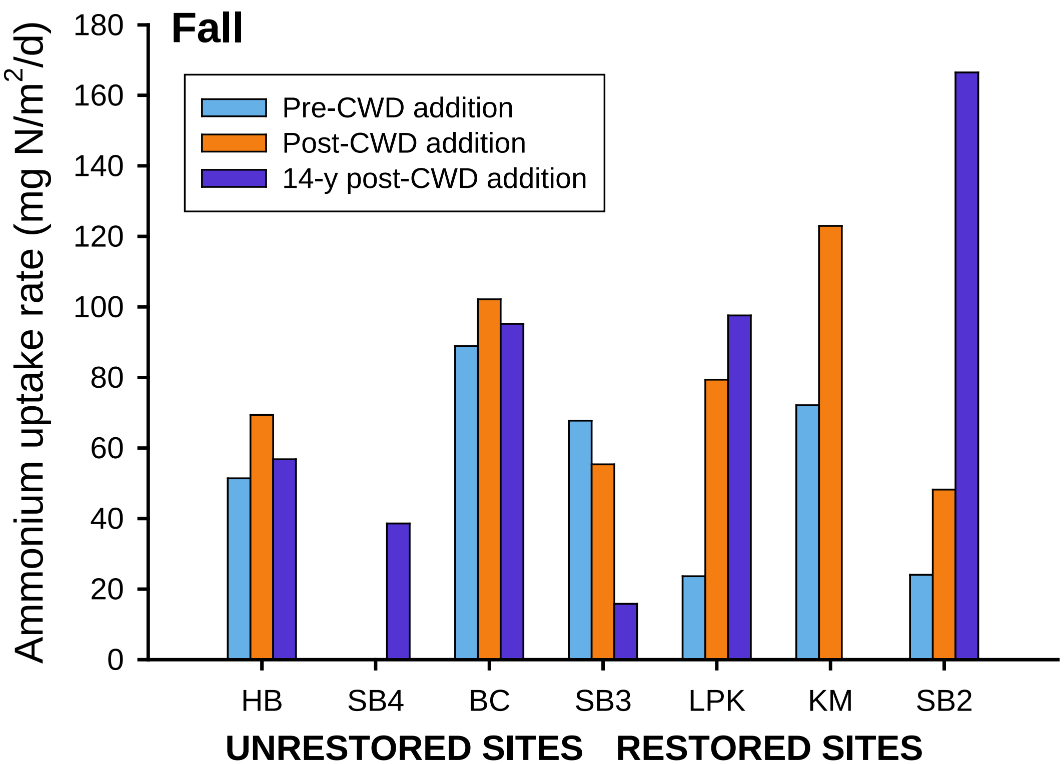
Whole-Stream Metabolism

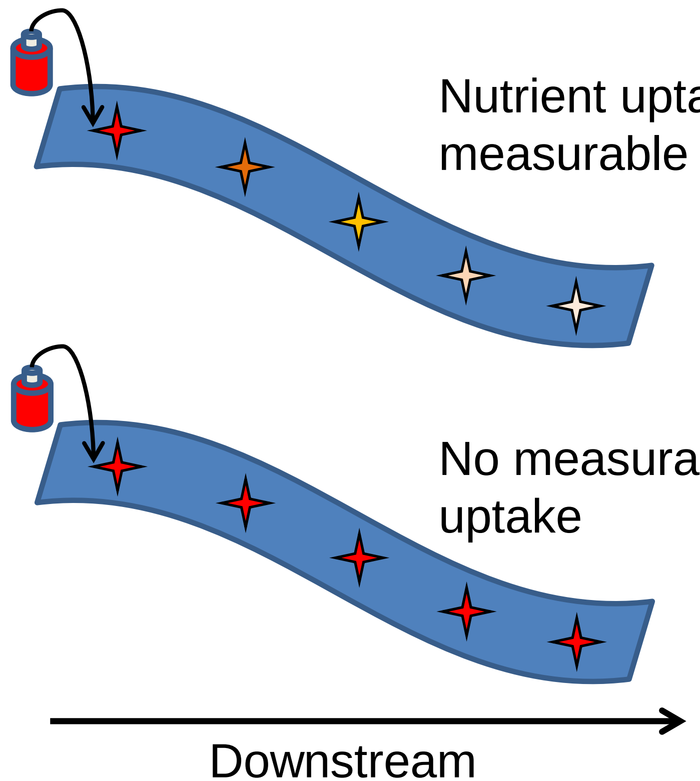
- Gross primary production indicator showed no change over the long term



Nutrient Uptake

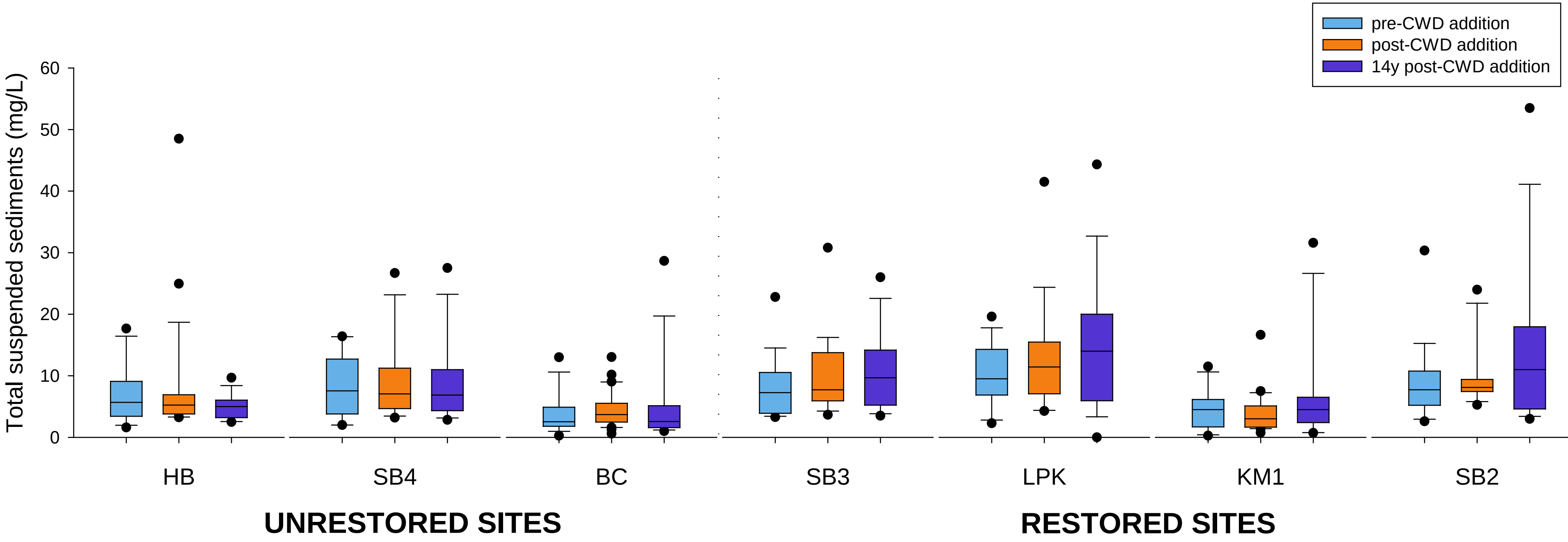
- Increased after CWD addition, but rates returned to baseline after 14 years





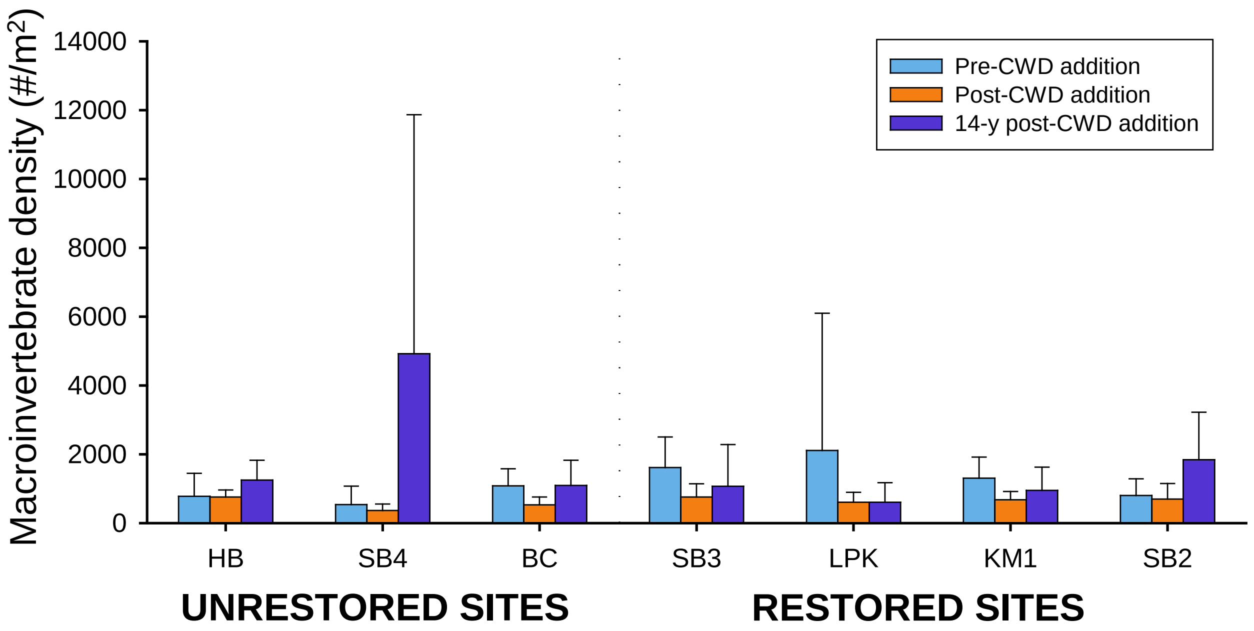
Water Quality

- No long-term effect of restoration on most water quality parameters
- Same finding as original project



Macroinvertebrates

- No consistent long-term effects on macroinvertebrate metrics



Macroinvertebrates

- No long-term effect on non-tolerant stream invertebrates

EPT *= Ephemeroptera, Plecoptera, Trichoptera (mayflies, stoneflies, caddisflies)*

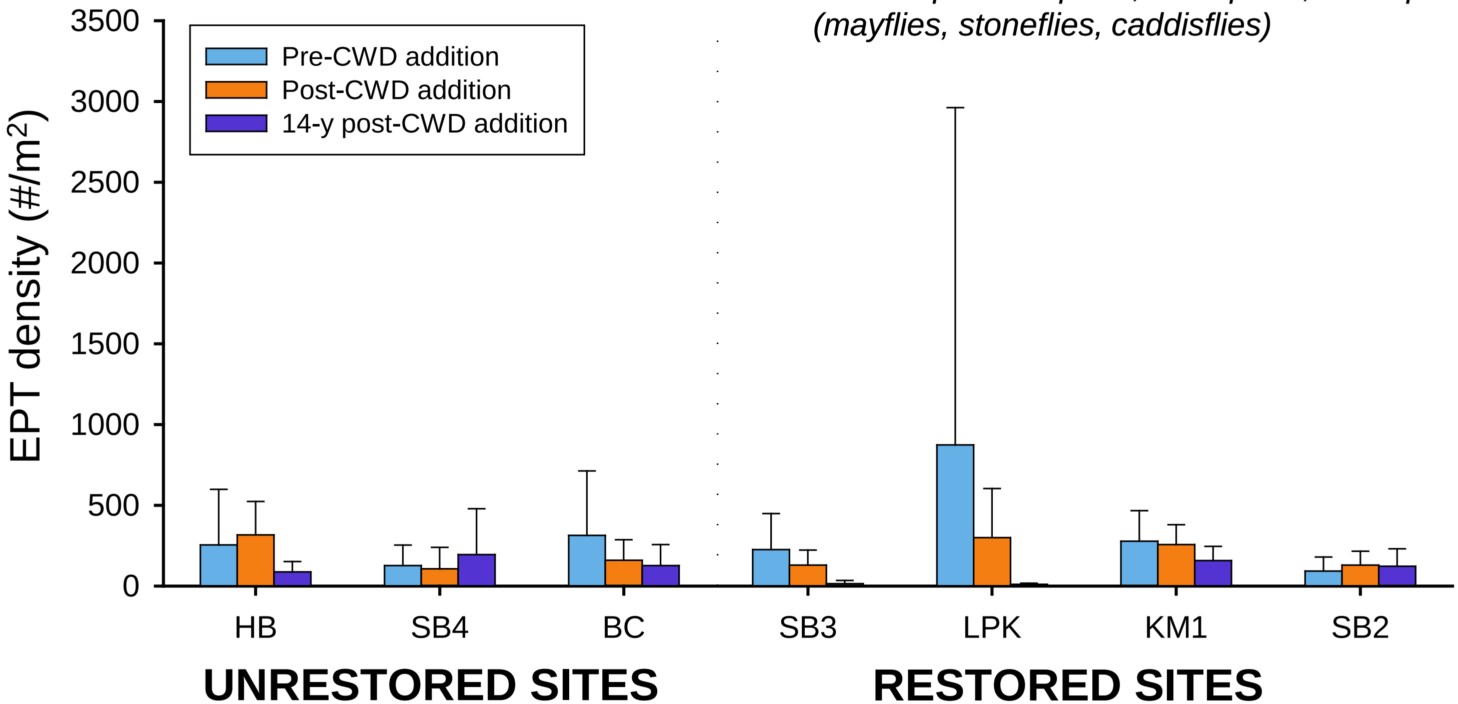
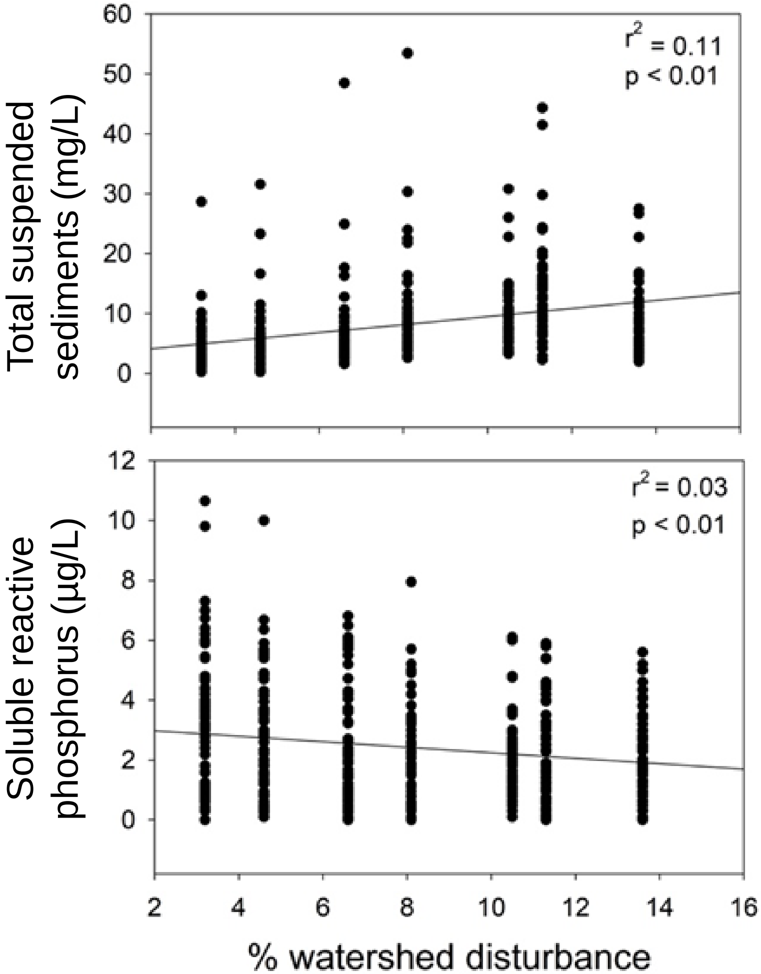


Image source: *http://cfb.unh.edu/StreamKey/html/biotic_indicators/indices/EPT.html*

Disturbance

- Watershed disturbance unchanged over the 14-year period
- Disturbance still appears to be negatively affecting some stream processes



Conclusions

- CWD dams still present after 14 years, but minimal long-term effects on streams
- Watershed disturbance may still be affecting streams; important to also focus on upland processes
- Long-term assessments very rare; ideal if restoration efficacy assessments captured seasonal and interannual variability in environmental and climatic conditions

Benefits to DoD

- CWD addition may not be a long-term restoration strategy at Ft. Benning if upland disturbance not simultaneously addressed
- CWD augmentation may be necessary due to burial by sediment
- Short- and long-term monitoring critical to determine whether restoration is an effective practice and is a worthwhile investment of limited resources

References

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For additional information, please visit

https://www.serdp-estcp.org/Program-Areas/Resource-Conservation-and-Resiliency/Infrastructure-Resiliency/Land-Use-and-Carbon-Management/RC-2704

Speaker Contact Information

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Q&A Session 1

Using Long-Term Data to Optimize Recovery of Understory Plant Communities in Longleaf Pine Ecosystems

John Orrock, Ph.D.
University of Wisconsin-Madison

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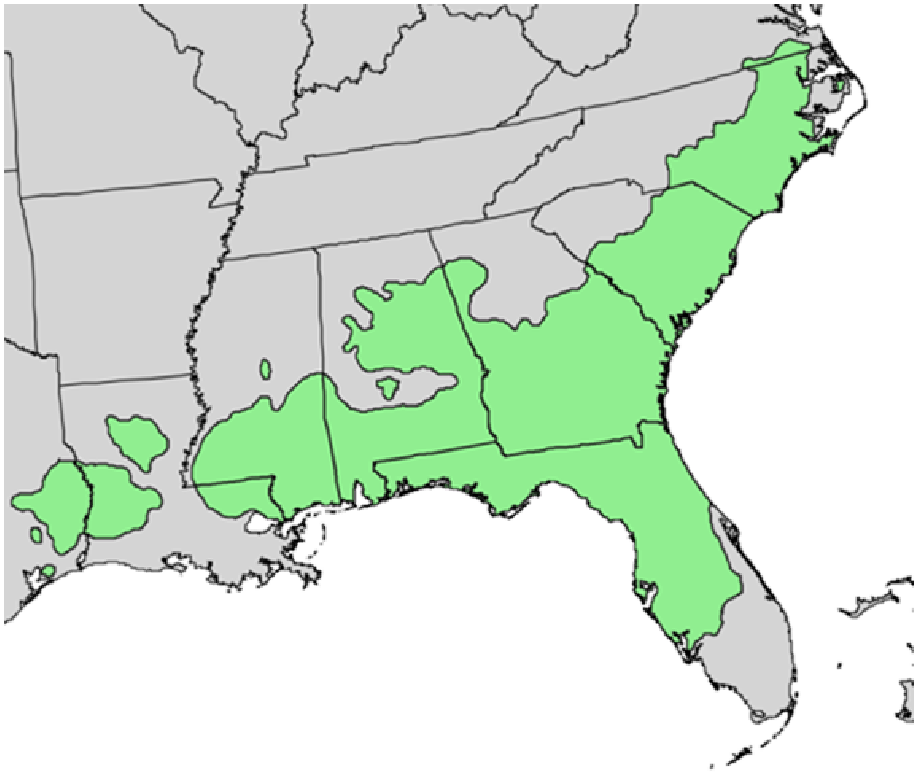
Agenda

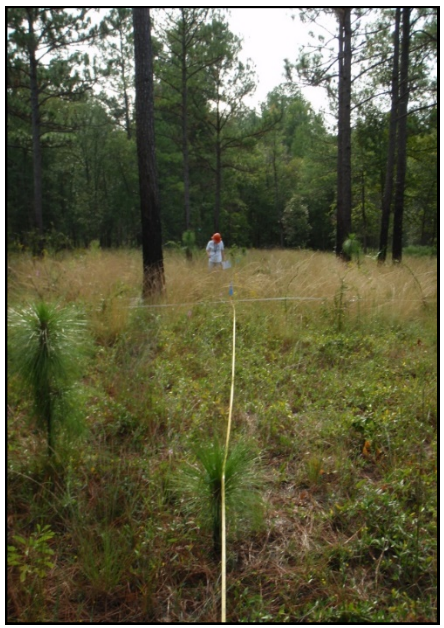
- Research objectives
- Approach
- Results
- Synthesis and implications
- Conclusions
- Benefits to DoD

Longleaf Pine Ecosystem



Research Objectives

- Maximize recovery of understory plant communities

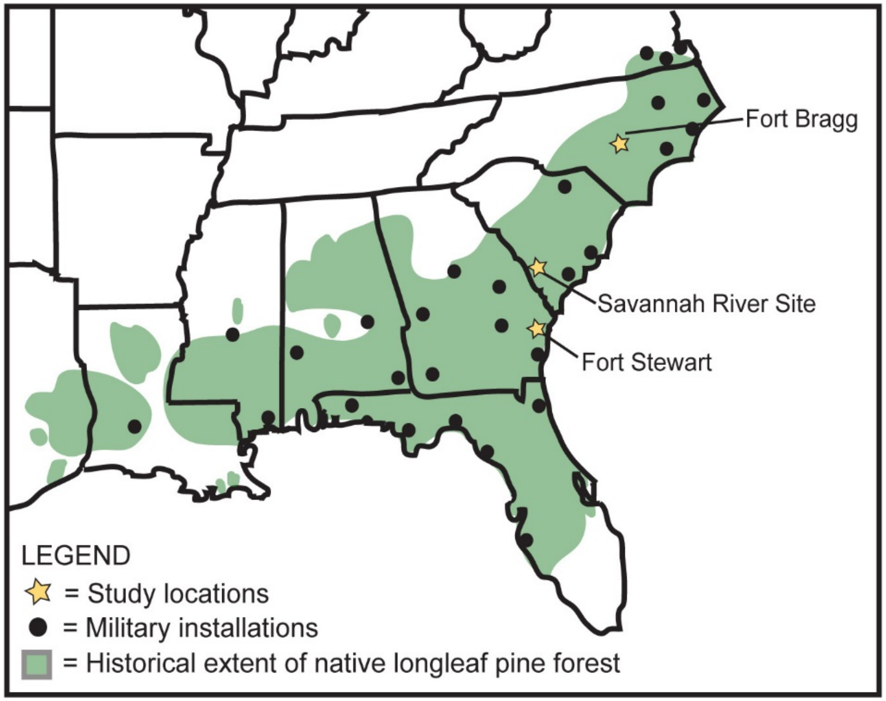


Research Objectives

- Maximize recovery of understory plant communities
- Determine the following:
  - The best predictors of recovery success
  - If recovery actions have lasting benefits
  - How management can promote recovery

Approach

Long-Term, Large Scale Experiment

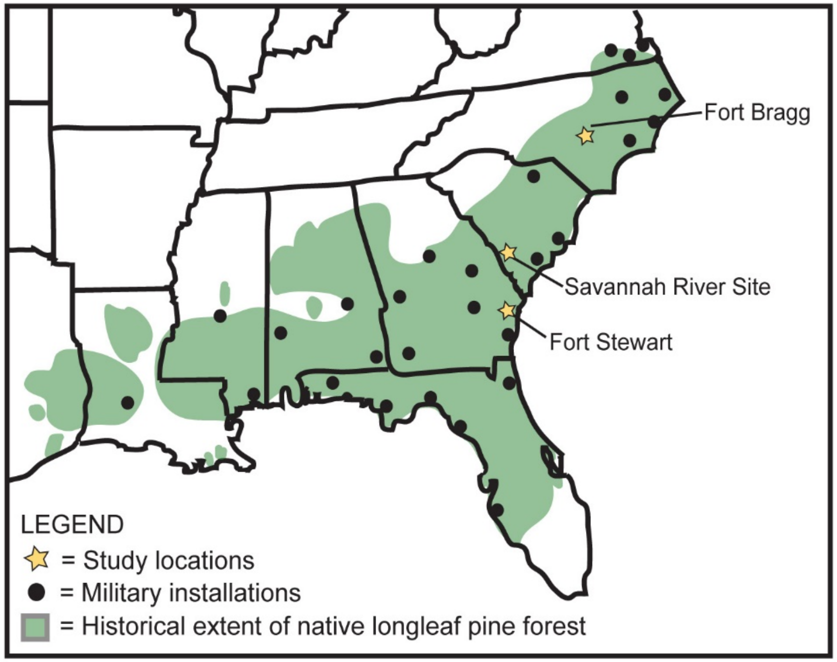


- 108 sites at 3 DoD/DOE facilities
  - Large-scale experiment
  - Added over 30 million seeds of 25 species
  - Collected vegetation data (2010-2013)

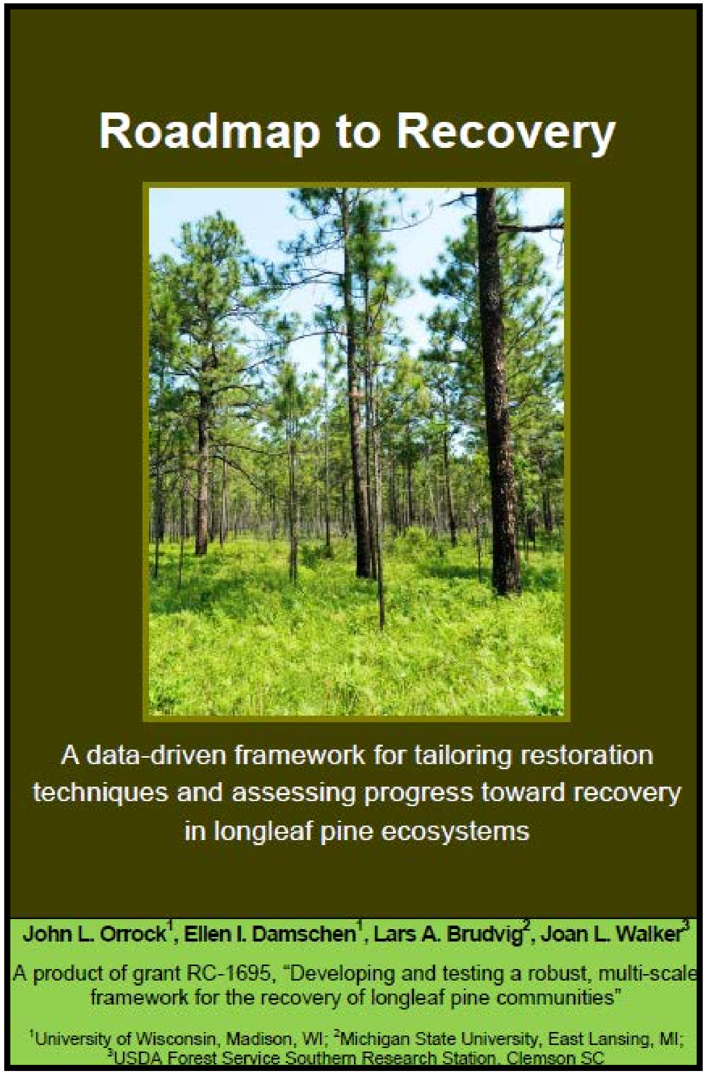
Seed Sowing at Fort Stewart

Approach

Long-Term, Large Scale Experiment



- 54 sites at 3 DoD/DOE facilities
  - Re-sample degraded sites 2017-2018
  - Determine if actions in 2010 yielded long-lasting recovery



Approach

Multi-Year Intensive Field Sampling

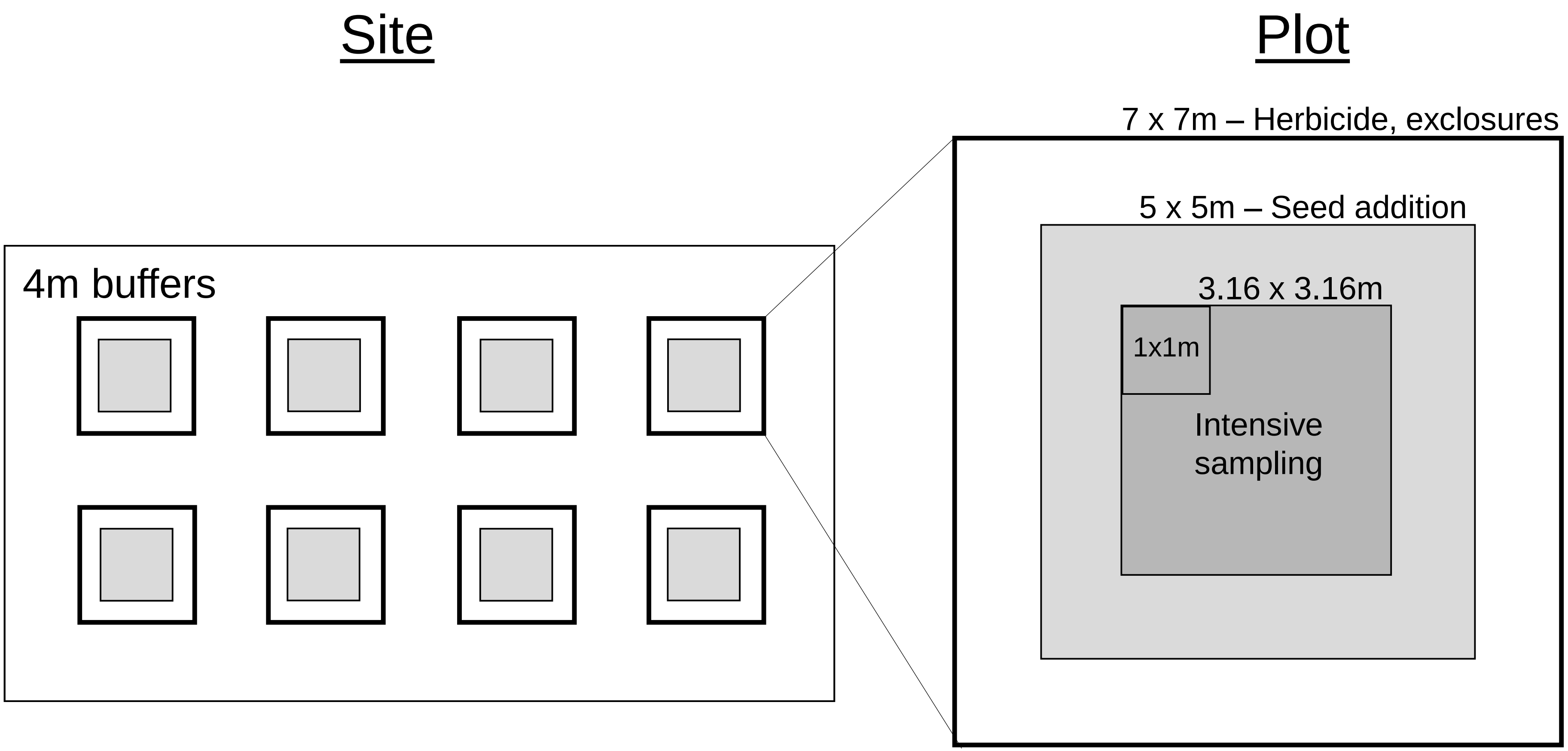






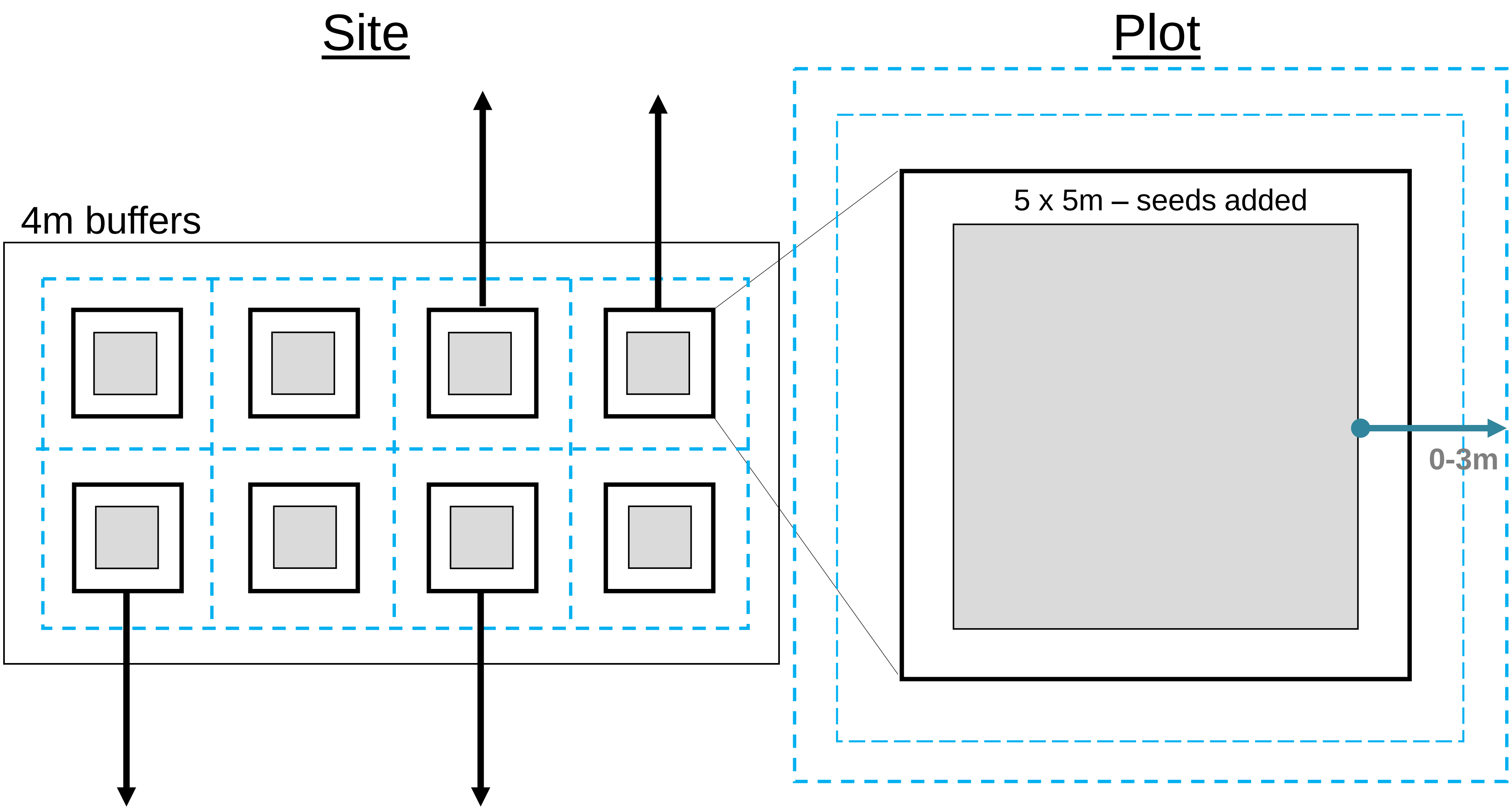

Approach

Intensive Field Sampling for Establishment and Persistence



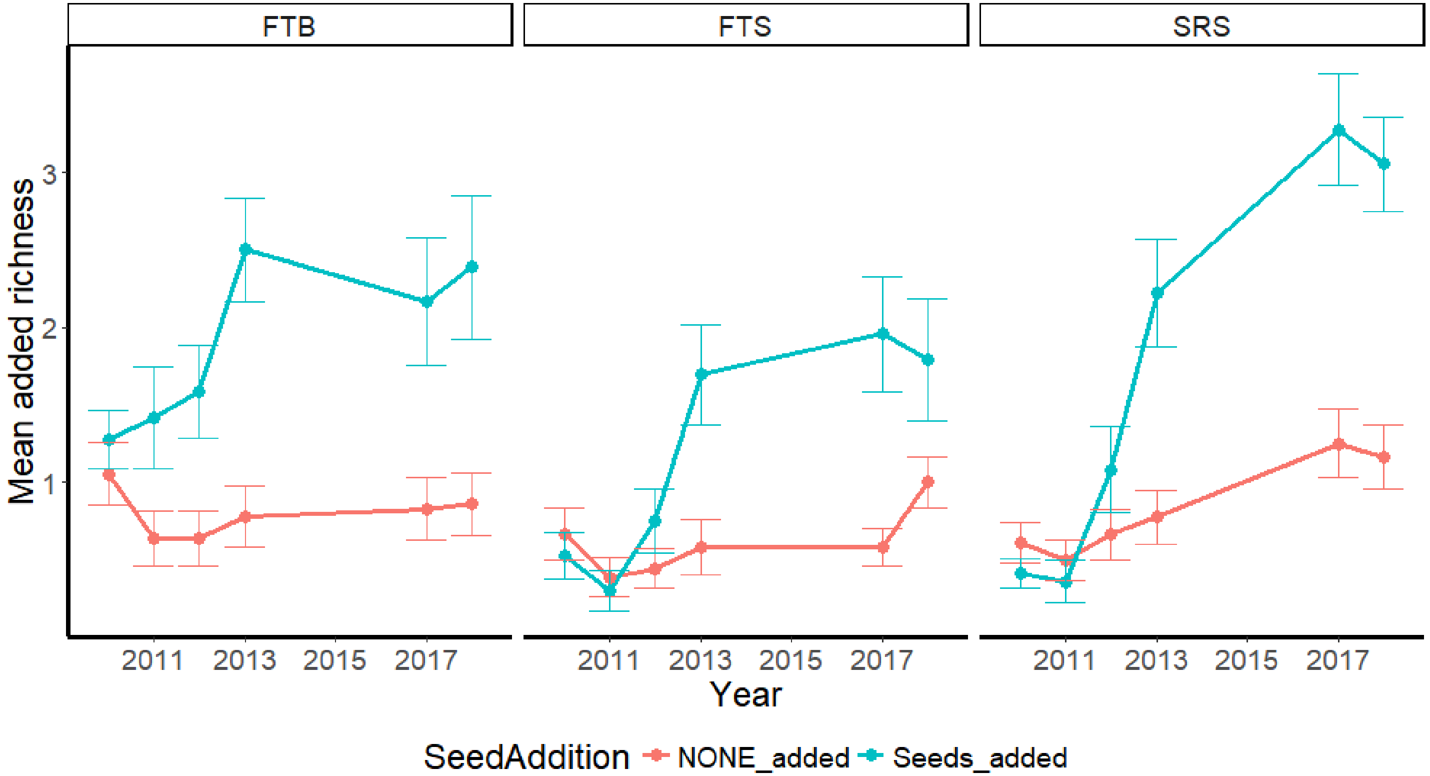
Approach

Intensive Field Sampling of Spatial Spread



Results

Seed Addition Consistently Improves Diversity

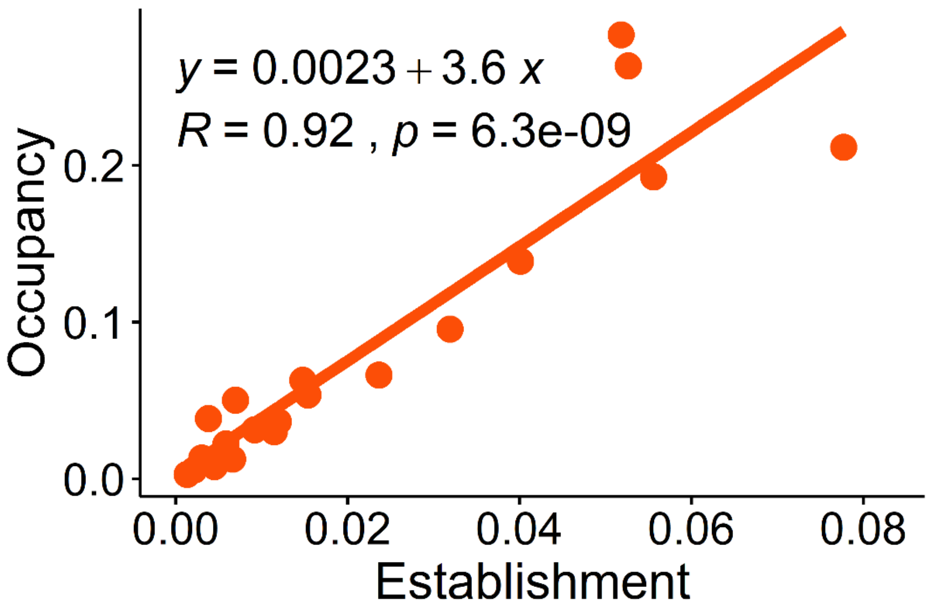


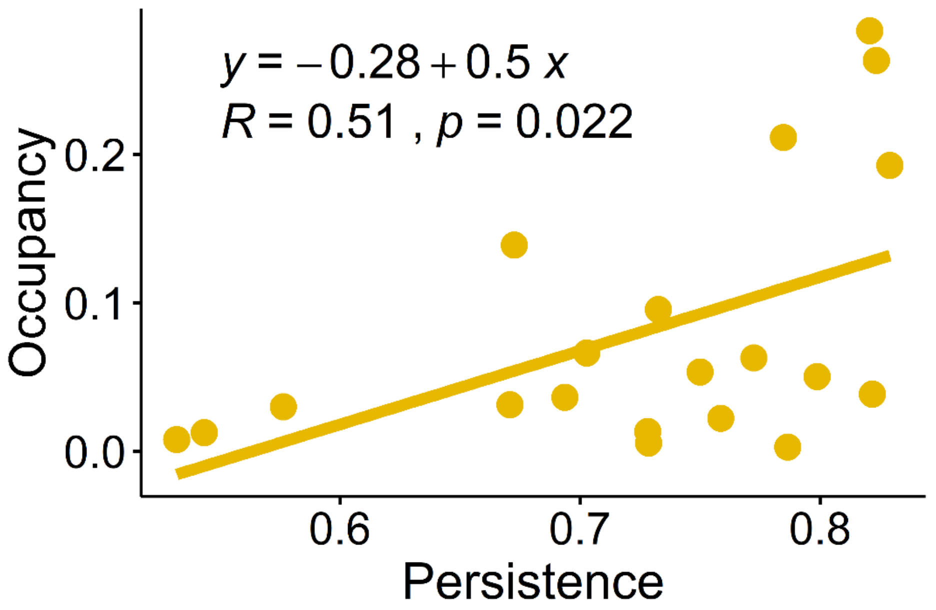
Coreopsis major

Rhexia mariana

Results

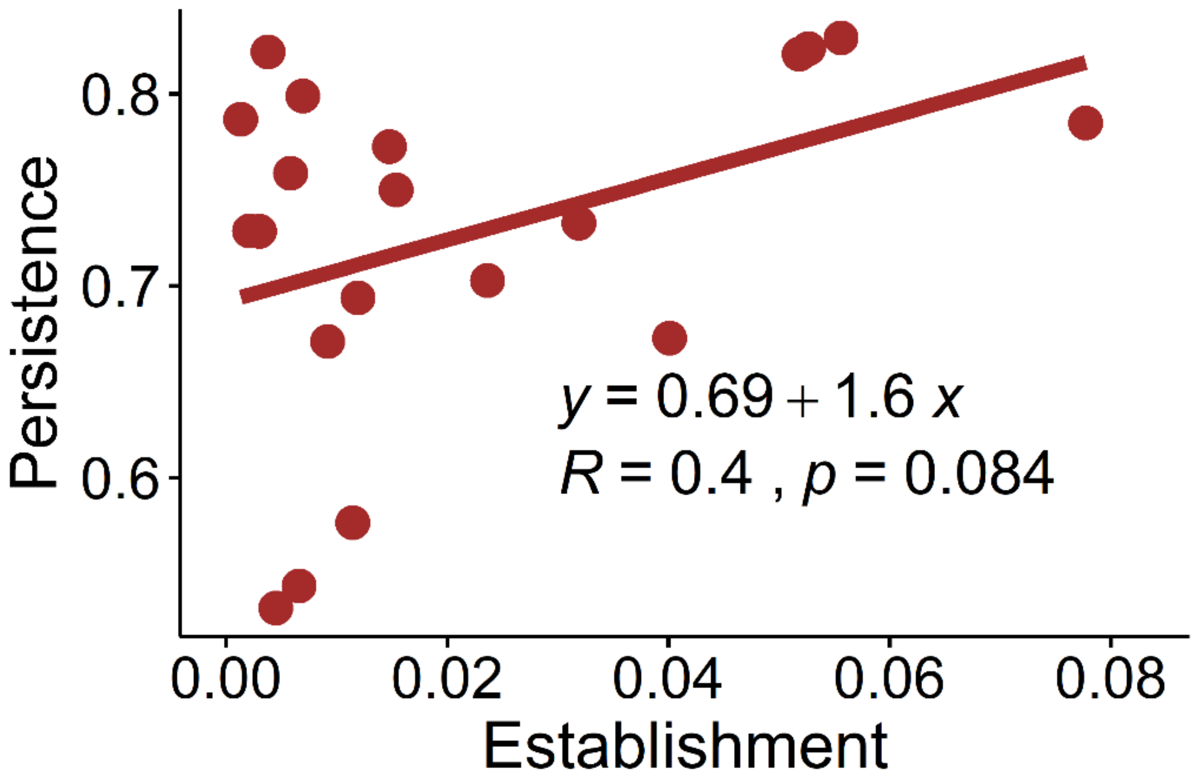
Establishment is the Key Process Determining Recovery





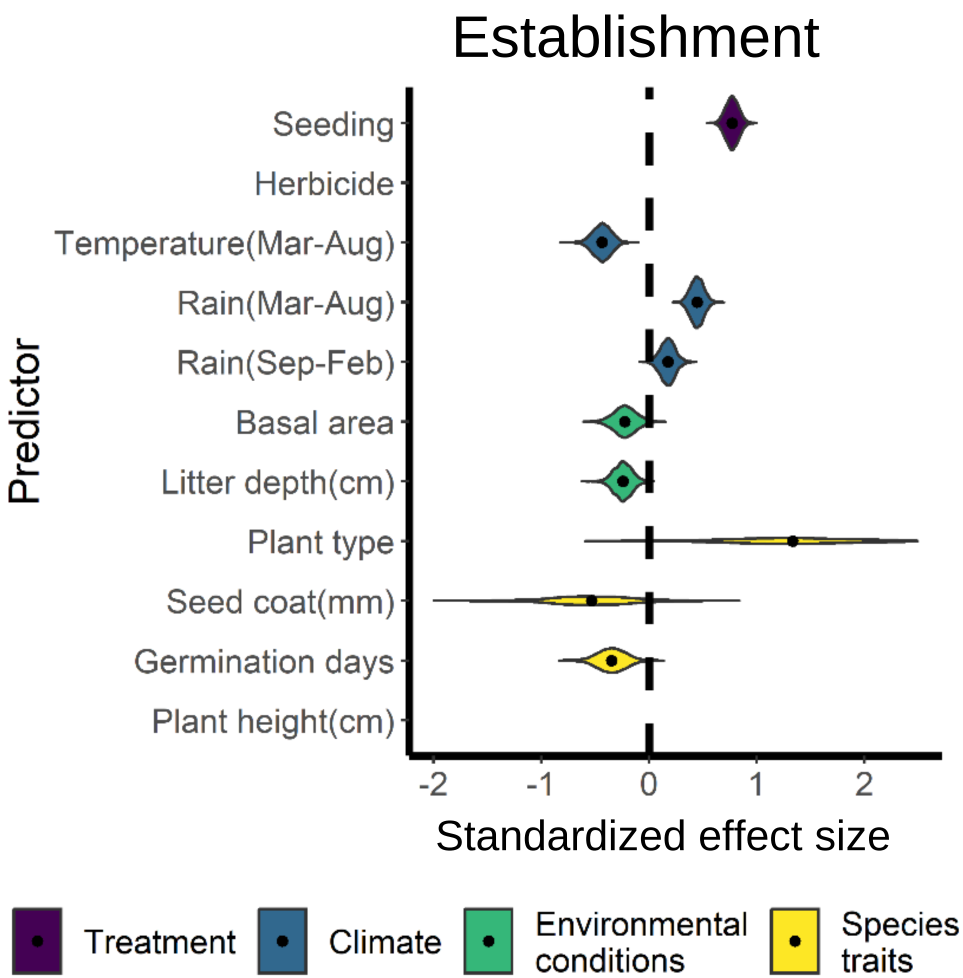
Results

Once Established, Persistence is Generally High



Results

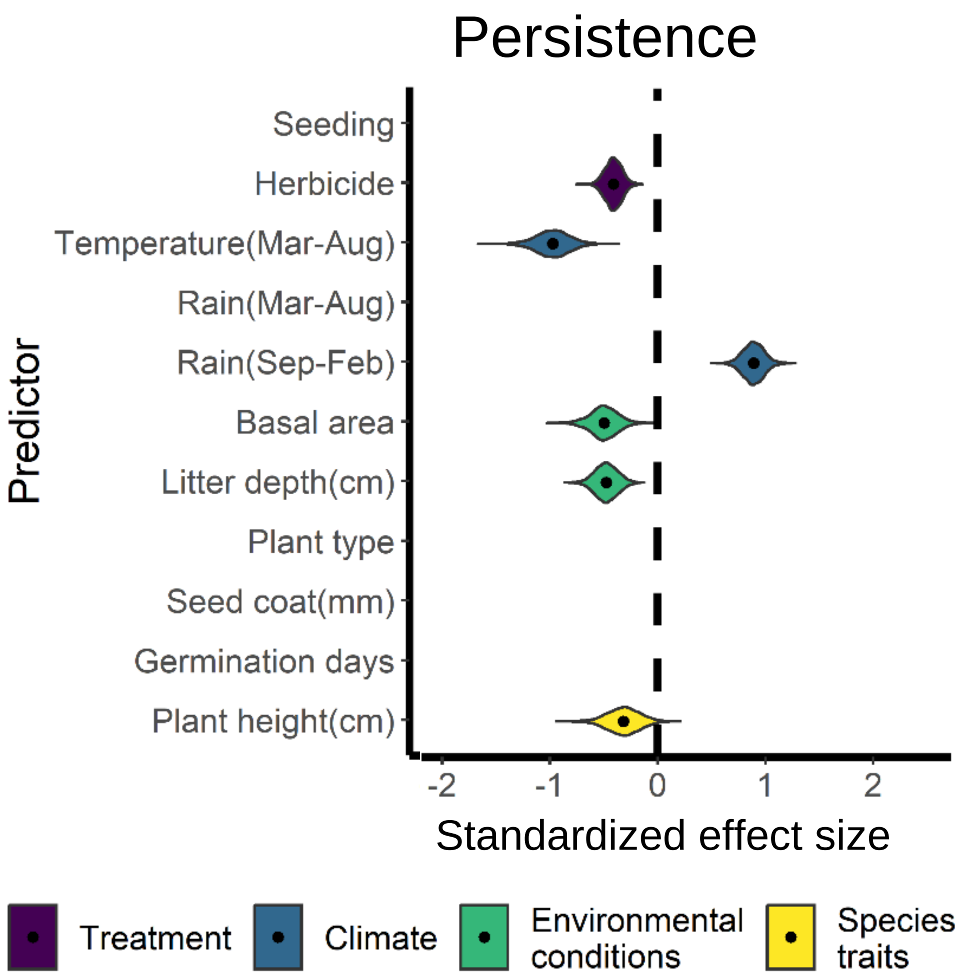
Key Factors Affecting Establishment



- Seed addition
- Climate
  - Temperature
  - Precipitation
- Management
- Plant traits

Results

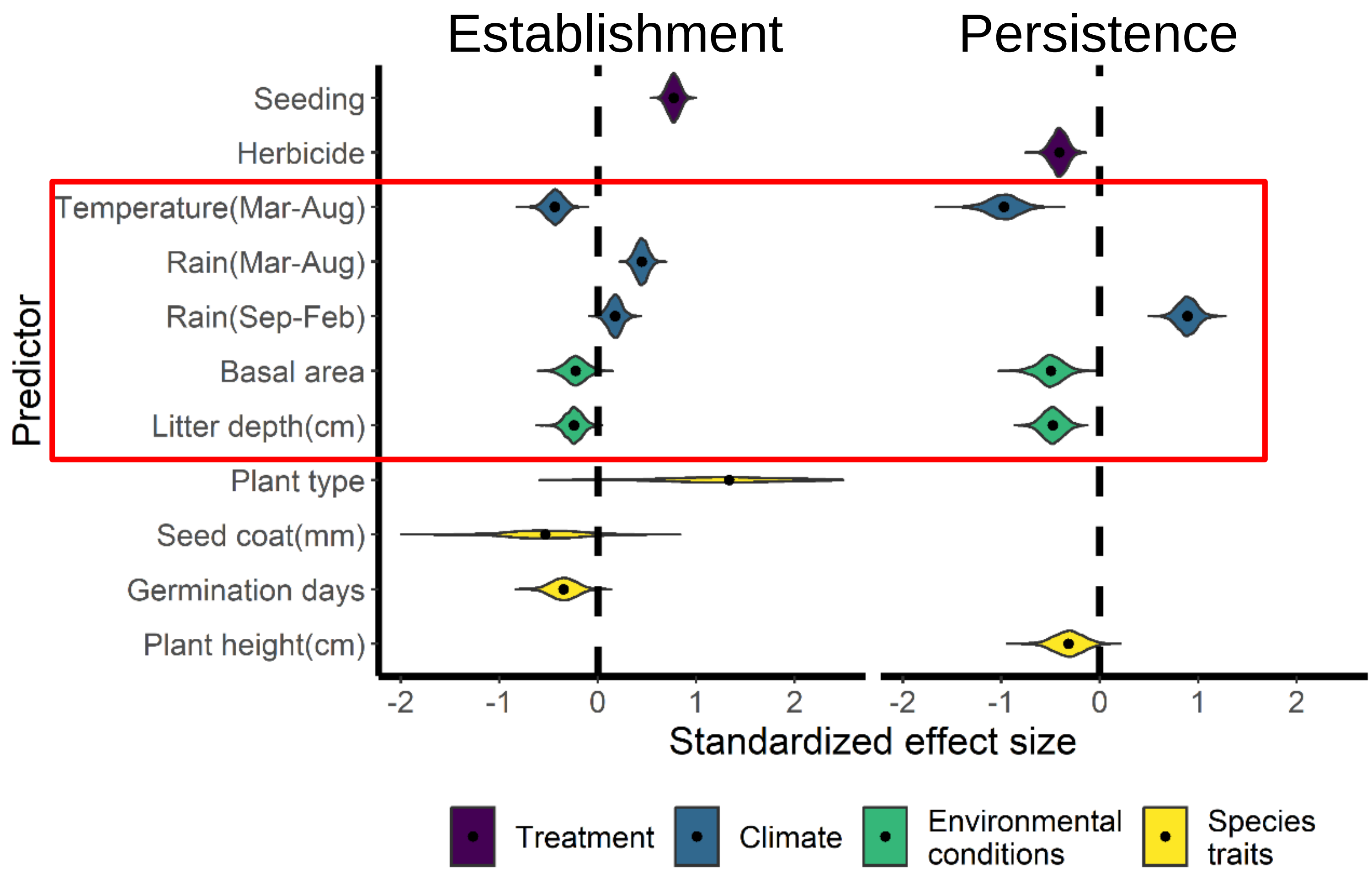
Key Factors Affecting Persistence



- Herbicide
- Climate
  - Temperature
  - Precipitation
- Management

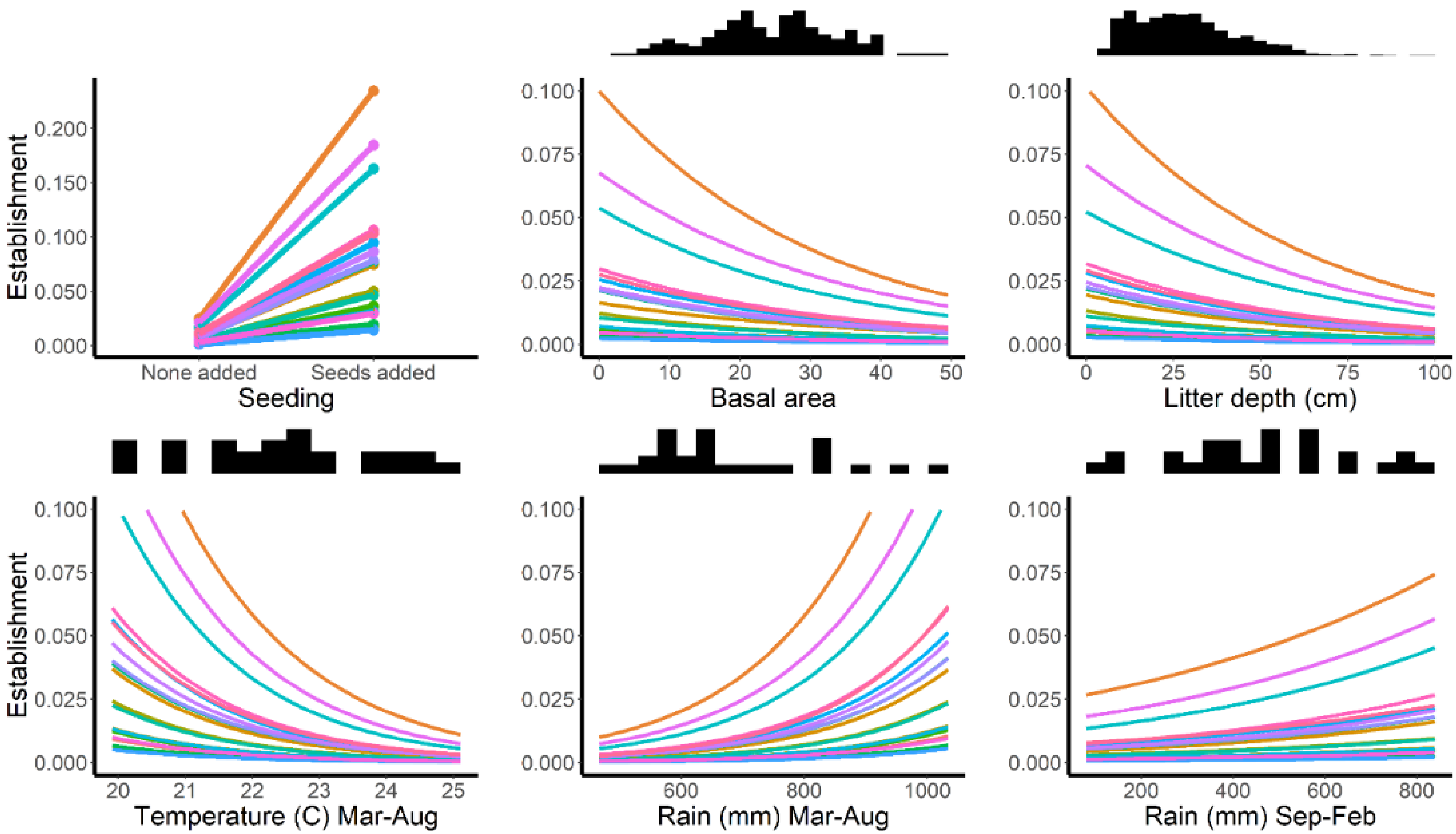
Results

Climate and Management Affect Establishment and Persistence



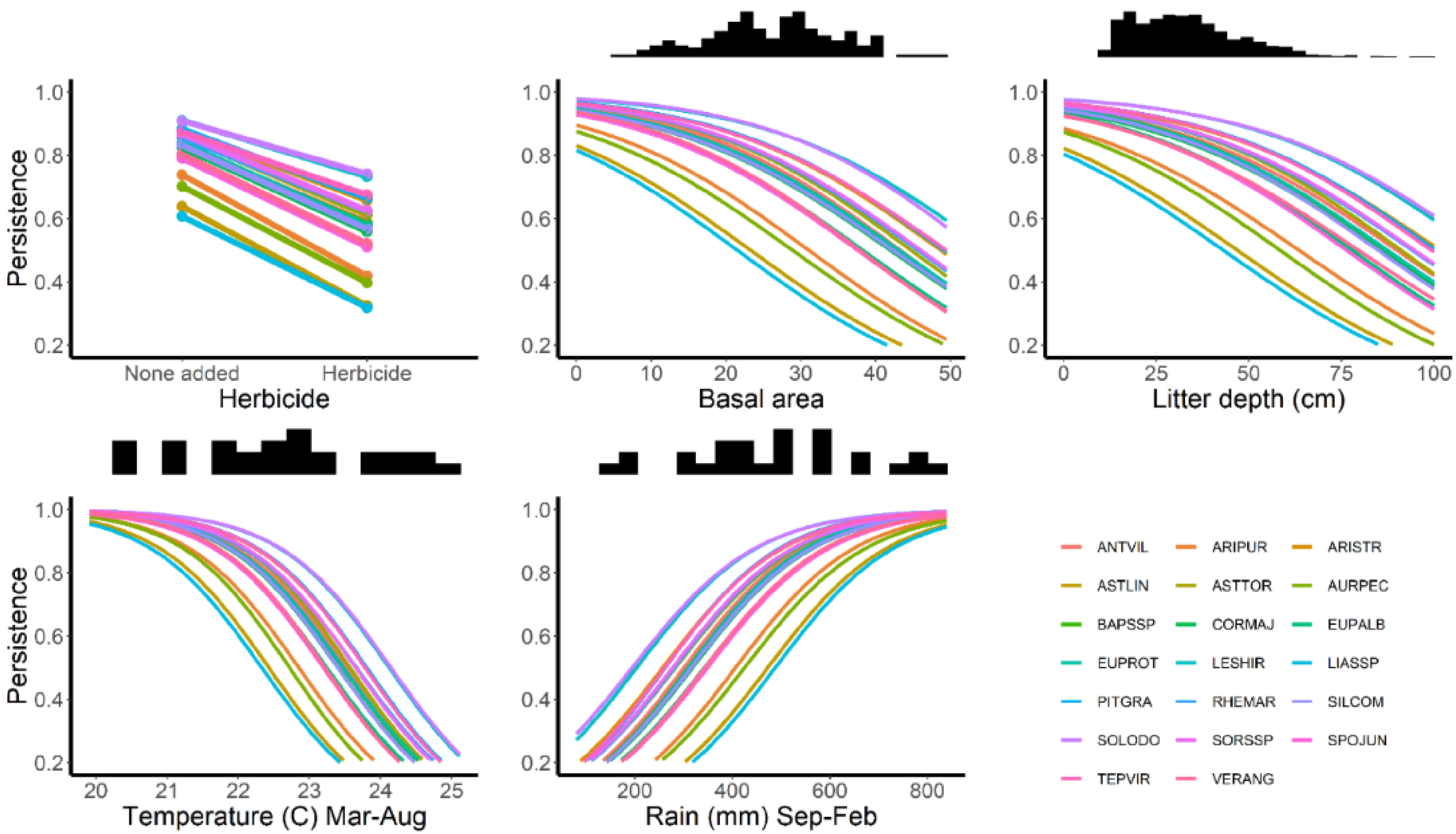
Results

Species-Specific Differences in Establishment



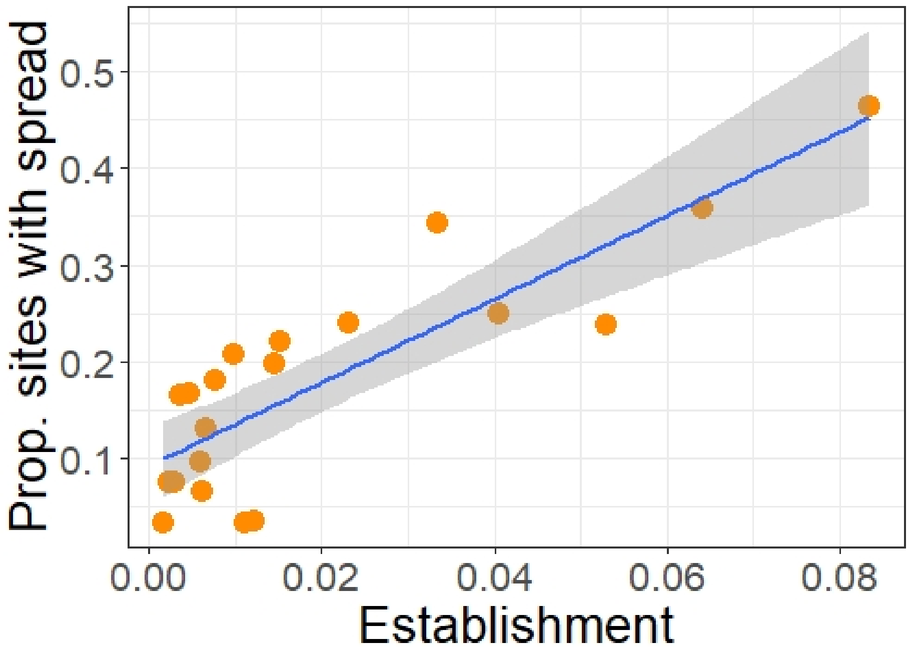
Results

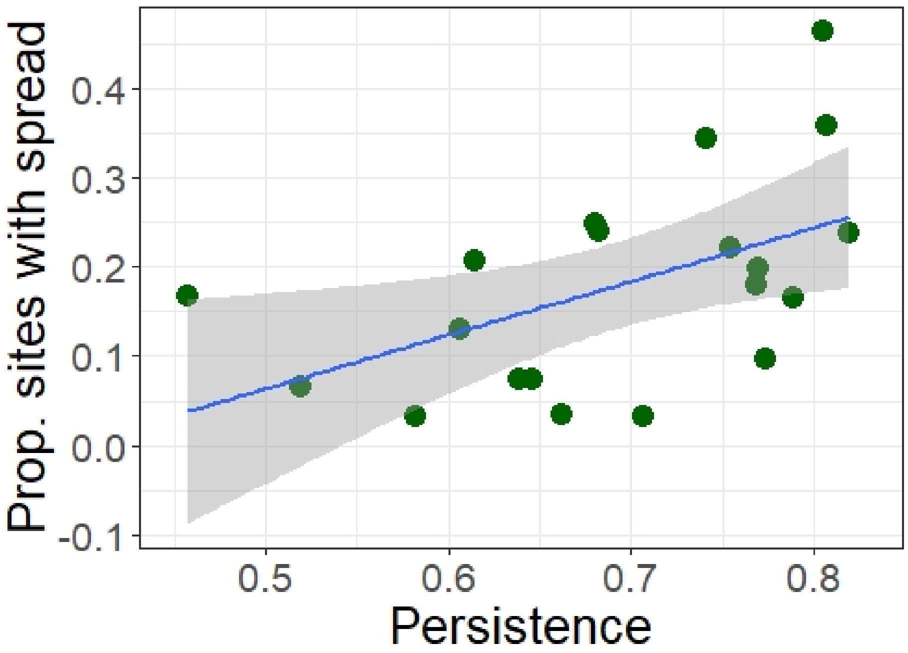
Species-Specific Differences in Persistence



Results

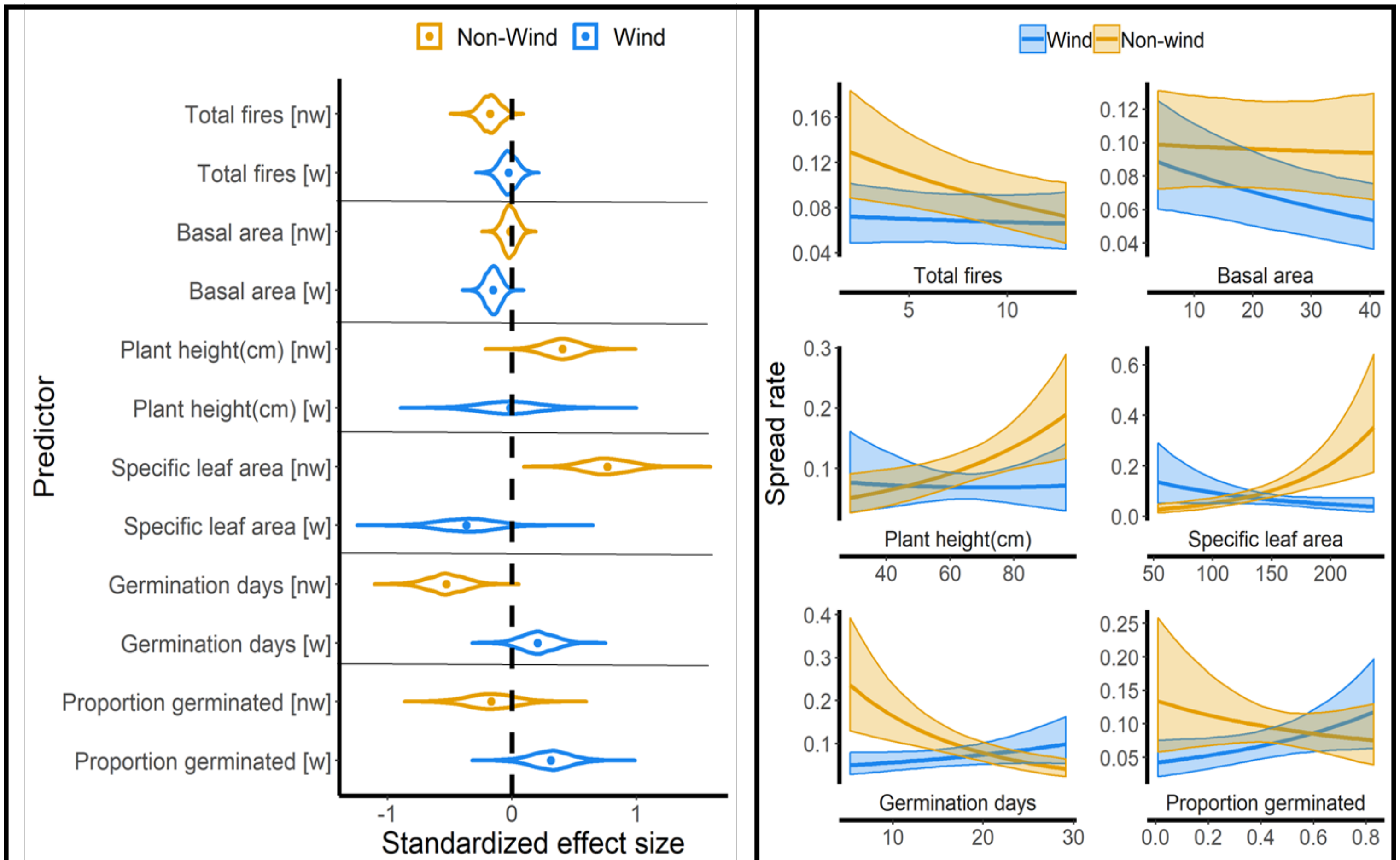
Establishment is the Primary Predictor of Spatial Spread





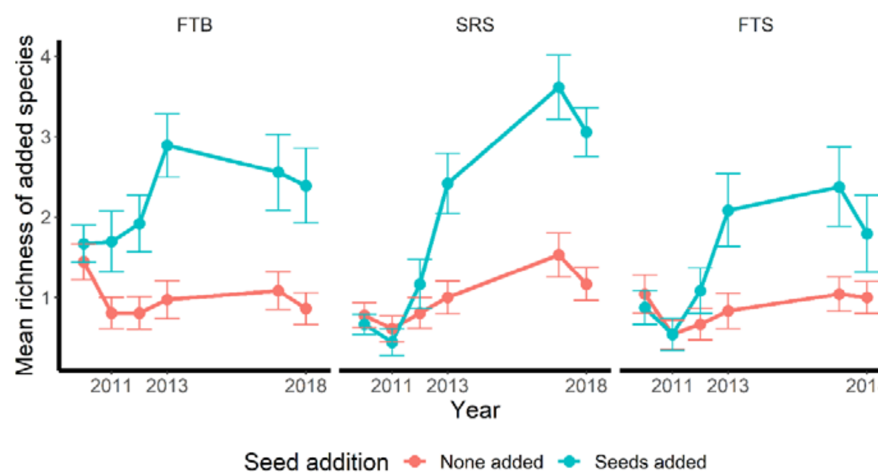
Results

Spatial Spread Depends on Plant Dispersal Mode



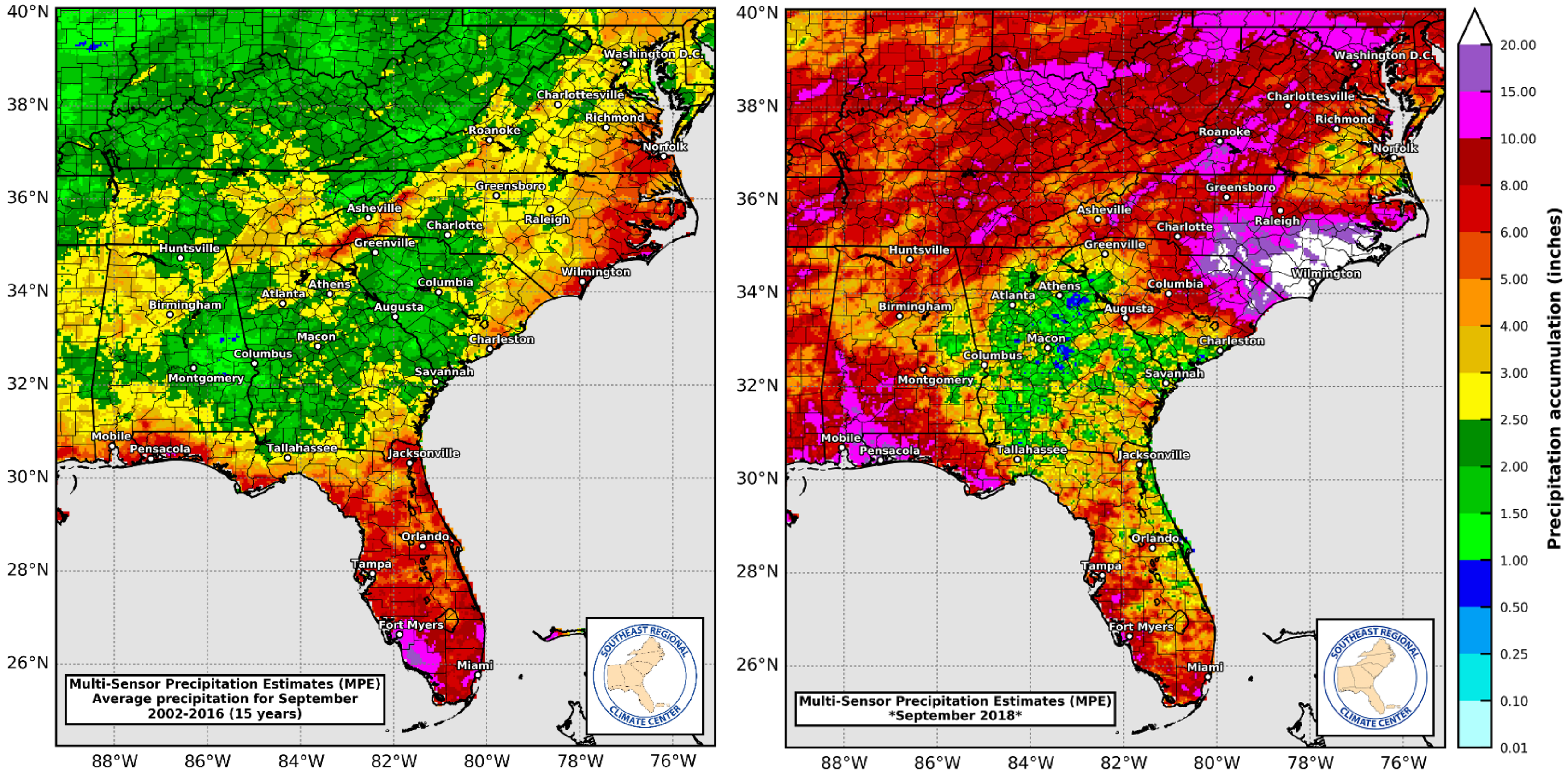
Synthesis and Implications

A Single Seed Addition May Initiate Long-lasting Recovery



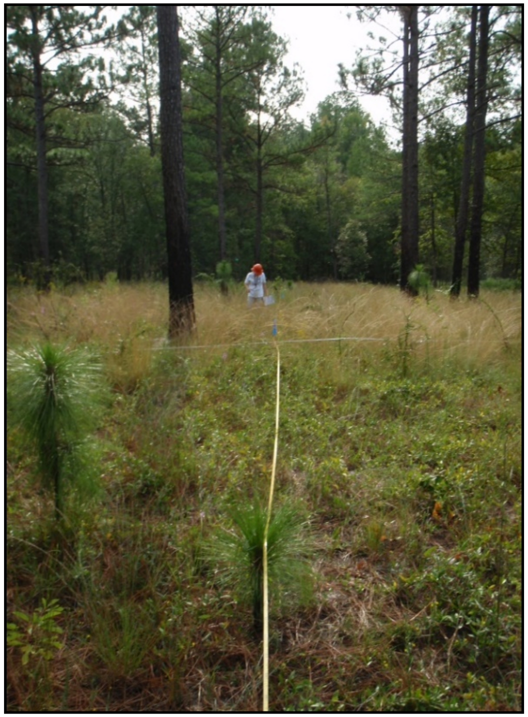
Synthesis and Implications

Optimal Recovery Depends on Climatic Variation



Synthesis and Implications

Once Established, Recovering Populations Continue to Spread



Conclusions

- Establishment is primary factor limiting recovery
- Seed limitation promotes establishment
- Once established, recovered populations persist and spread
- Climate and management can both affect recovery and spread

Benefits to DoD

- Seed additions may be a cost-effective means to promote recovery
- Single additions may yield long-lasting, self-spreading recovery
- Ability to optimize recovery to match climatic conditions and management priorities

Acknowledgements

- DoD/DOE partners
  - Janet Bracey Gray, Jason Monroe, David Heins, Timothy Beatty, Larry Carlisle, Dee Mincey, John Blake, Andy Horcher, DeVela Clark, Ed Olson
- Research scientists
  - Jen Cruz, Angela Larsen
- Graduate students and technicians
  - Savannah Bartel, Sabrie Breland

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jorrock@wisc.edu; 608-263-5134

Q&A Session 2

The next webinar is on April 9, 2020

Ecological Risk Assessment Approaches at PFAS-Impacted Sites

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Survey Reminder

Please take a moment to complete the survey that will pop up on your screen when the webinar ends