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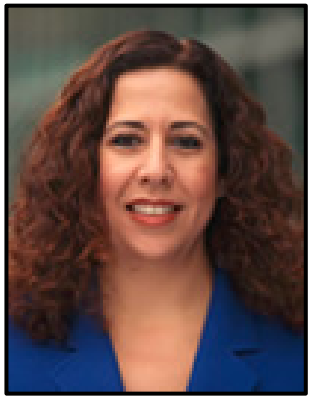
Management of Novel Hawaiian Ecosystems

December 7, 2017

SERDP DOD • EPA • DOE | ESTCP

Welcome and Introductions



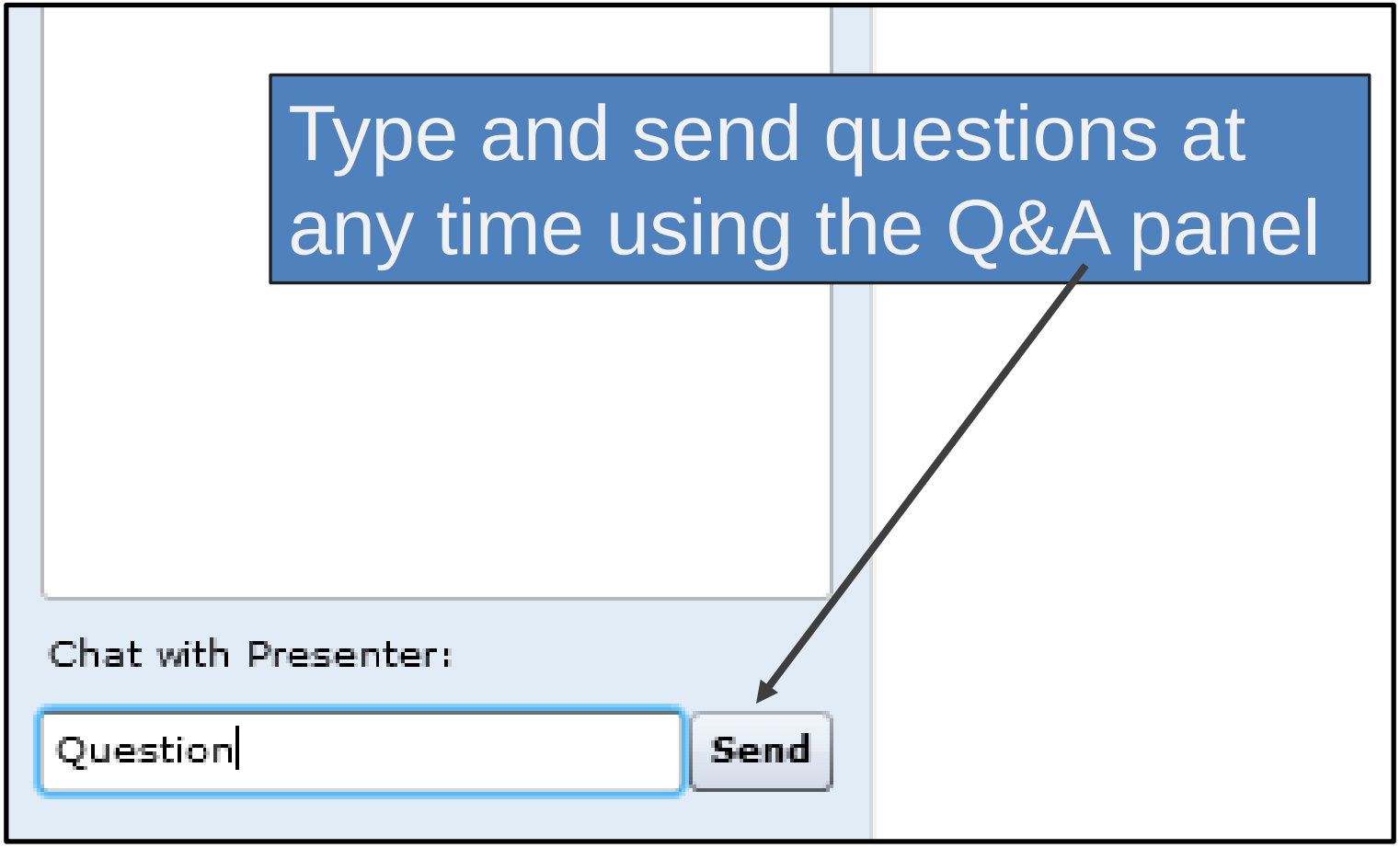
Rula A. Deeb, Ph.D.
Webinar Coordinator

SERDP DOD • EPA • DOE | ESTCP

Webinar Agenda

- **Webinar Logistics** (5 minutes)
  Dr. Rula Deeb, Geosyntec Consultants
- **Overview of SERDP and ESTCP** (5 minutes)
  Dr. Kurt Preston, SERDP and ESTCP
- **Quantitative Approaches Towards Restoration in Dryland Ecosystems in Hawaii** (25 minutes + Q&A)
  Dr. Susan Cordell, USDA Forest Service
- **Integrating Plant Functional Traits into Restoration Design: An Example in Hawaiian Lowland Wet Forest** (25 minutes + Q&A)
  Dr. Rebecca Ostertag, University of Hawaii at Hilo
- **Final Q&A session**

How to Ask Questions



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- Submit a question using the chat box

SERDP and ESTCP Overview

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

SERDP DOD • EPA • DOE | ESTCP

SERDP

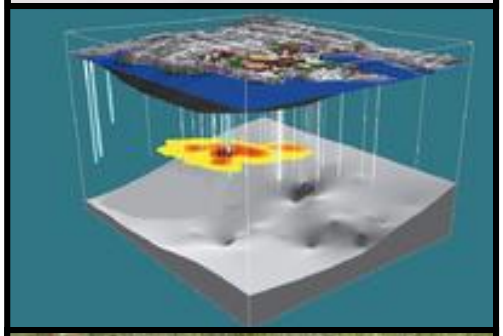
- Strategic Environmental Research and Development Program
- Established by Congress in FY 1991
  - DoD, DOE and EPA partnership
- SERDP is a requirements driven program which identifies high-priority environmental science and technology investment opportunities that address DoD requirements
  - Advanced 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

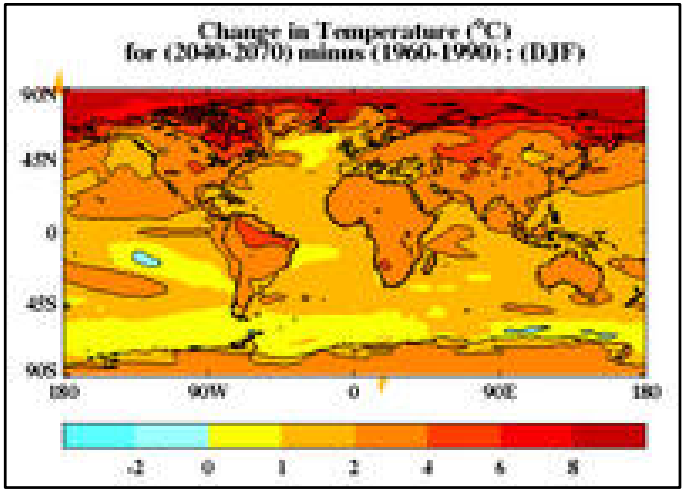
Program Areas

1. Energy and Water
2. Environmental Restoration
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
- Climate change
  - Vulnerability and impact assessment
  - Adaptation science
  - Land use and carbon management
- Air quality
  - Fugitive dust
  - Fire emissions



SERDP and ESTCP Webinar Series

- Webinars will continue every new weeks in 2018
- For upcoming webinars, please visit http://serdp-estcp.org/Tools-and-Training/Webinar-Series

Quantitative Approaches Towards Restoration in Dryland Ecosystems in Hawaii

Susan Cordell, Ph.D.
USDA Forest Service

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Goals for This Presentation

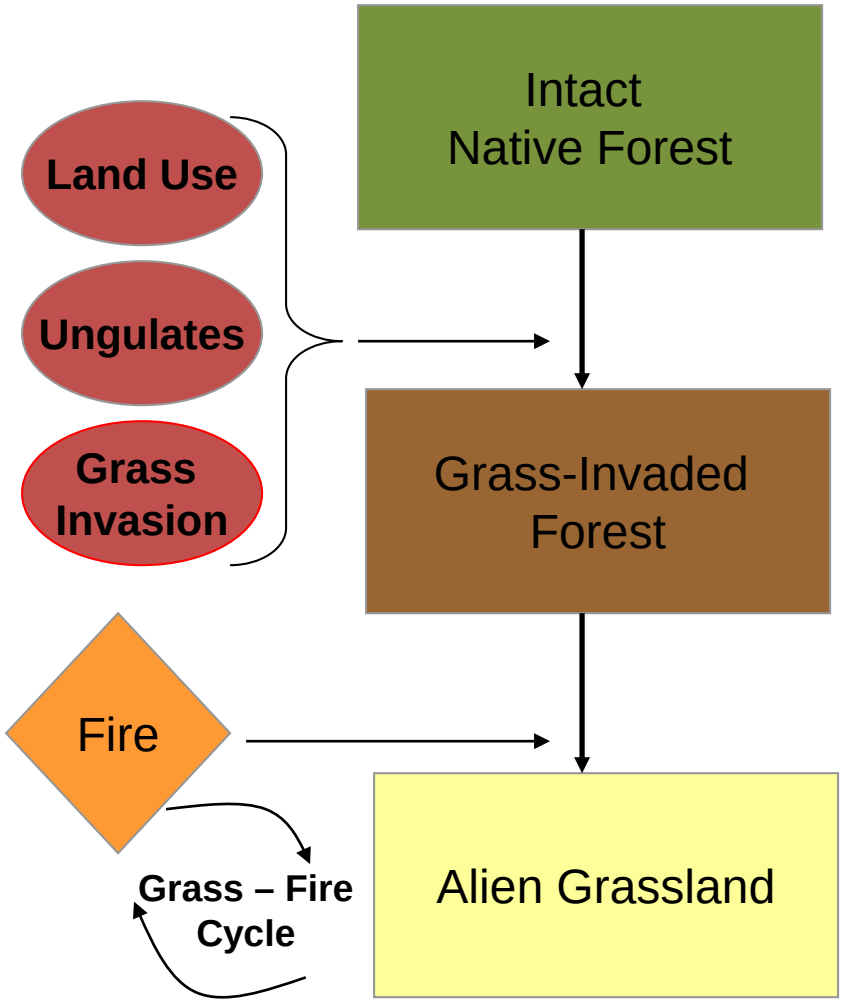
- Convey restoration challenges in Hawaii and the Pacific Islands
- Convince you why this is an important issue for biodiversity and Department of Defense (DoD) lands
- Elucidate strategies for restoration approaches and planning

Background

- Tropical dry forest resources in Hawaii and the Pacific are declining at alarming rates
- This is largely a result of fire, originating from invasion of native ecosystems by fire-prone exotic grass species
- Many DoD installations in Hawaii and the Pacific occur within tropical dry forests and contain numerous TERS (>50 species)
- DoD spends more than 10 million dollars per year in Hawaii protecting TES, often resulting in compromised ability to train
- Focused restoration planning allows for:
  - Conservation of biodiversity
  - Reduced management costs
  - Effective partitioning of multi-use landscapes

TES: Threatened and endangered species

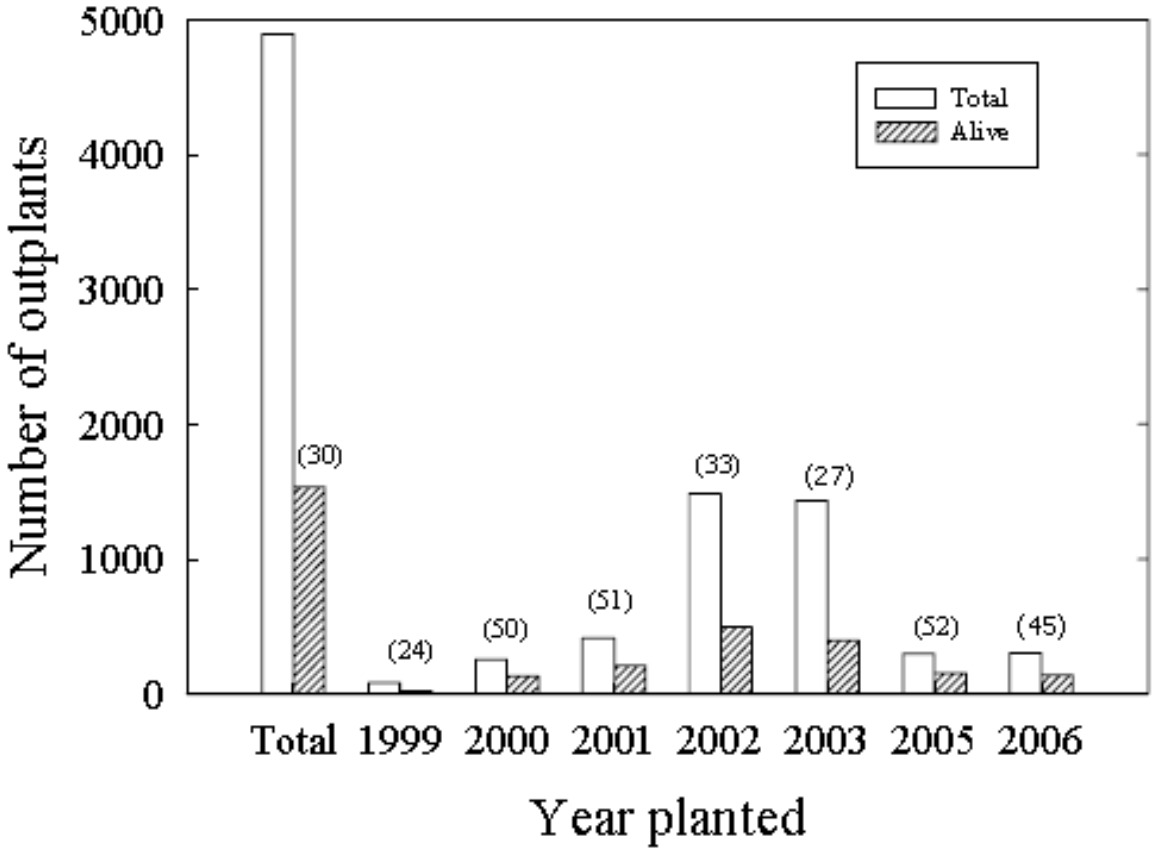
Dryland Ecosystem Change



D'Antonio and Vitousek, 1992

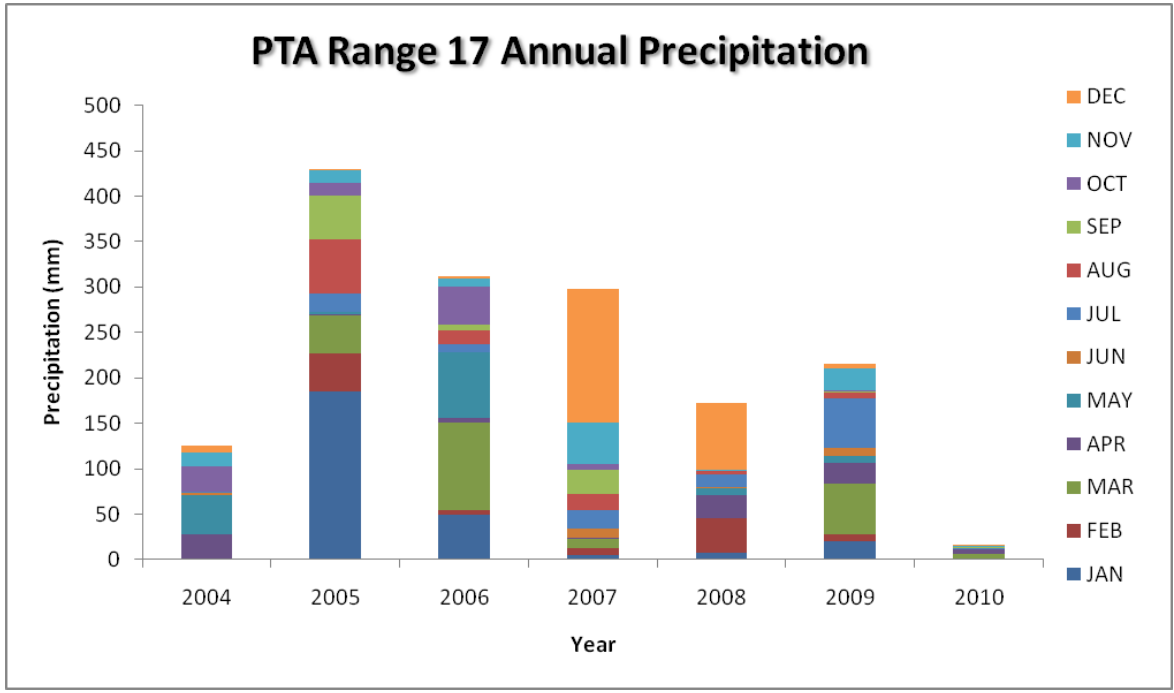
Challenges to Recovery

1. Survival is low and variable



Challenges to Recovery

1. Survival is low and variable
2. Extreme environmental conditions



Pohakuloa (PTA) has mean annual precipitation <500mm (19.7”), diurnal temperature variation, wind, wildfires

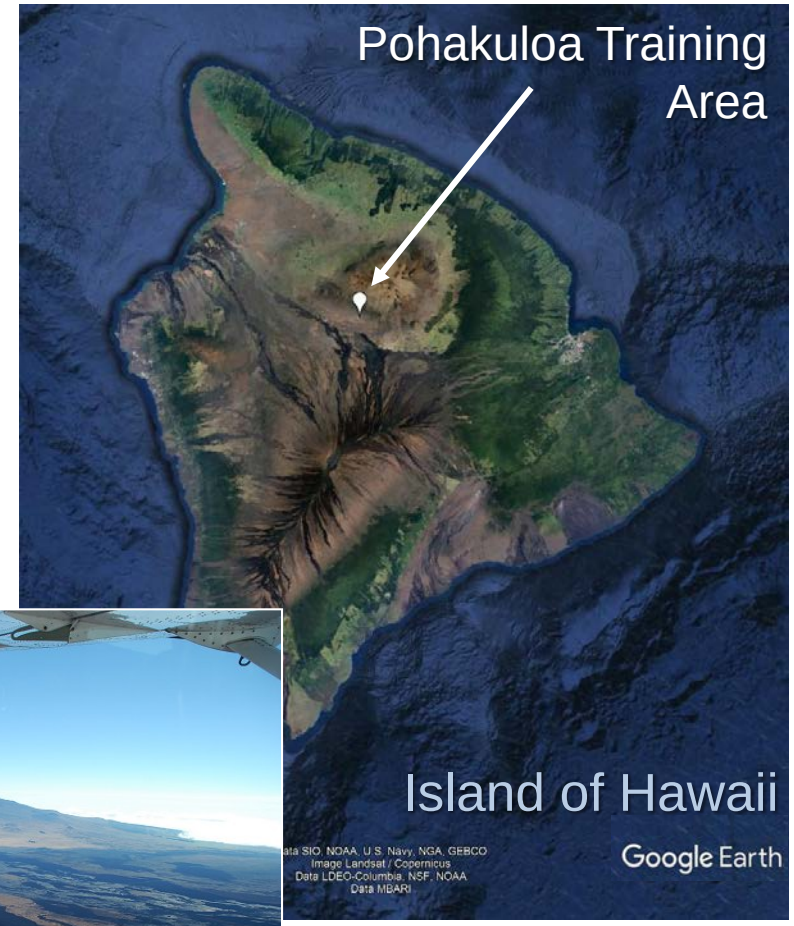
Challenges to Recovery

1. Survival is low and variable
2. Extreme environmental conditions
3. Desiccation stress

Seedling desiccation is a barrier to reintroduction across ecosystems
(Helenurm, 1998; Godefroid et al., 2011)

Challenges to Recovery

1. Survival is low and variable
2. Extreme environmental conditions
3. Desiccation stress
4. Large areas with limited access



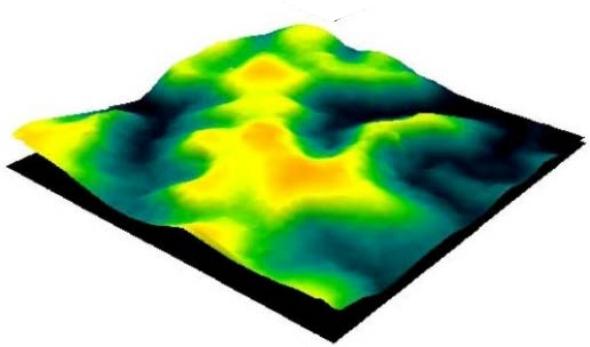
Increasing the Impact of Restoration

- **Objective**: Increase the impact of restoration by targeting activities to areas of the landscape where they will have the largest impact
- How?
  - Develop remote sensing tools for landscape mapping
  - Develop indicators of restoration suitability

Remote Sensing Tools for Restoration and Reintroduction

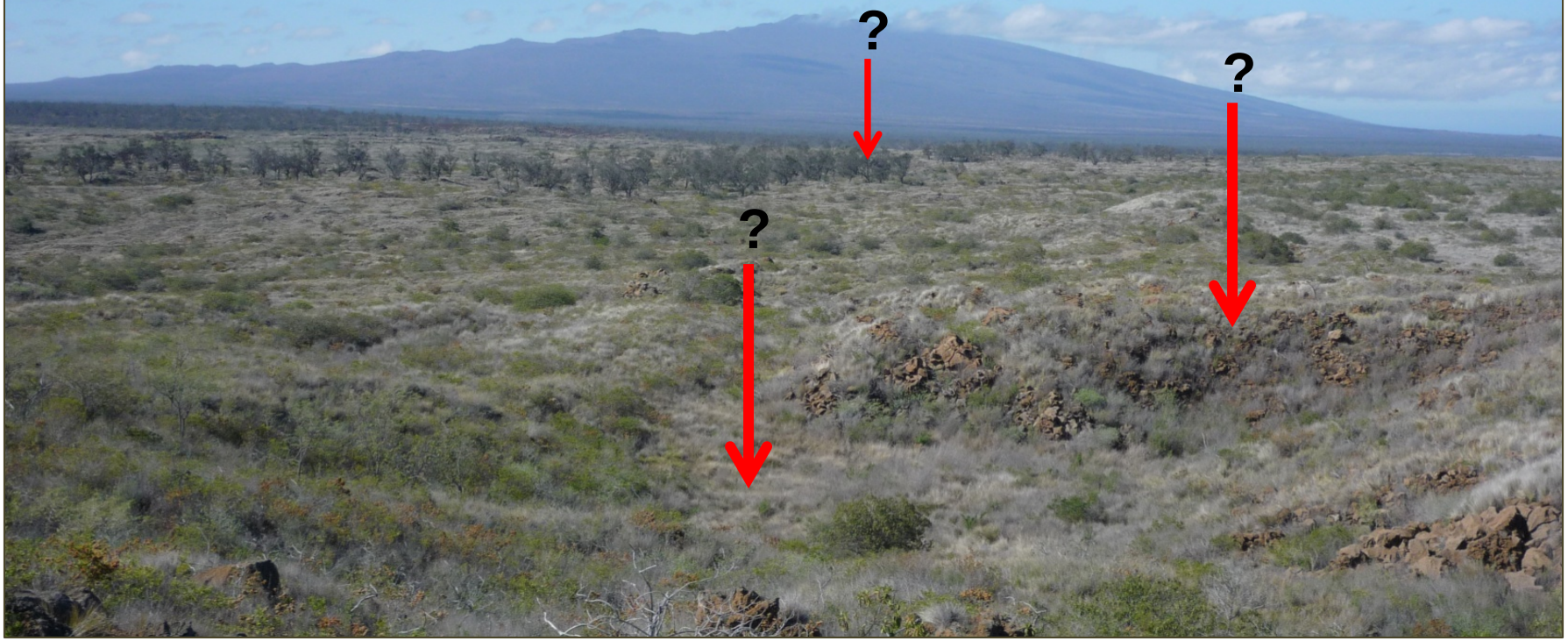
Eyes in the Sky, Plants in the Ground

© Ball Aerospace and Technologies Corp.



Successful Planting Locations

- Now that we have the tool – what are we looking for?
- Where on the landscape will outplanting be most successful?



Habitat Suitability Model

Light Detection and Ranging (LiDAR) → Digital Elevation Model → Habitat Suitability Model

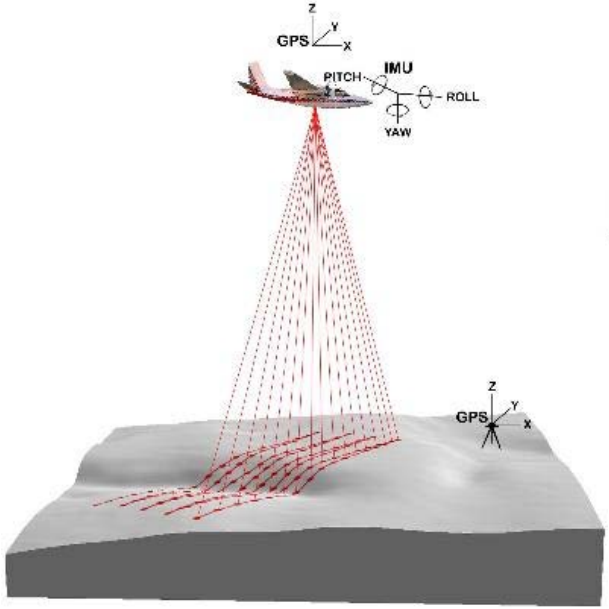
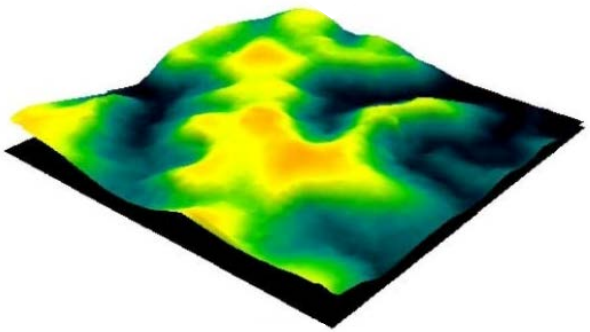


Image from http://forsys.cfr.washington.edu/



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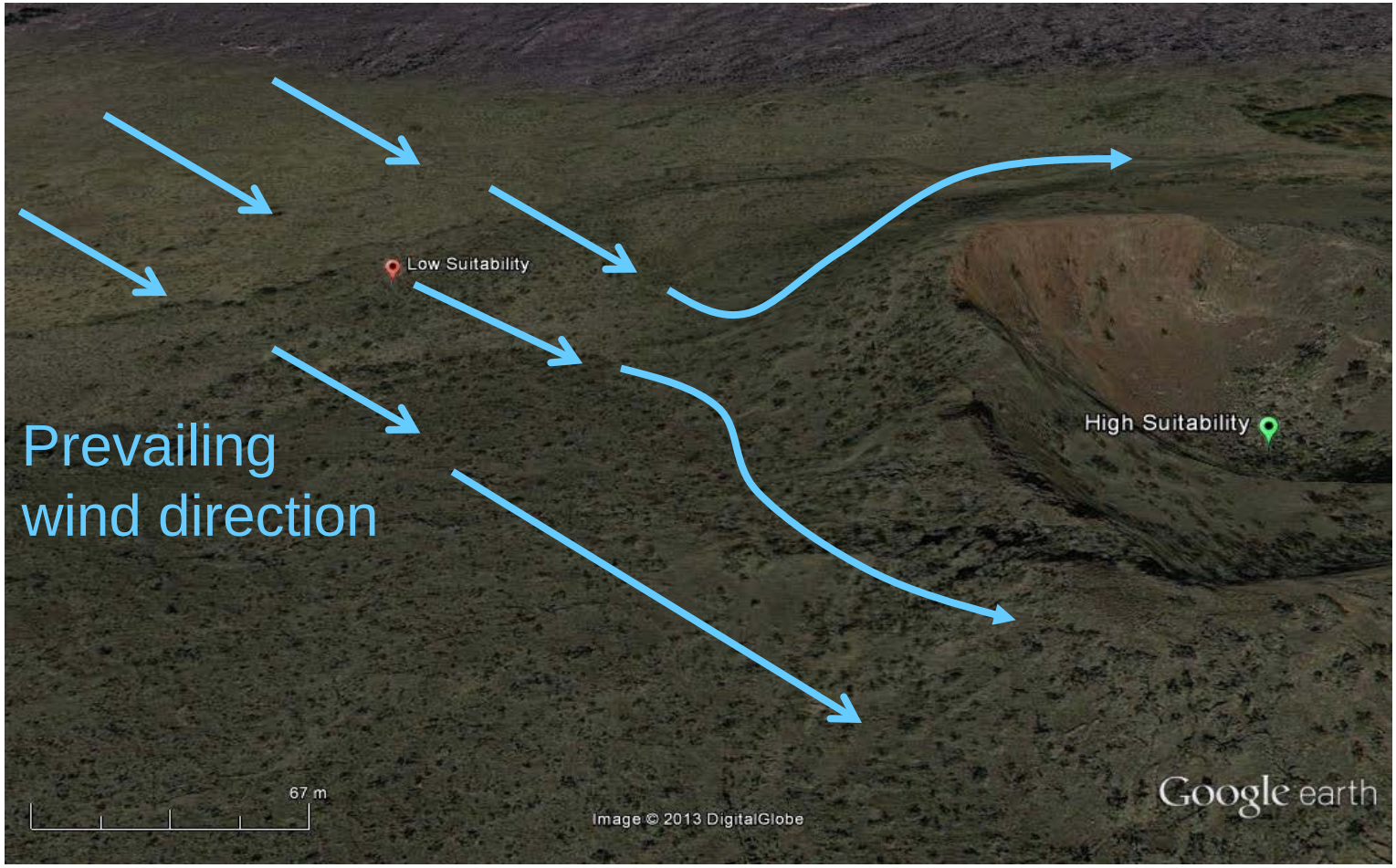
Questad et al., 2014. Ecological Applications

Habitat Suitability Model

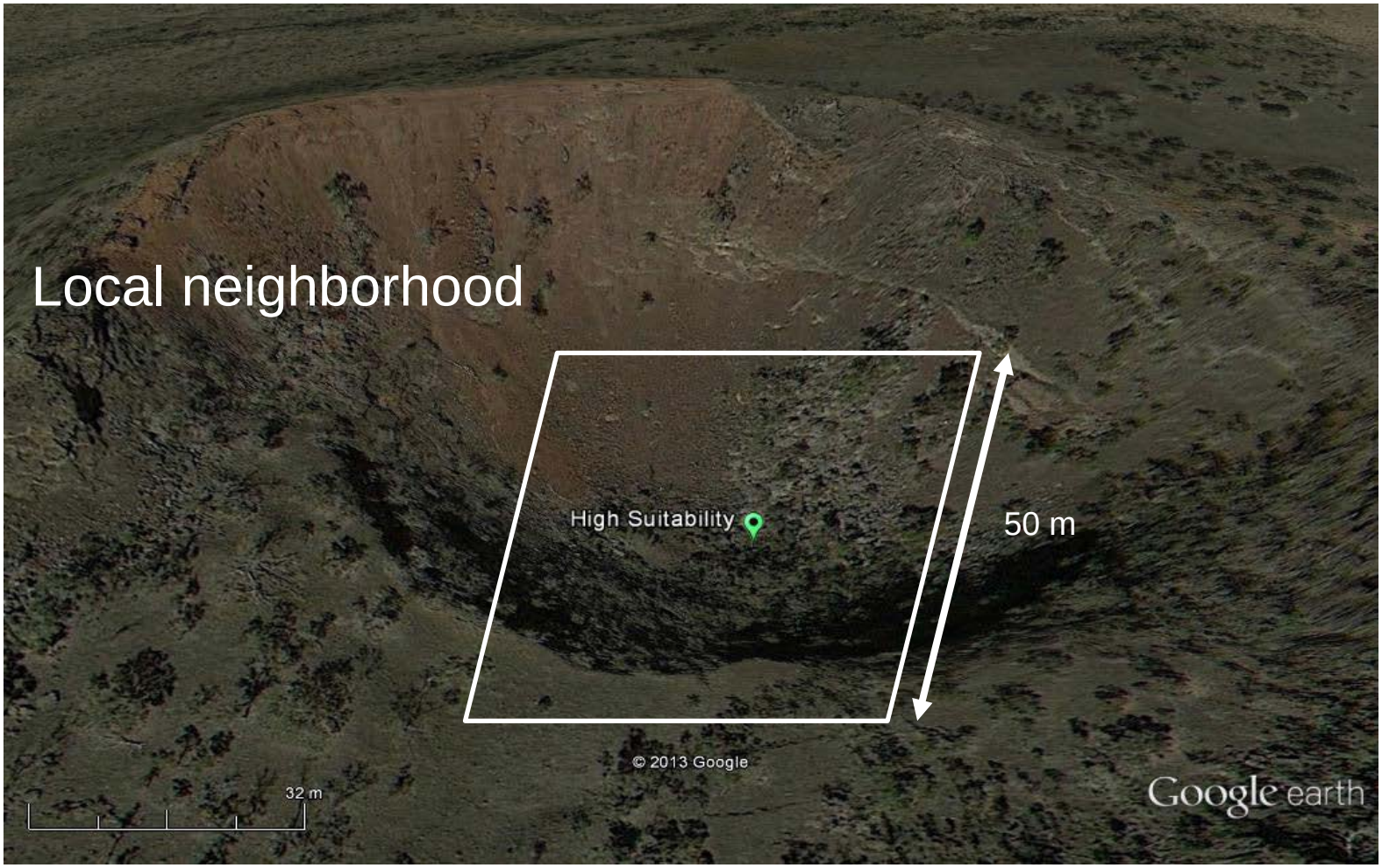
Leeward Criteria Variable



Questad et al., 2014. Ecological Applications

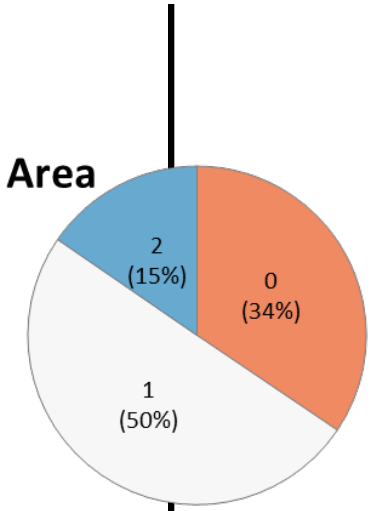
Habitat Suitability Model

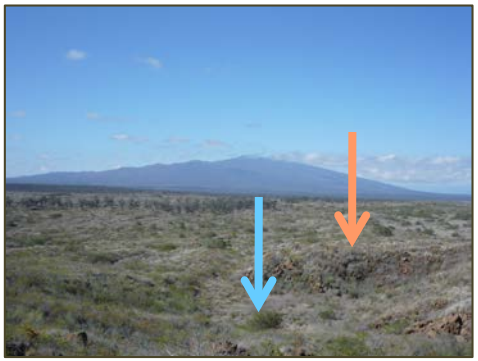
Descending Topography Criteria Variable



Questad et al., 2014. Ecological Applications

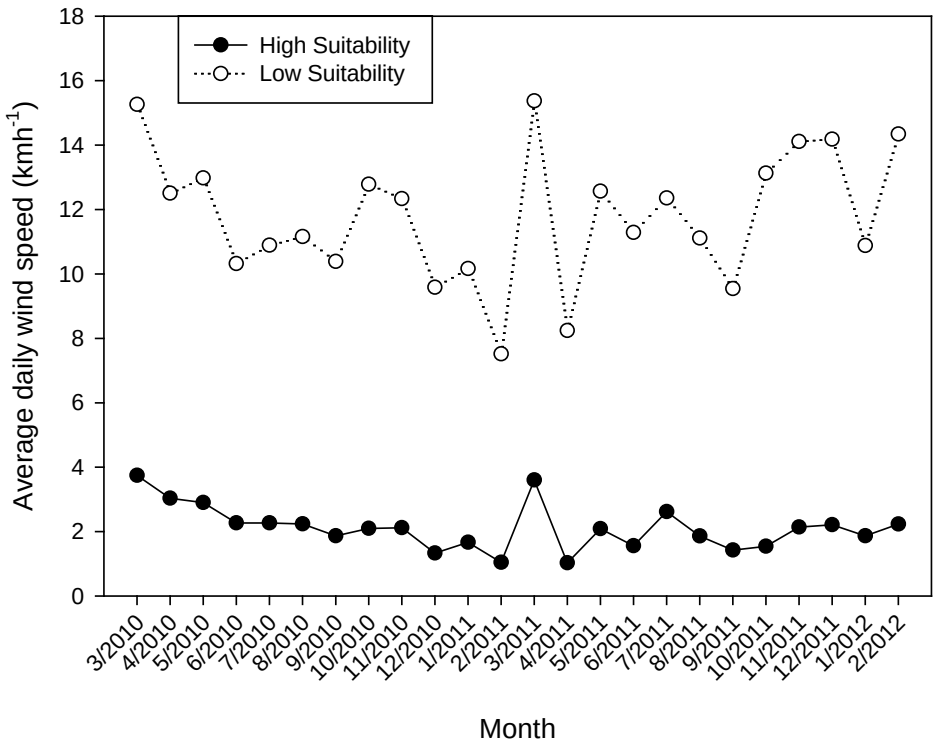
Habitat Suitability Model





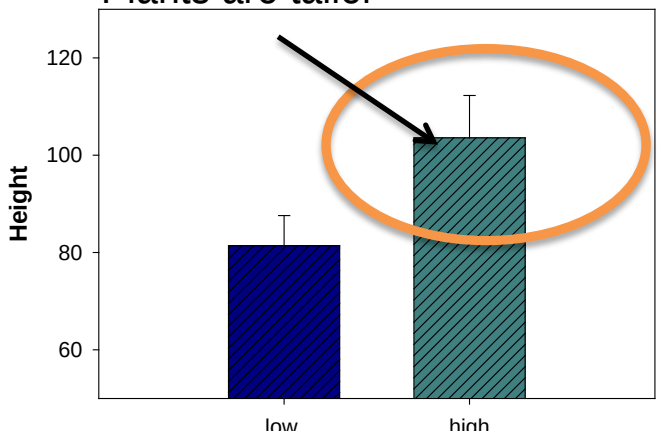
Questad et al., 2014. Ecological Applications

Biotic and Abiotic Evidence of Topographic Suitability

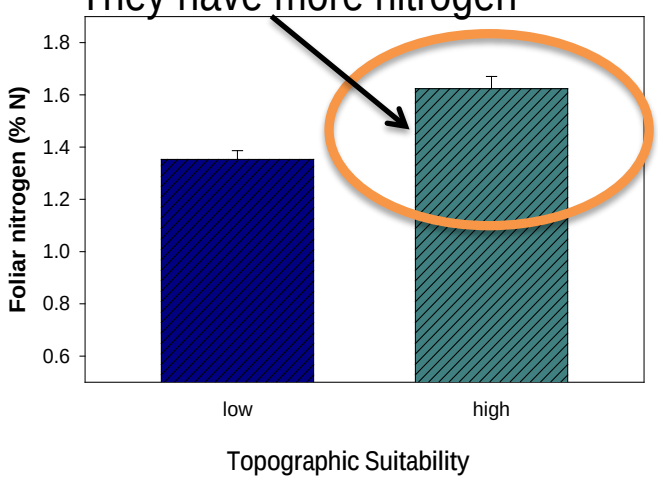


Biotic and Abiotic Evidence of Topographic Suitability

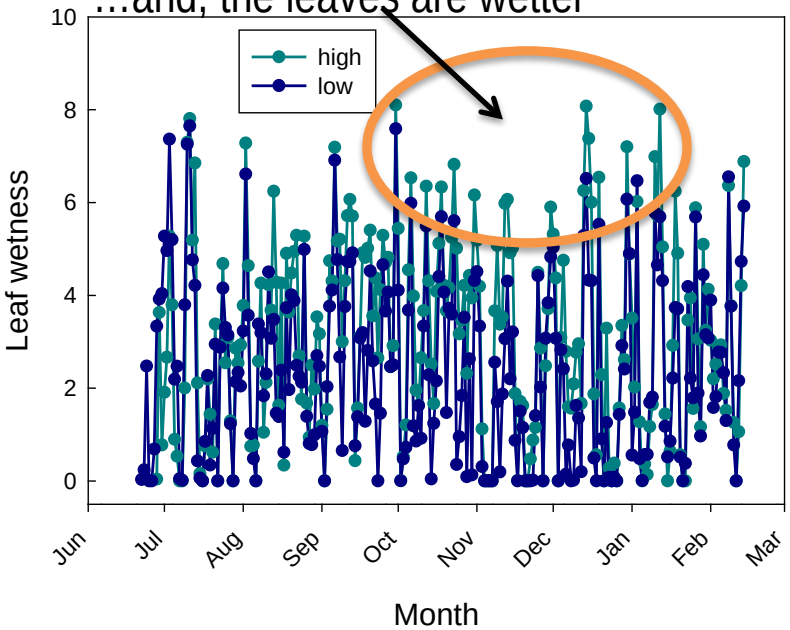
Plants are taller



They have more nitrogen



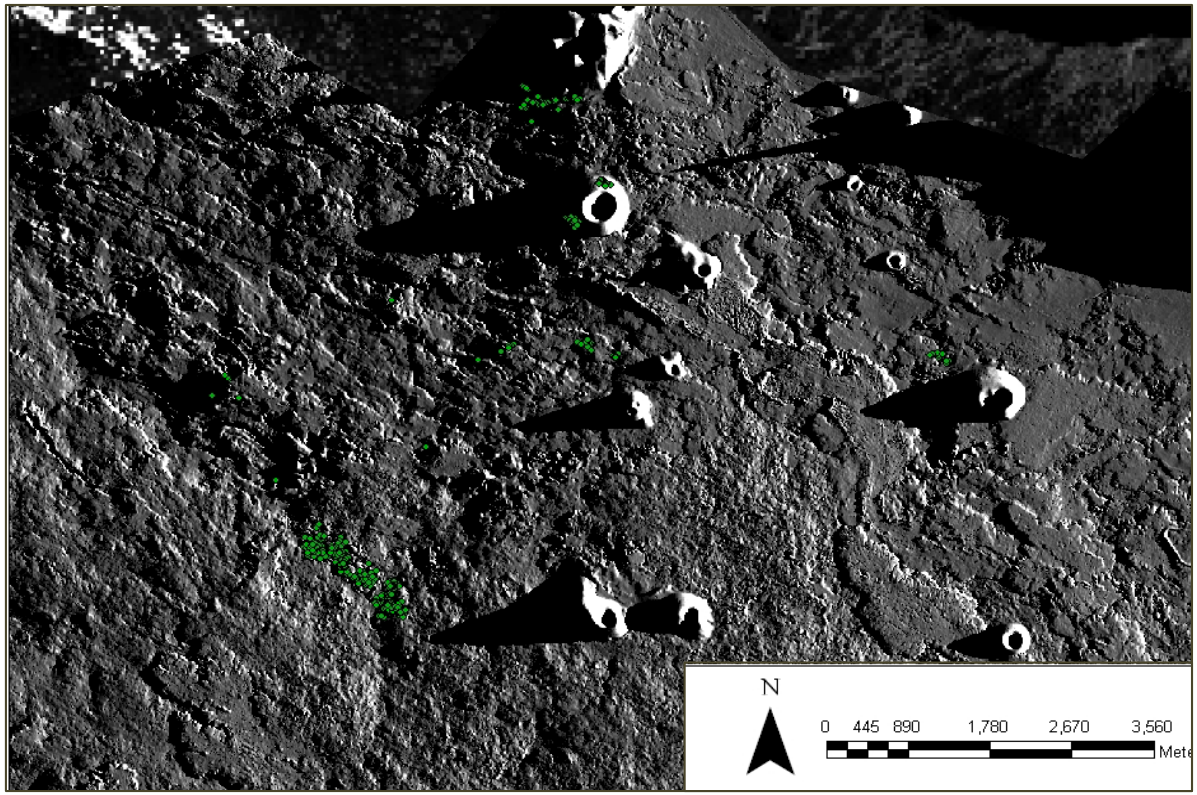
…and, the leaves are wetter



T&E Plant Species

Honohono

Haplostachys haplostachya



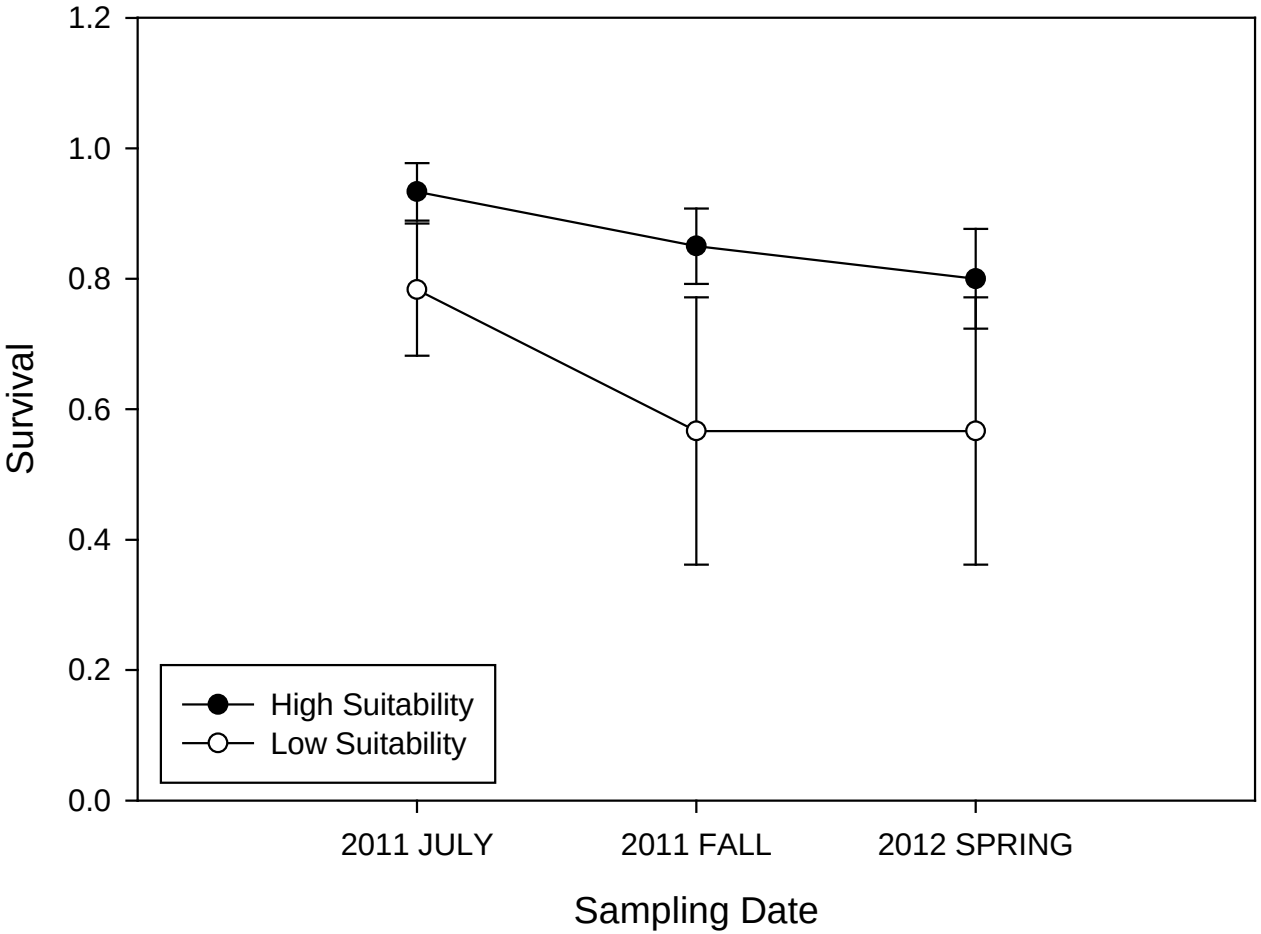
T&E Plant Species

- Habitat suitability associations of T&E species
  - Six species higher suitability
  - Two species lower suitability
  - Three species no association

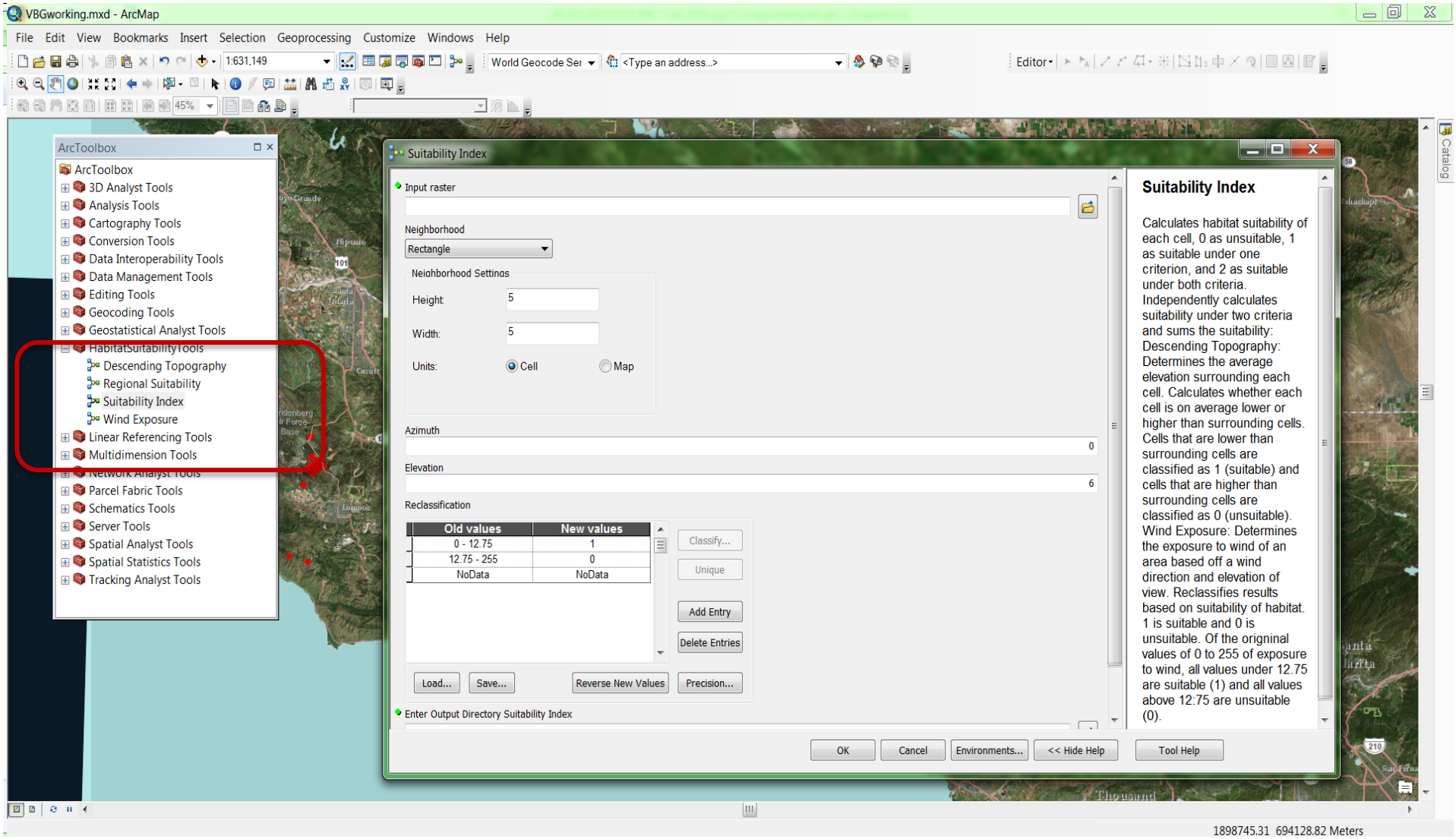
Haplostachys haplostachya

Stenogyne angustifolia

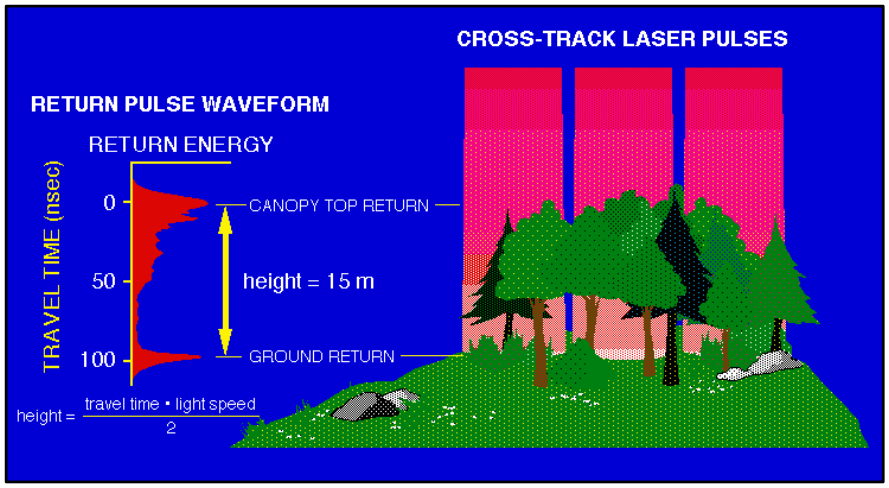
Native Restoration Trial



Now Available as an Extension for Arc Map

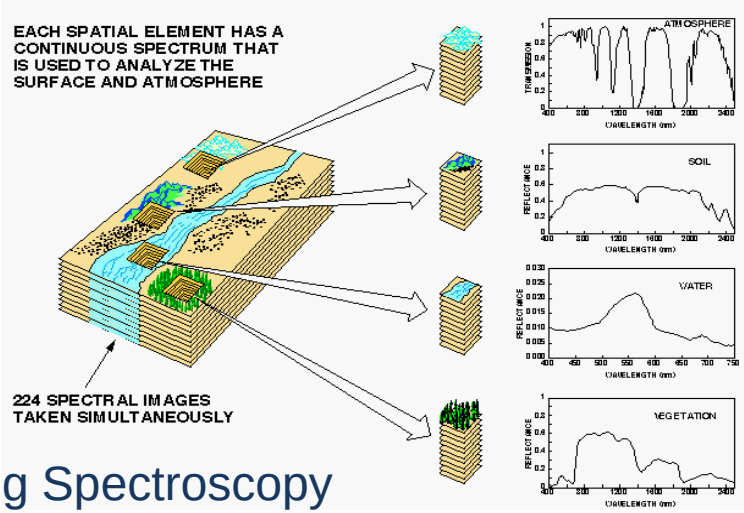


Restoration Planning at the Landscape Scale



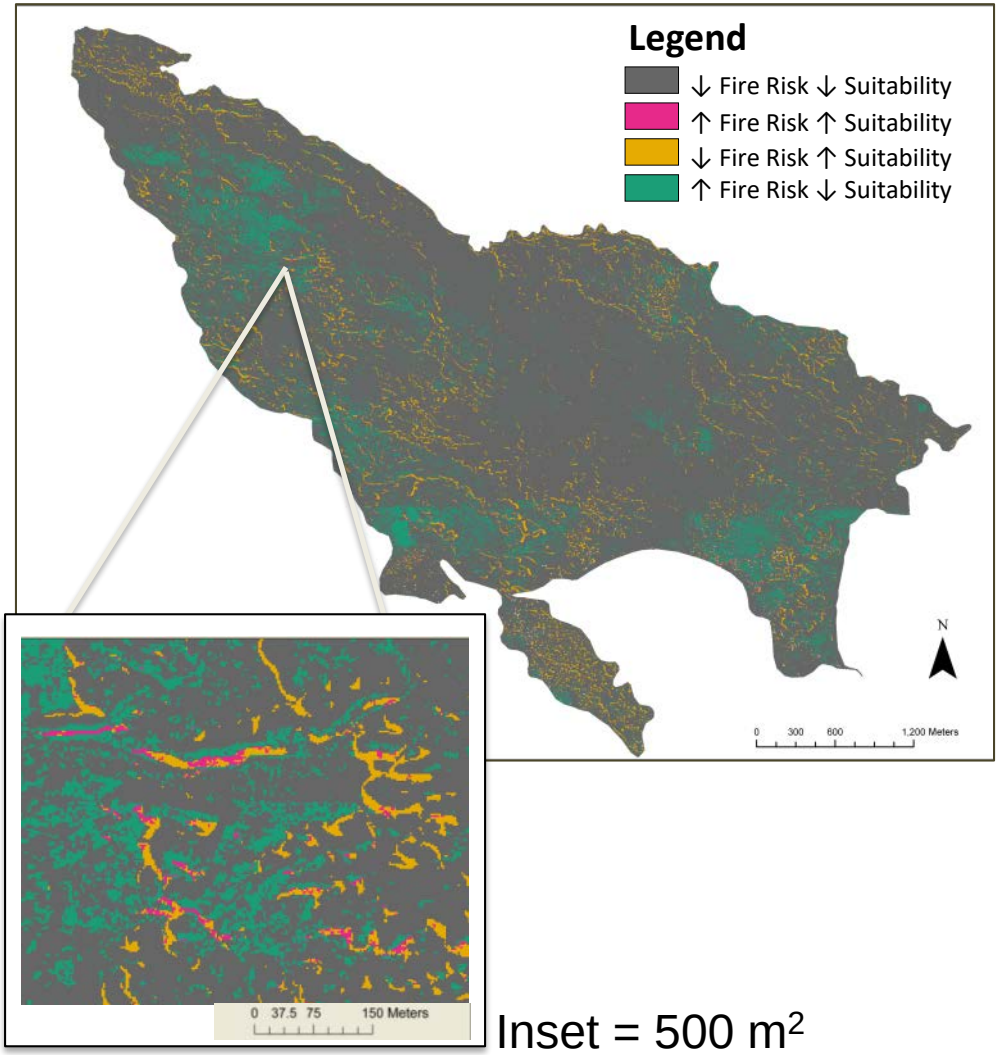
Laser Detection and Ranging (LIDAR)

If we add Imaging Spectroscopy to the HSM we can develop a 2.2 m resolution map of terrain, vegetation cover, species dominance, and fire fuel cover



Imaging Spectroscopy

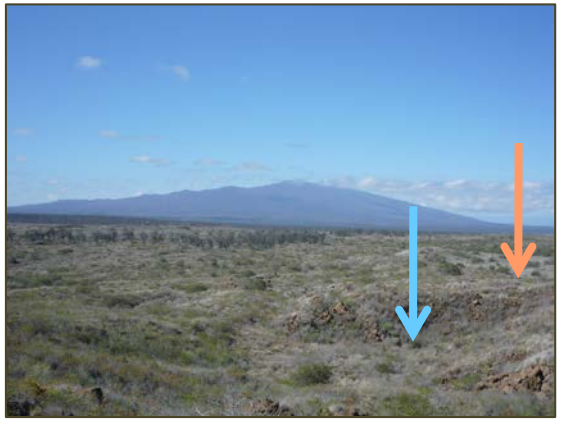
Categorize Multi-Use Landscapes



Inset = 500 m^2

1. Restoration to reduce fuels: target areas with high fire risk and high suitability for plant growth (pink)
2. Restoration of endangered plant populations: target areas with low fire risk and high suitability for plant growth (yellow)
3. Physical fire barriers – target areas with high fire risk and low suitability for plant growth (green)

Conclusions



- This DoD supported research program has served as an important catalyst for generating the necessary science to help address important natural resource management needs for Hawaii and the Pacific
- The HSM allows users to identify areas of the landscape where stakeholder activities can be prioritized based on biophysical and geomorphic characteristics
- This management strategy enables the installation to conduct training while conserving the natural resources upon which the quality of training ultimately depends

Acknowledgements

Erin Questad, James Kellner, Greg Asner, Samuel Brooks, Amanda Uowolo, Kealoha Kinney, Elliott Parsons, Micaiah Sutter

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Carnegie Institution for Science

USDA - Forest Service

USDA - Forest Service

USDA - Forest Service

USDA - Forest Service

Hawaii Division of Forestry and Wildlife

For additional information, please visit

https://www.serdp-estcp.org/Program-Areas/Resource-Conservation-and-Resiliency/Natural-Resources/Pacific-Island-Ecology-and-Management/RC-1645

https://www.serdp-estcp.org/Program-Areas/Resource-Conservation-and-Resiliency/Natural-Resources/Species-Ecology-and-Management/RC-201203

Speaker Contact Information

scordell01@fs.fed.us; 808-854-2628

SERDP DOD • EPA • DOE | ESTCP

Q&A Session 1

SERDP DOD • EPA • DOE | ESTCP

Integrating Plant Functional Traits into Restoration Design: An Example in Hawaiian Lowland Wet Forest

Dr. Rebecca Ostertag
University of Hawaii at Hilo

SERDP DOD • EPA • DOE | ESTCP

Agenda

- What is a trait-based restoration and why is it useful?
- A field example of functional trait-based restoration
- A computer tool to simplify the species selection process
- Transferability of the approach

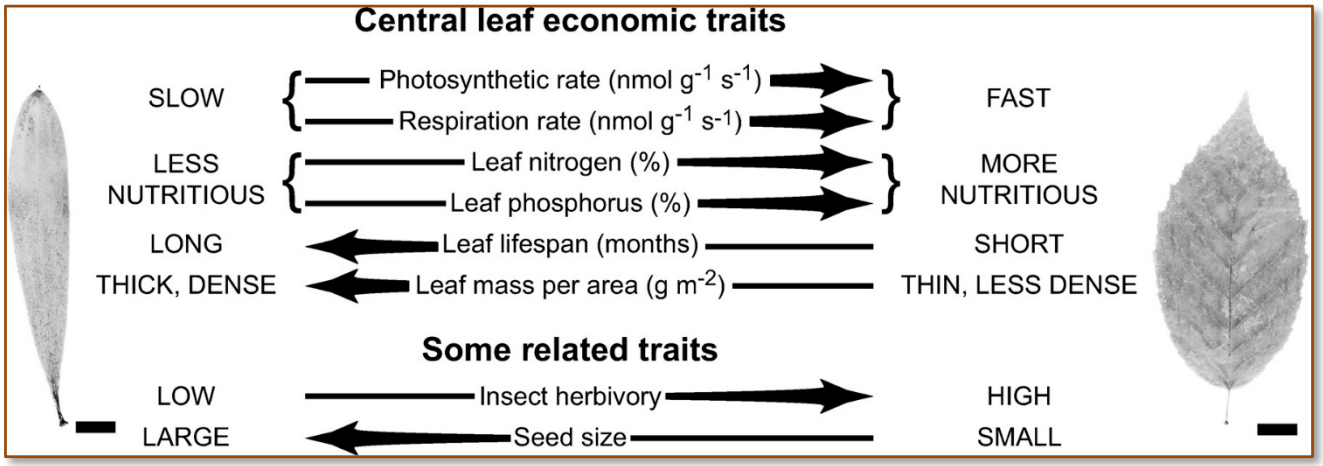
Restoration Challenges

- Presently, a restoration strategy involves “best guesses”
- Choosing species for restoration is difficult and subjective
  - Limited information about species ecology, genetics, physiology, and evolutionary biology
  - Lack of a reference system in some cases
  - Need to plan for unknowns (climate change, disturbance)
  - Other factors
    - Economics (e.g., cost of seed/plants, labor, time)
    - Logistics (e.g., availability of species, budget, timelines)
    - Goals and expectations of stakeholders

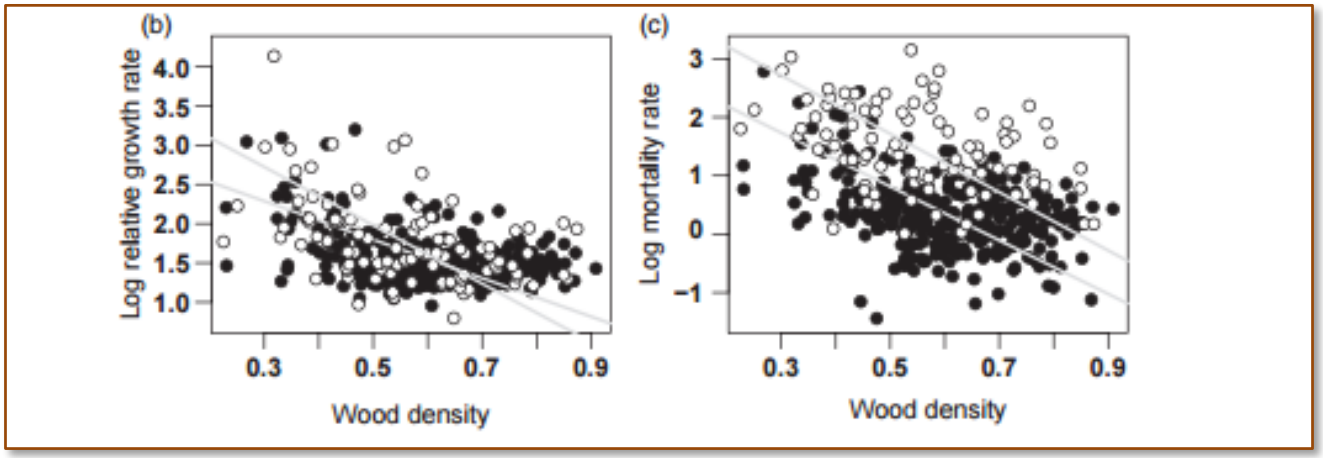
Functional Traits are Meaningful and Measureable

- Plant functional traits influence growth, reproduction, and survival
- Reflect resource use and life history tradeoffs
- Vary among species and environments
  - Reich (2014), J. Ecol. 102: 275-301

Functional Traits Relate to Ecological Processes



Royer 2008, Palaios 23: 421–423

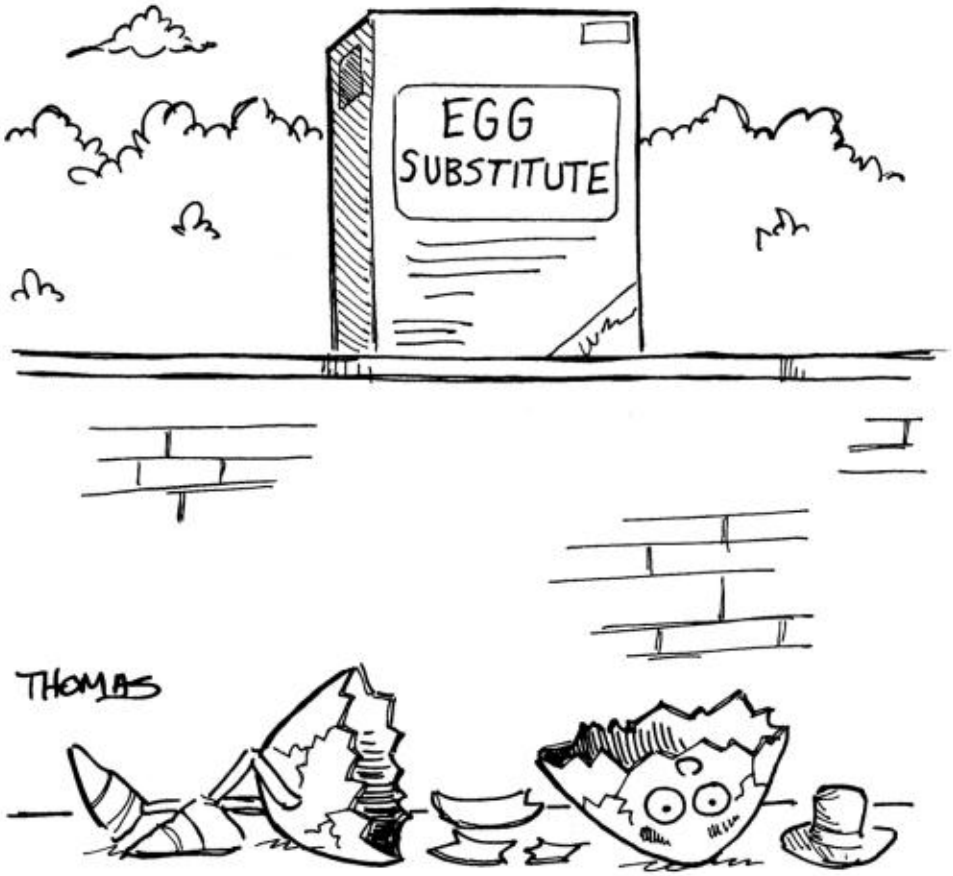


Reich 2014, J. Ecology 102: 275-301

Examples of Functional Traits in Restoration

Restoration Goal	Traits
Fire tolerance	Bark thickness, leaf water content, leaf size, resprout percentage, post-fire seed survival
Drought tolerance	Leaf size, leaf lifespan, water-use efficiency, leaf water content
Carbon storage	Wood density, photosynthesis, leaf carbon/nitrogen (C:N) ratio
Successional facilitation	Seed size, wood density, maximum height

Functional Trait-Based Restoration



1. Choose species with desired properties
2. Design restored ecosystem (think teams)

A How-to Guide

- Restoration goals defined
  - Can you incorporate the combined interests of land managers, ecologists, and other stakeholders?
- Trait selection
  - Resource-use traits selected should reflect the restoration goals, and environmental characteristics of the system
- Data preparation, selection, and analysis
  - Trait data are often already available from previous studies (both locally and in global databases) or can be collected easily
- Species decisions
  - Multivariate ordination (e.g., Principal Components Analysis, PCA) show how the selected species are arranged relative to one another, according to their traits

Ostertag et al. 2015, J. Appl. Ecol. 52: 805-809

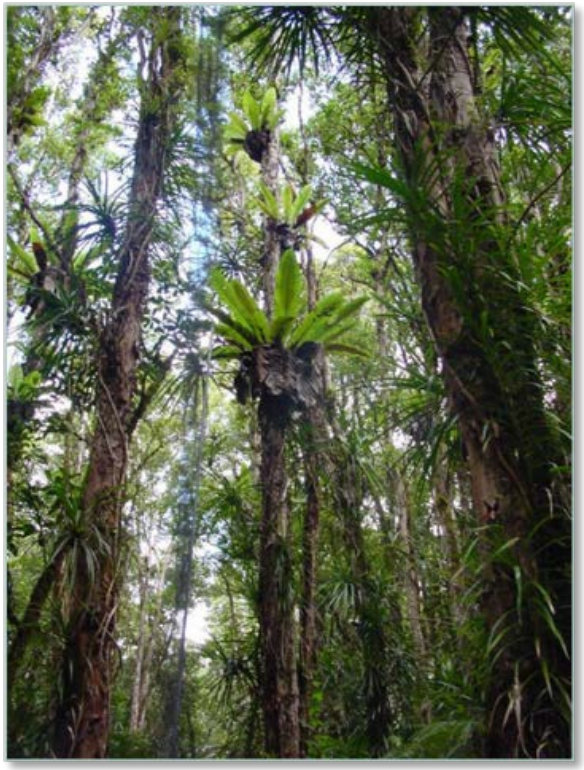
Keaukaha Military Reservation (KMR)

- Rare forest type – remnant patches
- No “reference site” exists
- Highly invaded understory, limited regeneration of native species
- 30 m elevation
- 3400 mm annual rainfall
- 1200 year old ‘a‘ā lava flow
- Initiated Liko Nā Pilina experiment at site in 2014

Cordell et al. 2016, Restoration Ecology 24: 139-144

Liko Nā Pilina Case Study

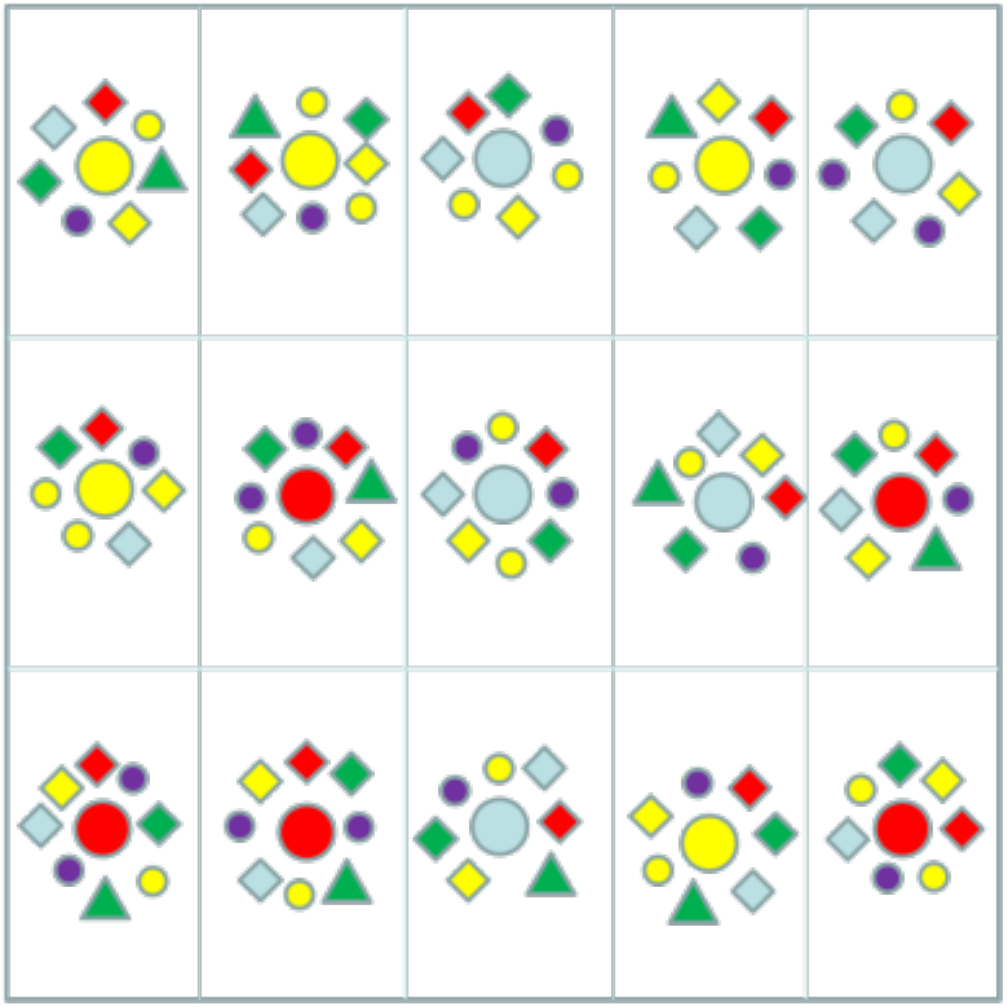
- Restoration goals defined
  - Invasive resistance, carbon storage, military training, native seedling regeneration
- Trait selection
  - 15 traits (leaf, wood, reproduction)
- Data preparation, selection, and analysis
  - Collected our own data for 13 species
- Species decisions
  - Using Restoring Ecosystem Servives Tool (REST) computer program



The Liko Nā Pilina Activities

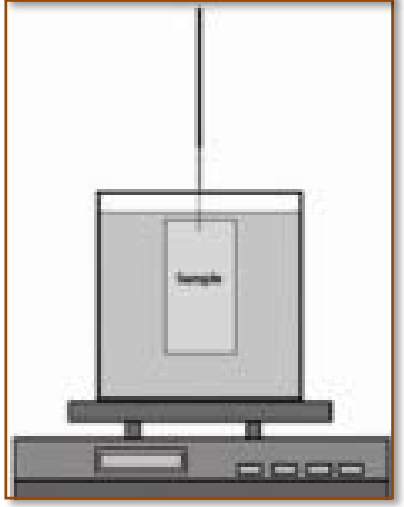
- Clear invasive species
  - Invasive resistance, carbon storage, military training, native seedling regeneration
- Replant mixtures with specific combinations of functional traits
  - Using computer program tool
- Long-term monitoring

Planting Design Example



Functional Trait Sampling

- Some traits can be sampled easily and cheaply
- Some traits can be found in the literature
- Global databases
  - TRY Plant Trait Database (Kattge et al. 2011, Glob. Change Biol. 17: 2905-2935.)
  - Hawai'i Weed Risk Assessment
  - More to come in REST program (https://hilo.hawaii.edu/faculty/ostertag/LikoNaPilina)



Traits Sampled for Liko Nā Pilina

Functional Trait	Biology	Source of Data
Leaf-to-petiole ratio	Light acquisition, self-shading	Measured
Leaf thickness (mm)	Resource acquisition, longevity, resource use	Measured
Leaf mass per area (g/m^2)	Photosynthesis, longevity	Measured
Leaf Nitrogen (%)	Photosynthesis, leaf quality	Measured
Leaf Carbon (%)	Leaf construction, resource use	Measured
Leaf Carbon:Nitrogen	Leaf longevity, fast to slow strategies	Measured
Leaf Phosphorus (%)	Leaf quality	Measured
Stem specific gravity (g/cm^3)	Diameter growth rate, mortality rate, hydraulic capacity, carbon storage	Measured

Traits Sampled for Liko Nā Pilina

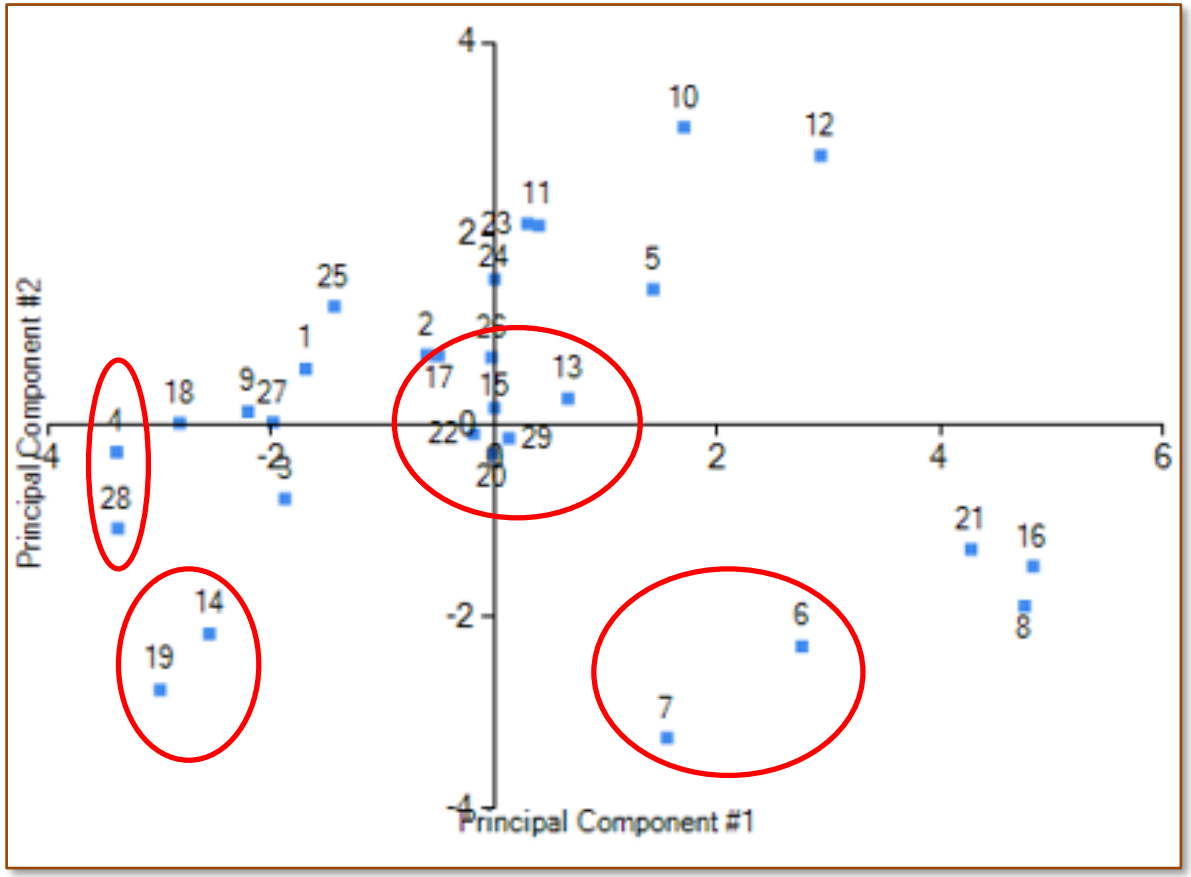
Functional Trait	Biology	Source of Data
Instantaneous water-use efficiency	Water use efficiency, resource use and acquisition	Measured
Max. plant height (m)	Competitive vigor, plant fecundity, light acquisition	Literature
Seed mass (g)	Dispersal, longevity, survival	Literature
Leaf area (cm^2)	Photosynthetic capacity, resource allocation	Measured
Leaf water content (%)	Resource use and allocation, fast-slow strategies	Measured
Stature	Dispersal, longevity, carbon storage	Measured
Canopy architecture	Light interception, stability	Measured

Restoring Ecosystem Services Tool (REST)

- Performs a principal components analysis (PCA) showing you the relationships among species - exploratory data analysis
  - Reveal patterns and relationships among species
  - Reduce many variables (the traits) to a smaller number of variables (PCA 1 and PCA 2)
- PCA is standardized so that traits can be of different magnitude
- REST provides the visual. As a manager, you then decide what to do with that information
  - Best used as a planning tool
  - Meant to be iterative process

Species Choice in Restoration

Started with 29 Species, 15 Traits



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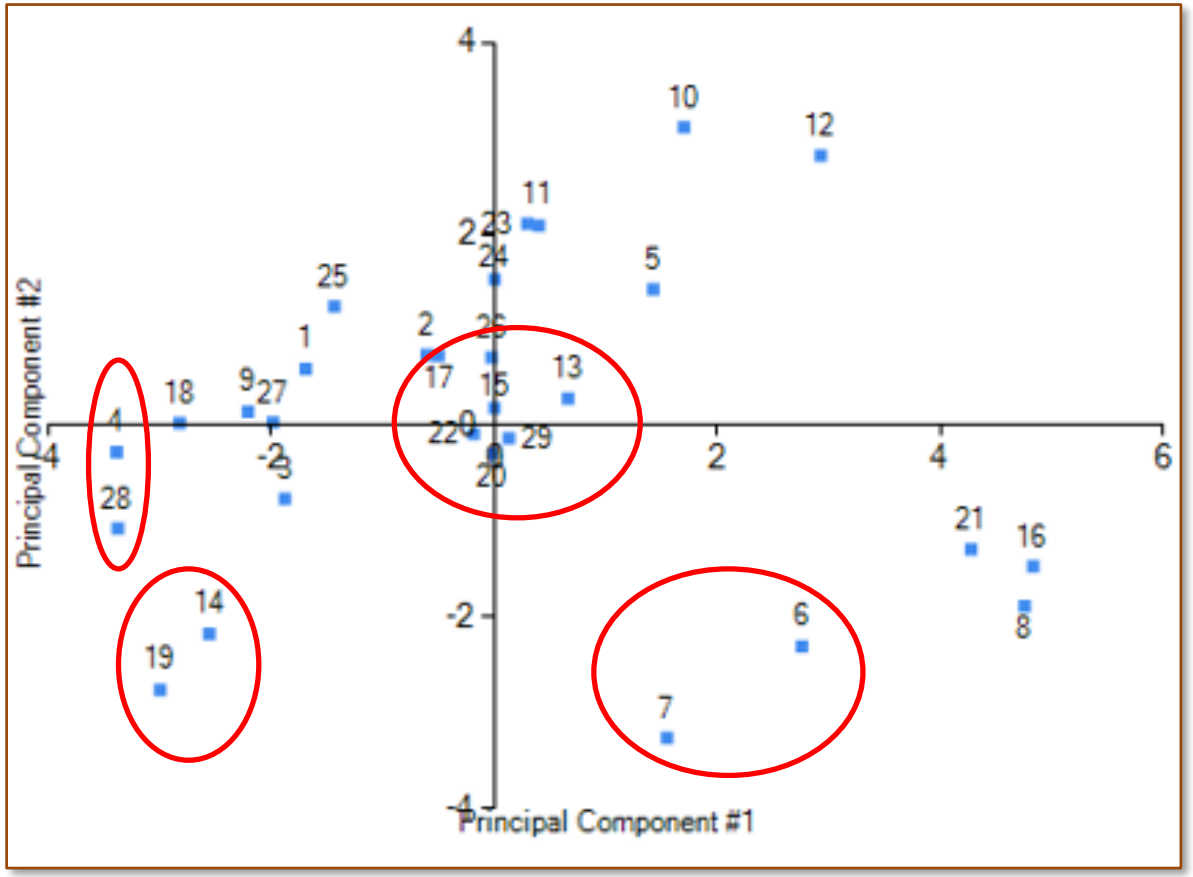
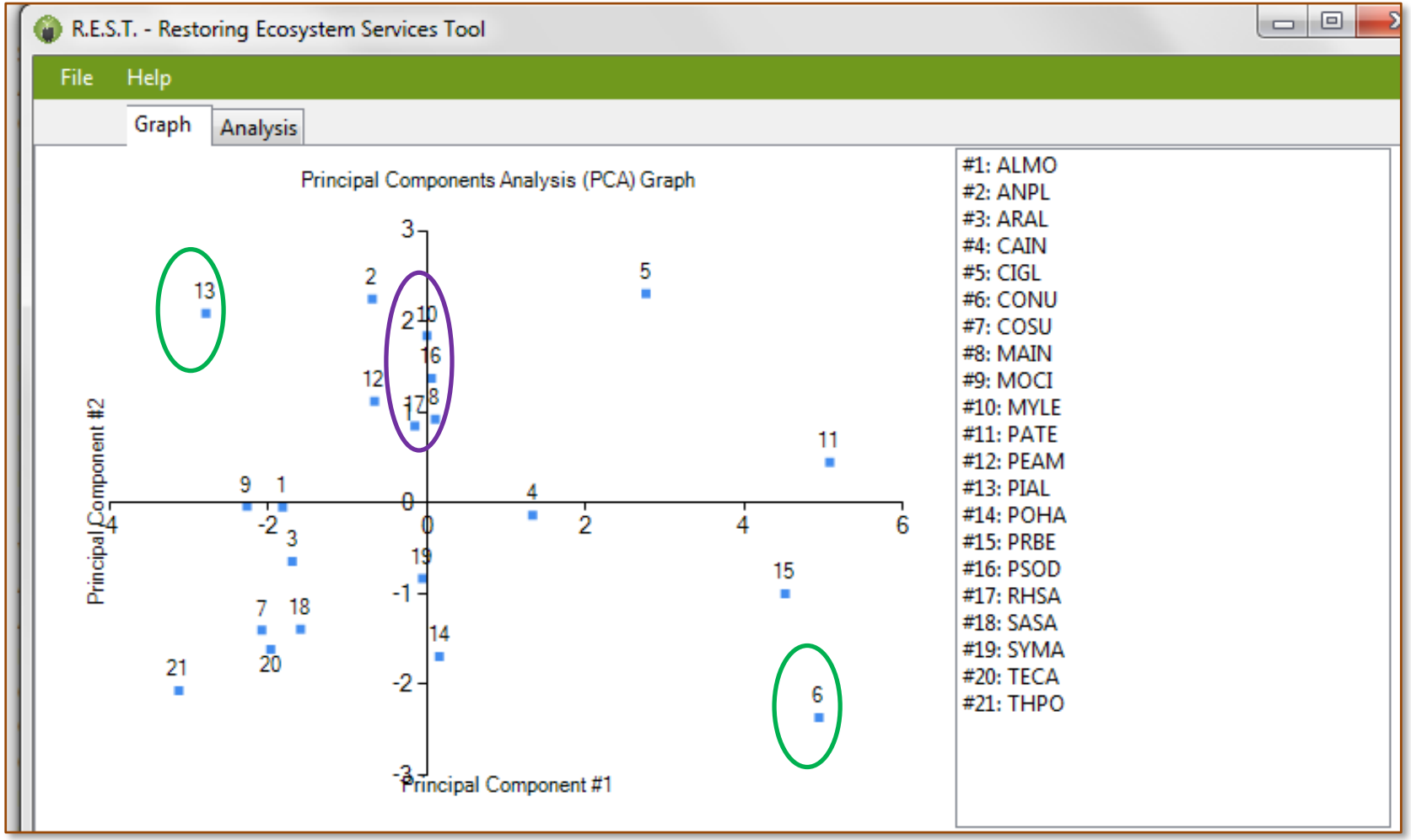


Removals

- #7: Only need 1 tree fern
- #19: Doesn't reproduce well
- #4: Hard to propagate
- #13: Edge of range
- #29: Uncommon

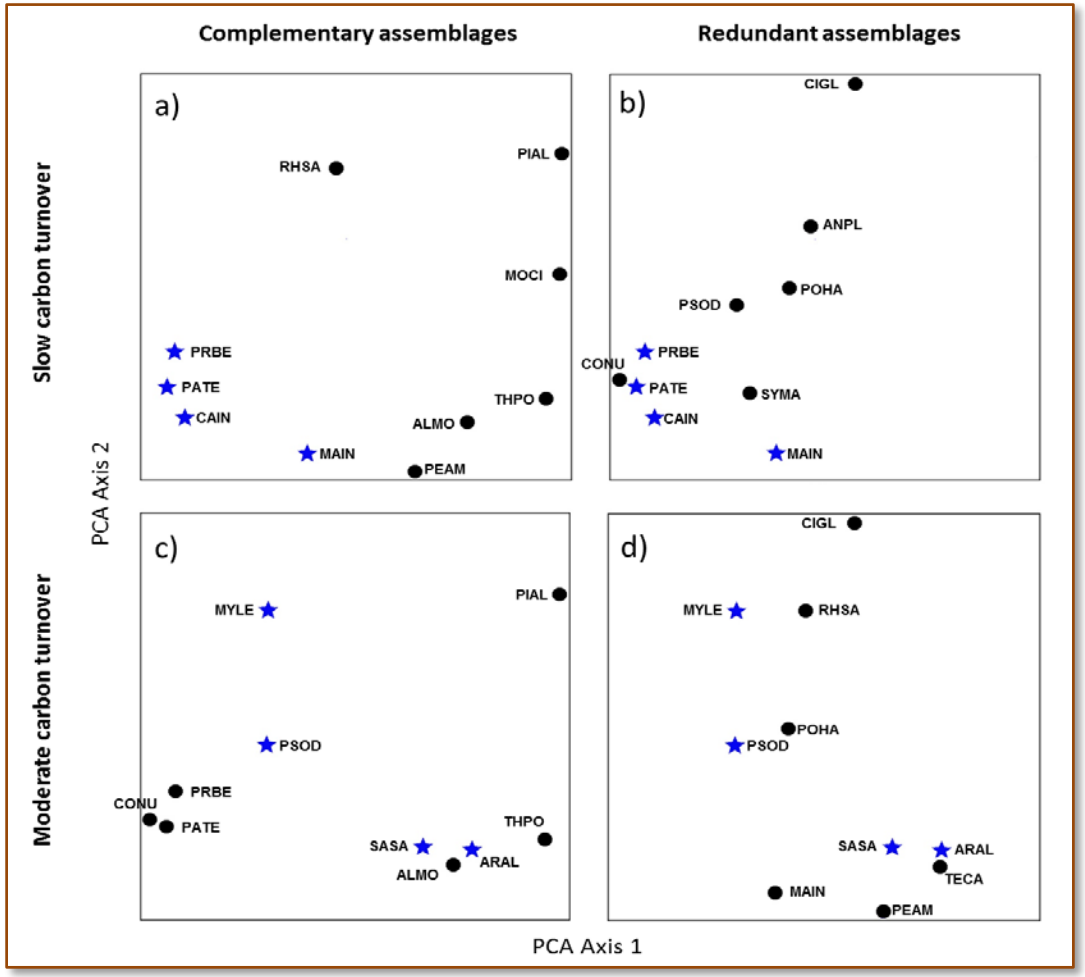
Plus decided to take out the species already present in the forest canopy: #10, #12, #22

Final Species List



Numbers correspond to species; actual meaning of abbreviations not important for this demonstration

Final Treatments



4-letter codes correspond to species; actual meaning of abbreviations not important for this demonstration

Help! What Traits do I Choose?

Trait	Function
Wood density/stem specific gravity	Tradeoff between fast growth and mechanical support
Leaf mass per area/specific leaf area	Tradeoff between fast growth and short leaf lifespan
Seed mass	Tradeoff between seed dispersal and seedling survival
Leaf nitrogen	Tradeoff between stress tolerance and competitiveness
Maximum height	Tradeoff between low and high light environments, affects dispersal

Adler et al. 2014, PNAS 111: 740-745
Van Bodegom et al. 2014, PNAS 111: 13733-13738
Kunstler et al. 2016, Nature 529: 204-207

DoD Benefits

- Functional-trait based restoration is an application of ecological theory
  - Determines appropriate mixes of species
  - Theory can be applied to a variety of situations
- Using REST is cost-effective
  - Simplifies the process for managers
  - Can decrease management interventions
  - Allows for simulations

Conclusions

- Functional trait-based restoration is a new conceptual approach that can be applied broadly, and involve all types of species
- The REST program is a tool to design functionally well-balanced ecosystems
- Well-planned restoration should reduce costs and ecological surprises

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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-2117

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Q&A Session 2

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