DoD Natural Resources Program

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Limitations on Post-fire Regeneration in Māmane (*Sophora chrysophylla*) in Hawaii

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Limitations on Post-fire Regeneration in Māmane (*Sophora chrysophylla*) in Hawaii: Can Fertilization & *Rhizobium* Amendments Increase Germination and Growth?

Department of Defense
Legacy Resource Management Program
Project # 16-831

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The Problem

Regeneration of a dominant tree species can be limited, even under natural conditions

- Examples:
  - *Quercus robur* (pendulate oak) in central Europe (Mölder et al. 2019)
  - *Pinus sylvestris* (Scots pine) in NE Spain (Vila Cabrera et al. 2012)
  - Pioneer trees in Guam (Caves et al. 2013)

- Reasons:
  - Unknown biotic or abiotic factors
  - Anthropogenic land use practices underlie regeneration problems

The Hawai‘i Example

(Photo Credit: Jack Jeffrey, USGS. Public domain.)

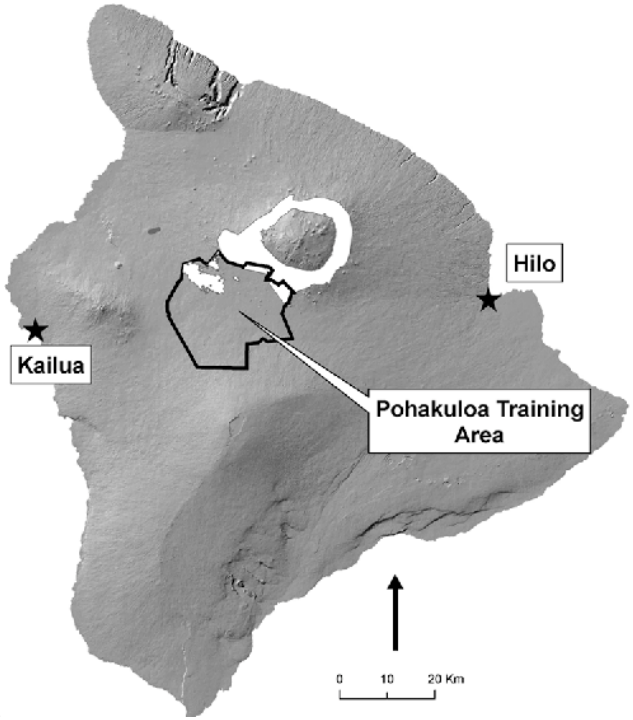
Sophora chrysophylla (māmane)

- Legume, N-fixing
- Subalpine forest dominant
- Exclusive food source for endangered bird, *Loxioides bailleui* (Palila)
- Palila restricted to the subalpine woodland on Mauna Kea on Hawai’i Island
- Regeneration in some areas and not others

Anthropogenic Factors

Pōhakuloa Training Area

- High elevation dry forest
- 3% of PTA is within the Palila critical habitat designation
- Dominated by māmane and naio
- Wildfire in 2010



Map published by Weisse *et al*. 2010. Pōhakuloa Training Area (PTA) is located on the Island of Hawai'I between Mauna Kea and Mauna Loa volcanoes. Palila critical habitat and endangered plant habitats are indicated in white. Palila are critically endangered and are limited to the slopes of Mauna Kea.

Supporting DoD Missions

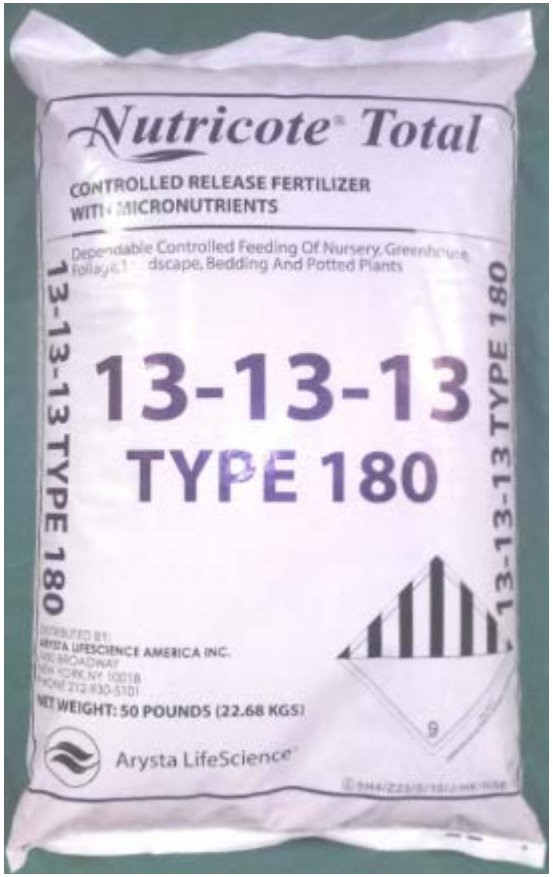
1) Maintaining quality training lands
2) Environmental stewardship of land resources; protected species

Developing and testing effective procedures to improve regeneration of subalpine forests

Observations at PTA

- Lots of seeds but few seedlings of māmane
- Fire may have transformed soil quality
- Previous work: seed addition and watering did not increase regeneration

Potential Amendments



- Loss of nutrients from fire?
- Lack of *Rhizobium* for N fixation?
- Can we use additions to improve germination and growth?

Hypotheses

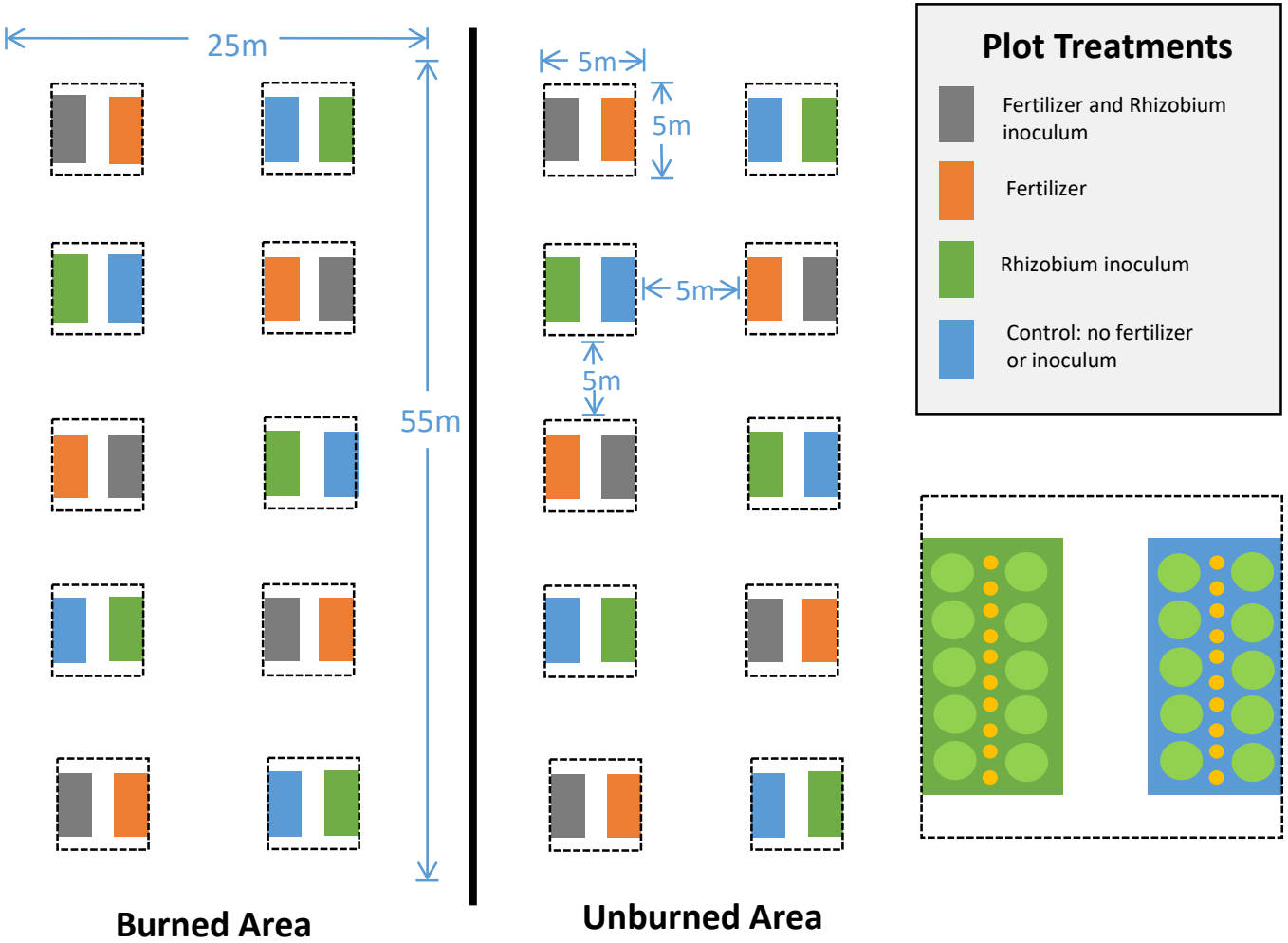
Can regeneration limitations be overcome with amendments?

H1: Māmane germination and growth are decreased by burning

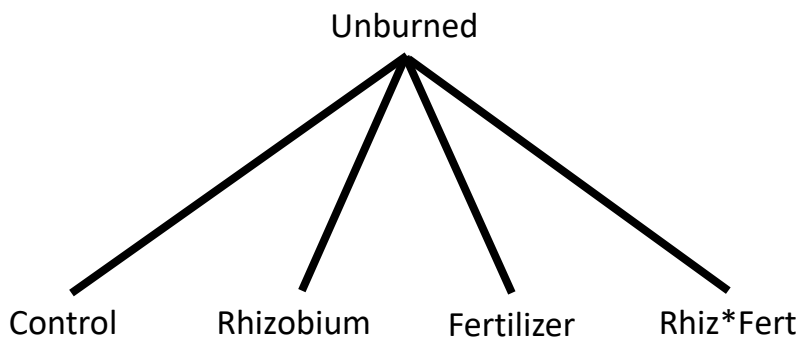
Māmane germination and growth is increased by:
H2A: Amendments of fertilizer
H2B: *Rhizobium* N-fixing bacteria

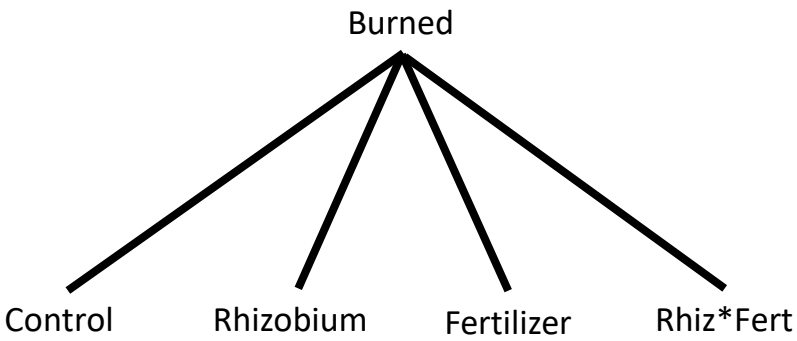
H3: There is a significant synergism between fertilization and *Rhizobium*

Experimental Design



Analysis: Nested ANOVA



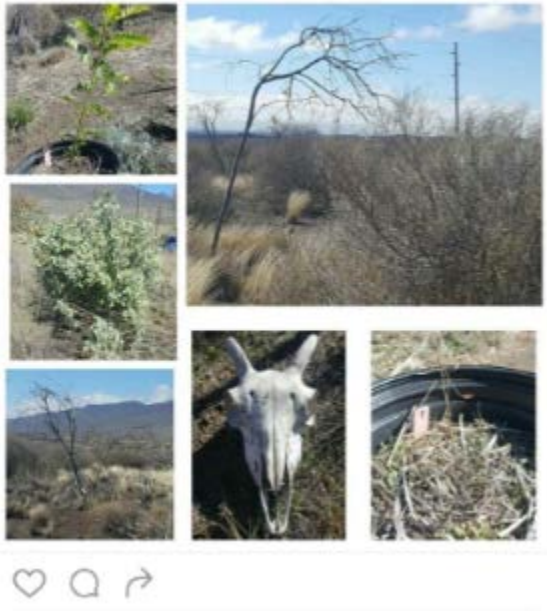


Response variables: germination, relative growth rates of height, basal diameter, volume, biomass

Field Measurements

23 likes

Challenges



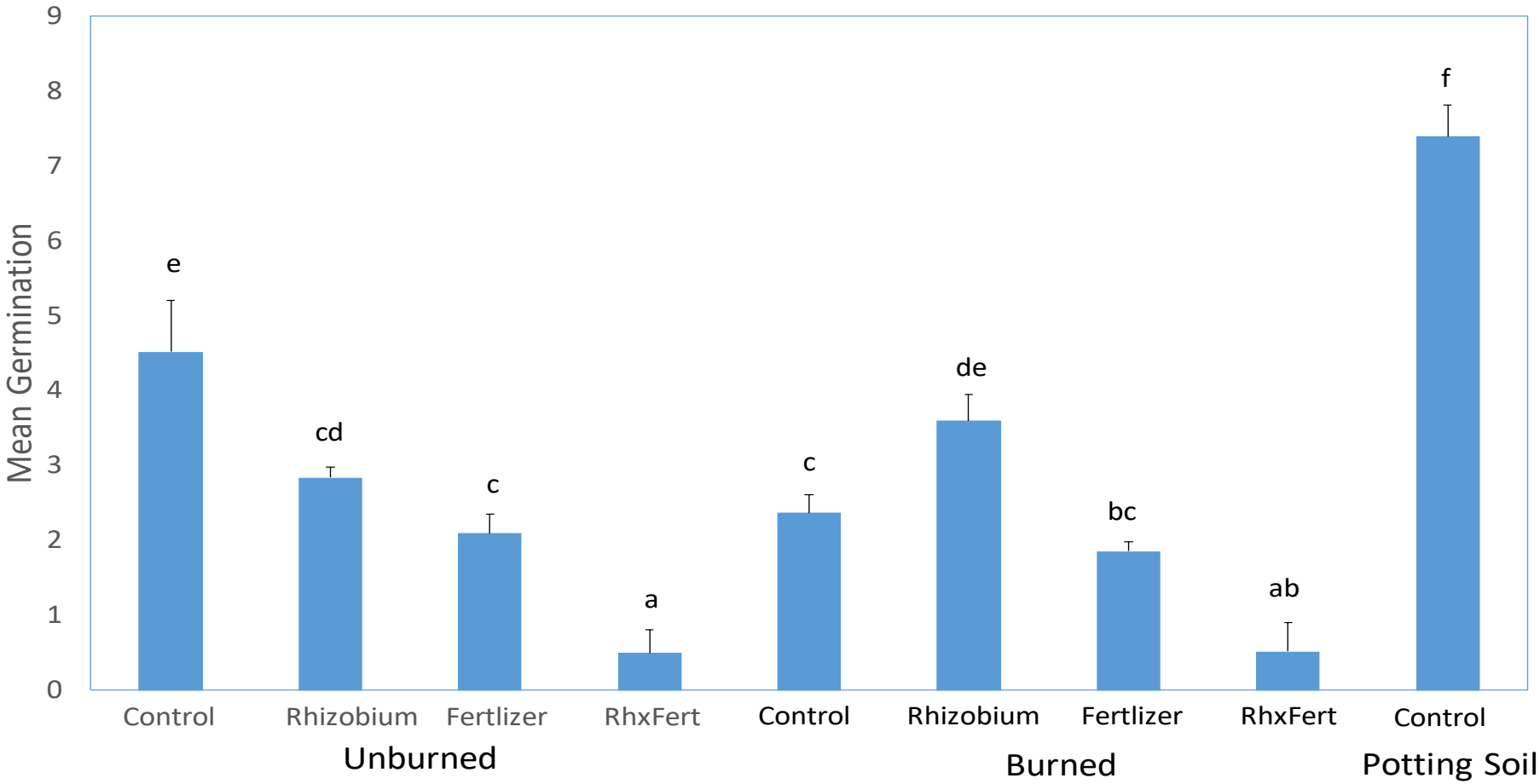
Desiccation, game birds, and frost

Results

- Focus on greenhouse germination experiment rather than field germination
- Discuss burned vs. unburned, and the effects of the treatments

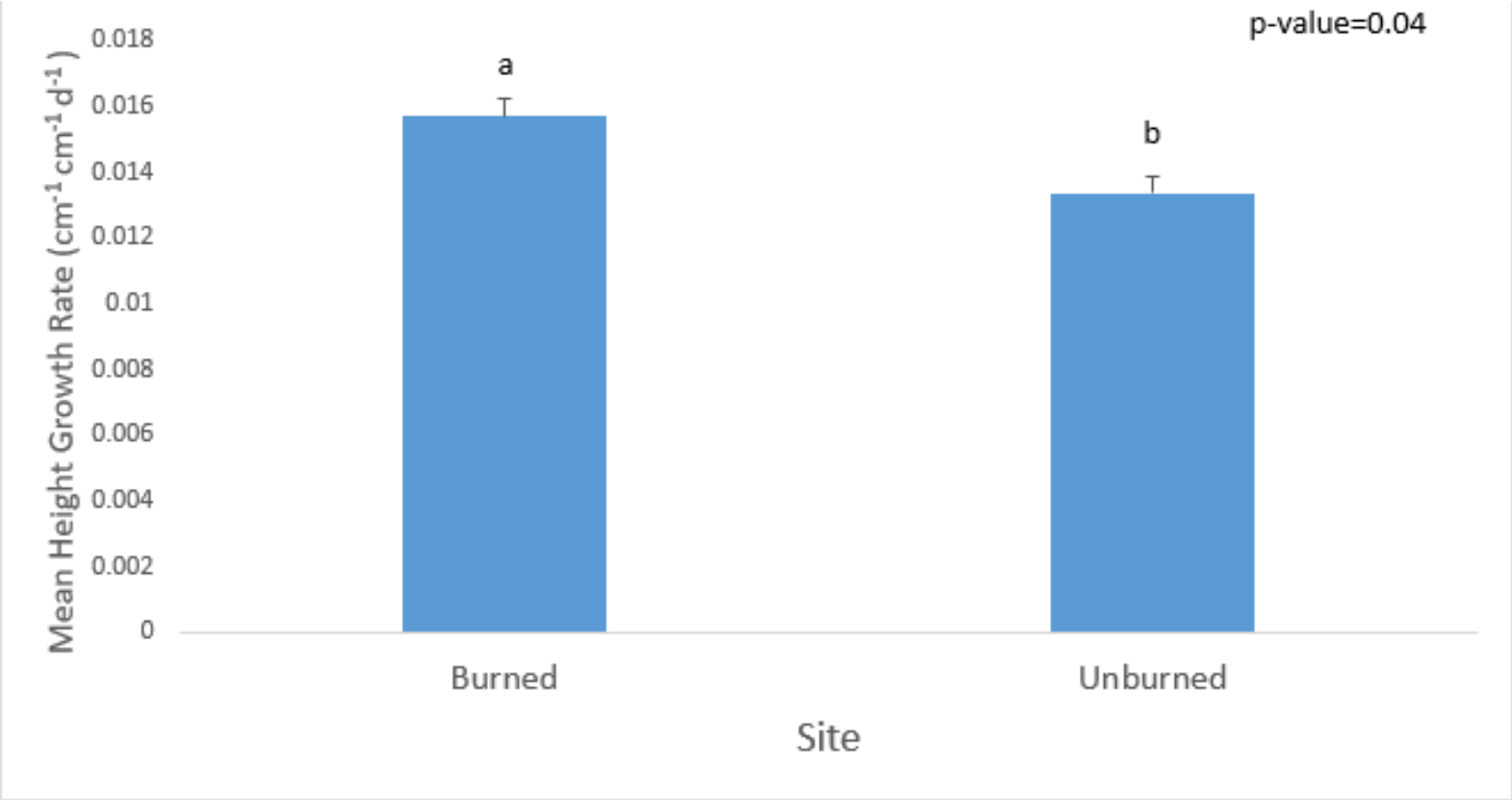
Greenhouse Germination Study

Greenhouse Germination

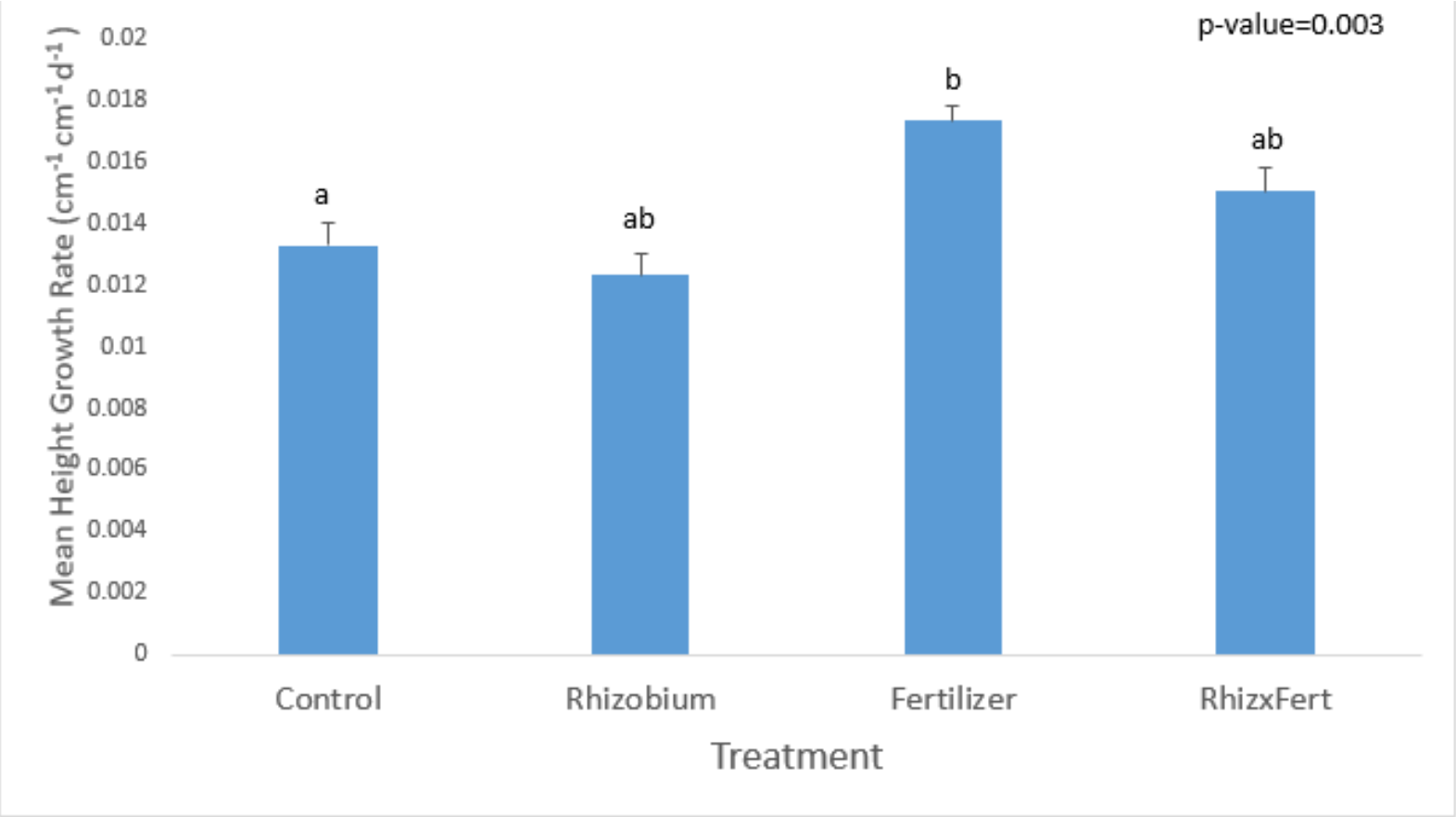


Field Study

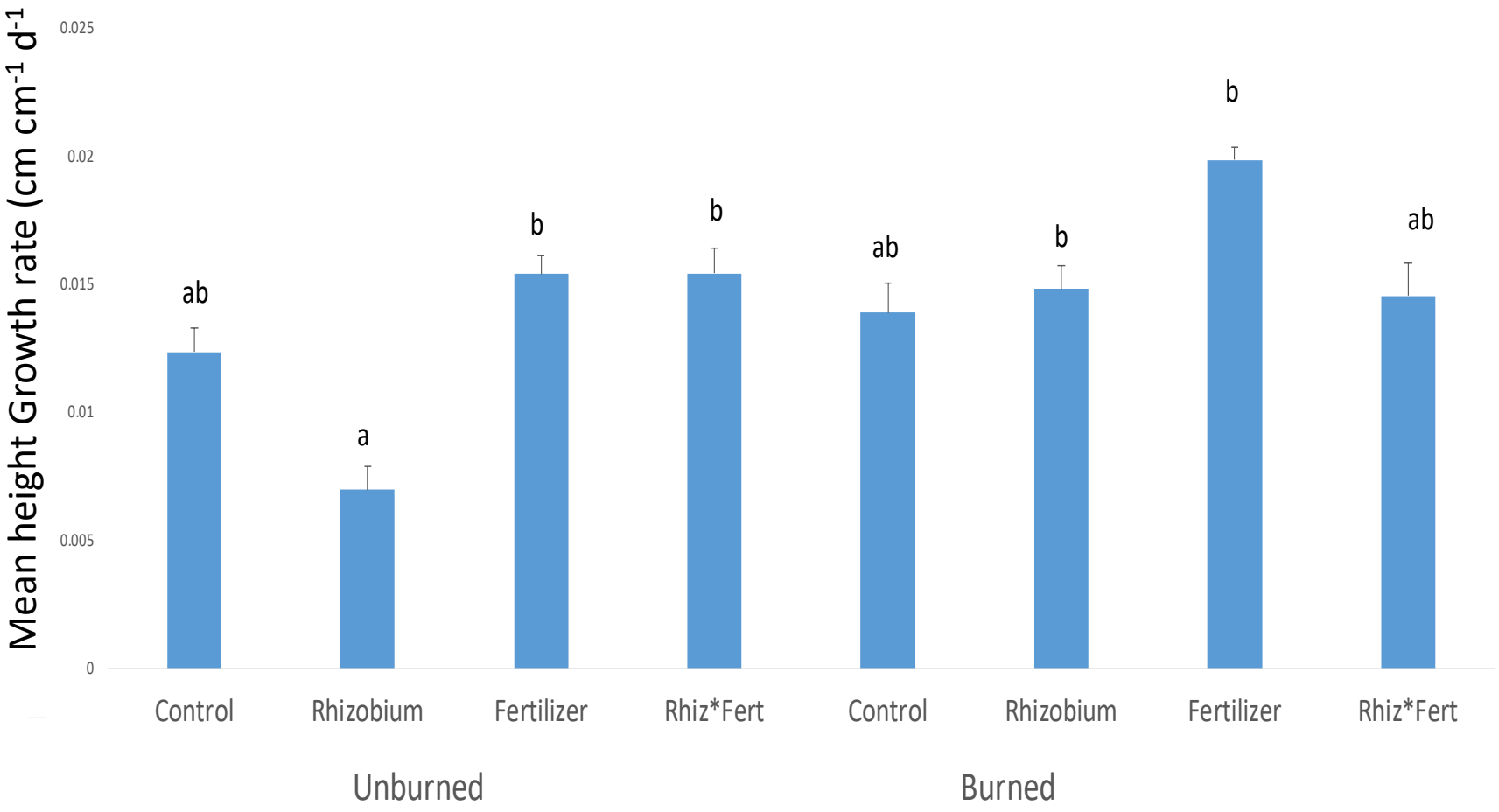
Effect of Site on Height



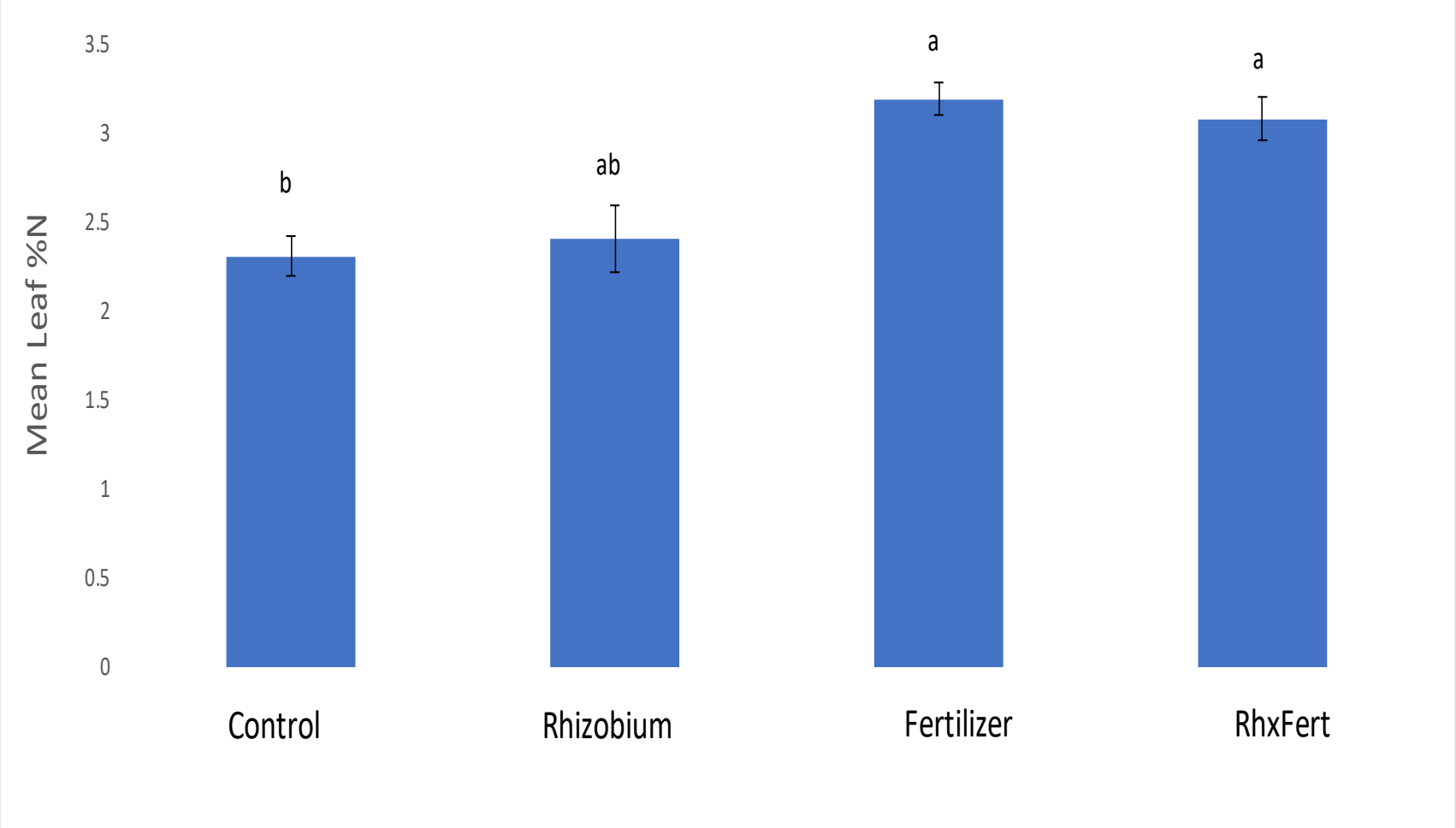
Effect of Treatment on Height



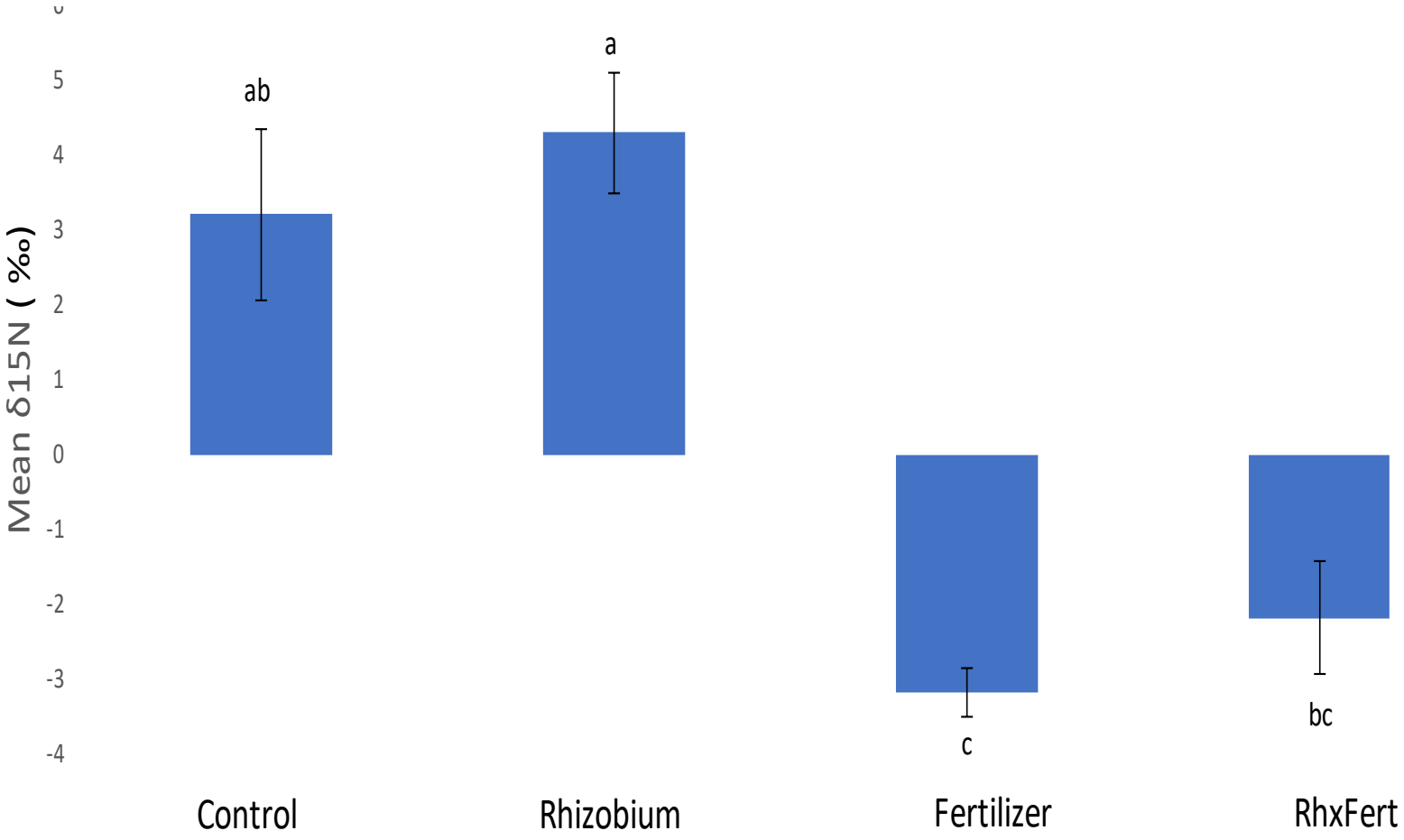
Effect of Site & Treatment on Height



Mean Leaf Tissue % Nitrogen



Mean Leaf Tissue δ15N



Discussion

Germination was complicated, but suggests that fertilization and soil properties may be have an inhibitory effect

Growth:

- Burned site had increases in growth, not supporting H1.
- *Rhizobium* addition usually did not enhance growth (H2B not supported), while fertilizer addition did (H2A supported)
- Synergistic effect was not noticeable (H3)

Nutrients

- N-fixation levels might be low; no evidence for fixation with *Rhizobium* added

Discussion

Something about the biotic or abiotic characteristics of the site or soil negatively impacts māmane regeneration

- Germination is the main bottleneck
- PTA soils are older than other areas, could be related to water-holding capacity, hydrophobic soils, or pathogens.
- Other possibilities: soil microorganisms, hormone exudates from roots or decomposing leaves, soil pH, soil moisture

Discussion

No evidence that nitrogen fixation is the problem

- In nursery seedlings, *Rhizobium* enhances the growth and survival of māmane
- Perhaps commercial *Rhizobium* inoculum (Guard N) is not compatible with this species
- Perhaps the combination of fertilizer and *Rhizobium* inoculum may not be effective in water-stressed ecosystems

More Questions

- What is the impact of non-native game birds?
- N-fixation levels?
- Is the soil microbial community involved in inhibiting germination or growth?

Mahalo!

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