Native grass – pathogen dynamics and non-native escape from disease: *Andropogon virginicus* and smut fungus

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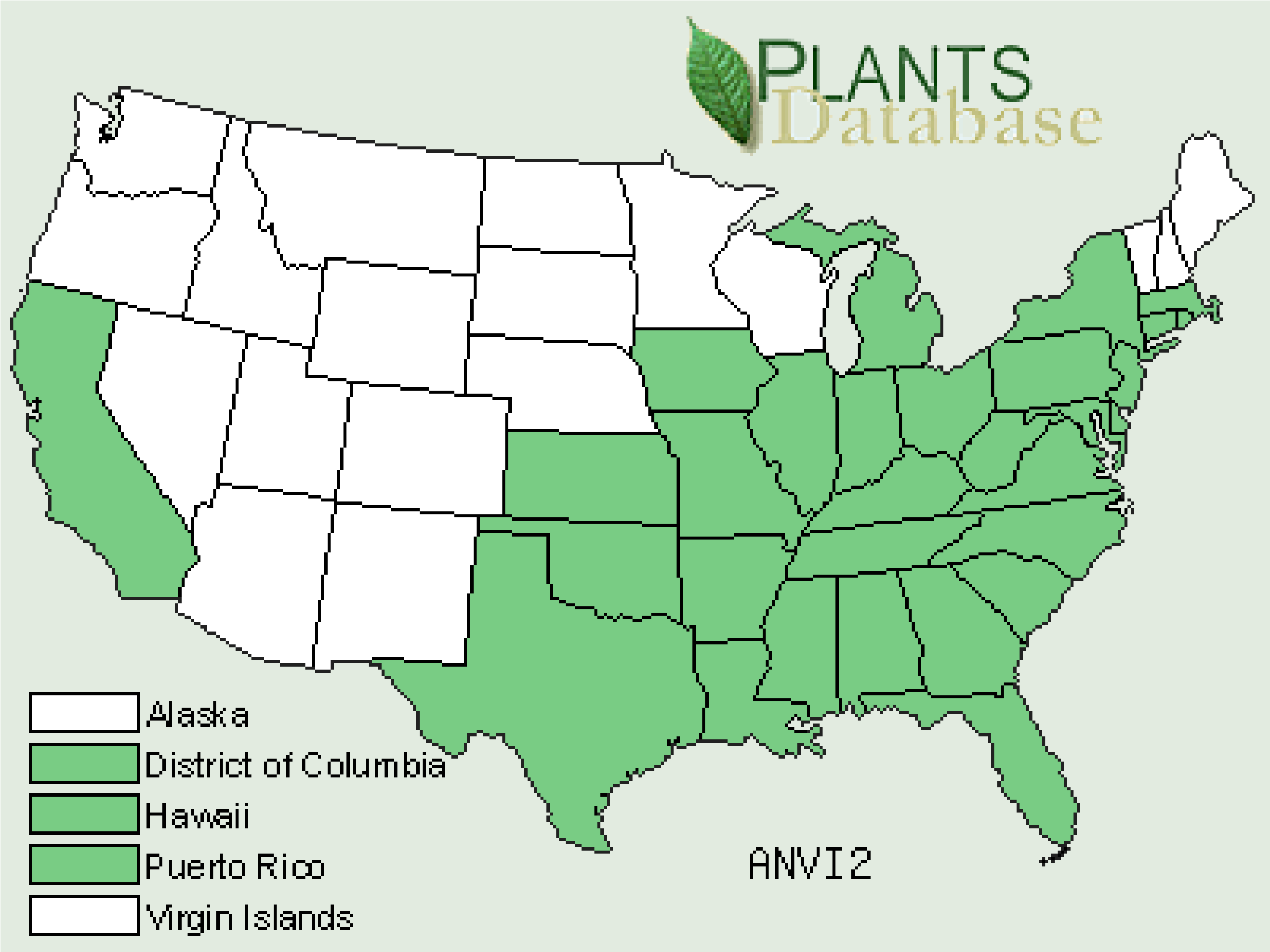
Andropogon virginicus (broomsedge)

old field successional C_4 grass common on low fertility, low pH soils; a pasture weed

Distribution in the United States



Naturalizing in California

- no categorization as invasive in any source
- mostly in Central Valley counties

Restricted to wet soils in California

Invasive in Hawaii

HEAR – Hawaiian Ecosystems at Risk Project

http://www.hear.org/pier/species/andropogon_virginicus.htm

“Introduced and invasive”

Hawaii

Maui

Molokai

Kauai

Oahu

Lanai

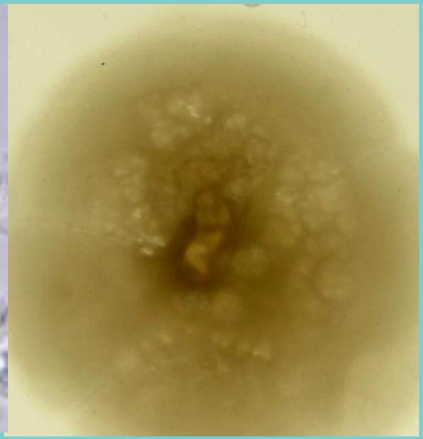
Also “invasive” in Australia, New Zealand, other Pacific islands

Hawaii Volcanoes National Park, the Steam Vents

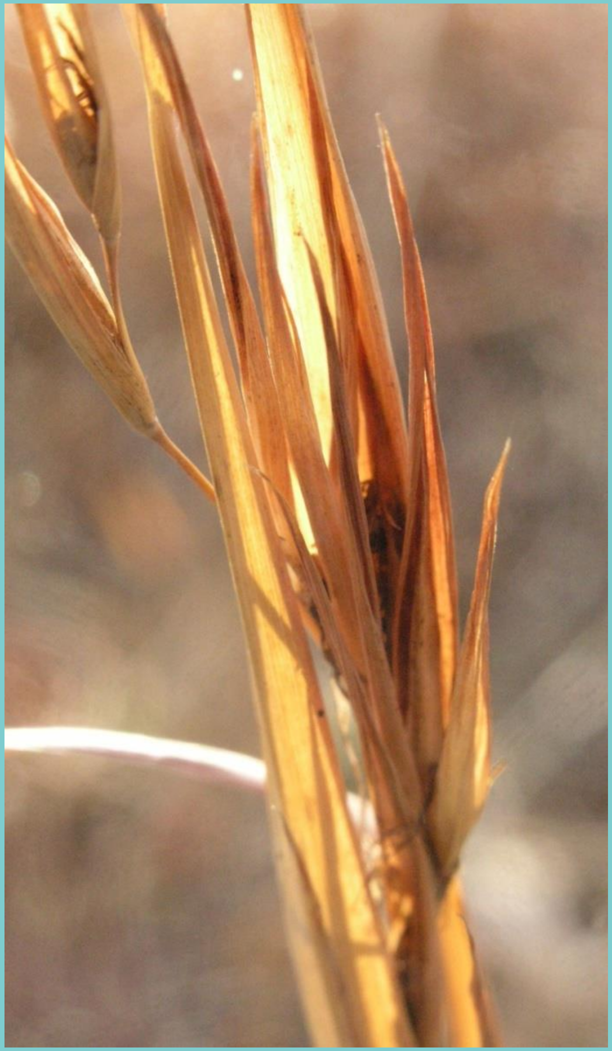
Hawaii Volcanoes National Park

Hawaii Volcanoes National Park

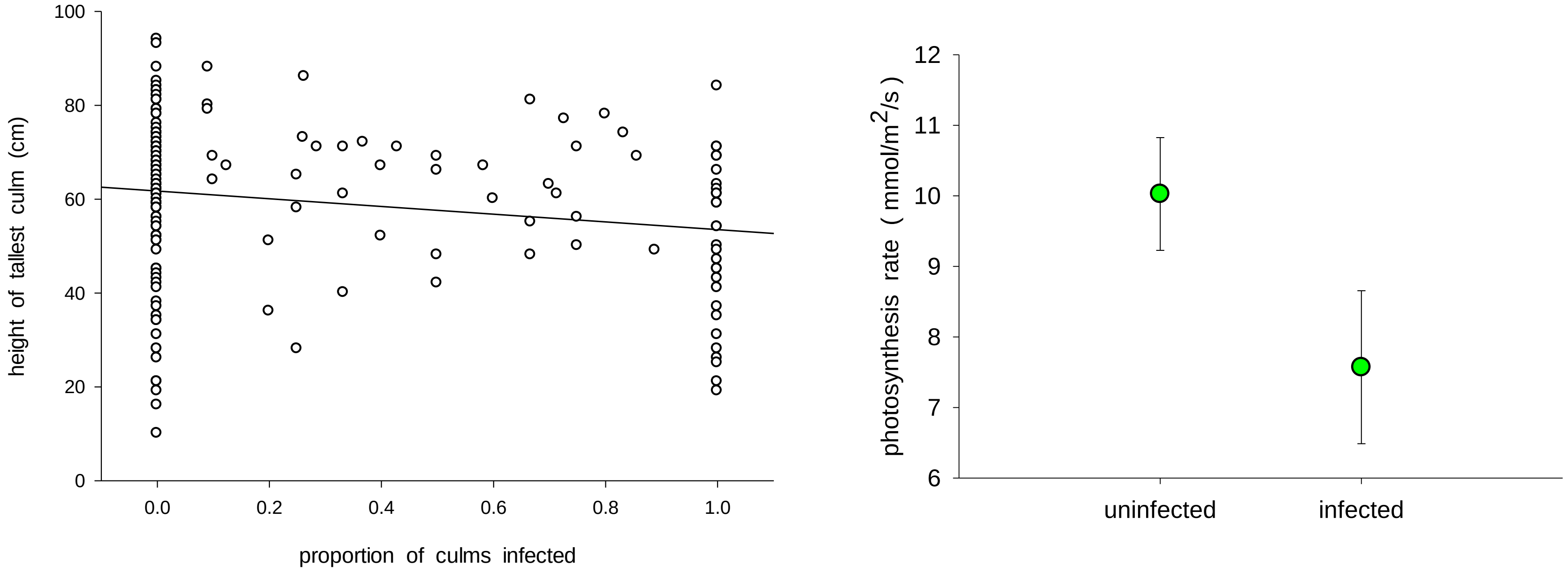
Infection by the
plant pathogen
Sporisorium ellisii,
a smut fungus
(Basidiomycetes)



Infected plants have lower or zero reproduction



Infected plants are smaller and have lower photosynthesis rates.



Do the Enemy Release Hypothesis (ERH) and the Evolution of Increased Competitive Abilty Hypothesis (EICA) apply to broomsedge invasion of Hawaii ?

- Does the smut fungus help regulate broomsedge populations in the native range ?
- Is the smut fungus absent in Hawaii ?
- Do native and non-native populations differ in vigor and competitive ability ?

Part I

Multi-year intensive study of two populations in New Jersey

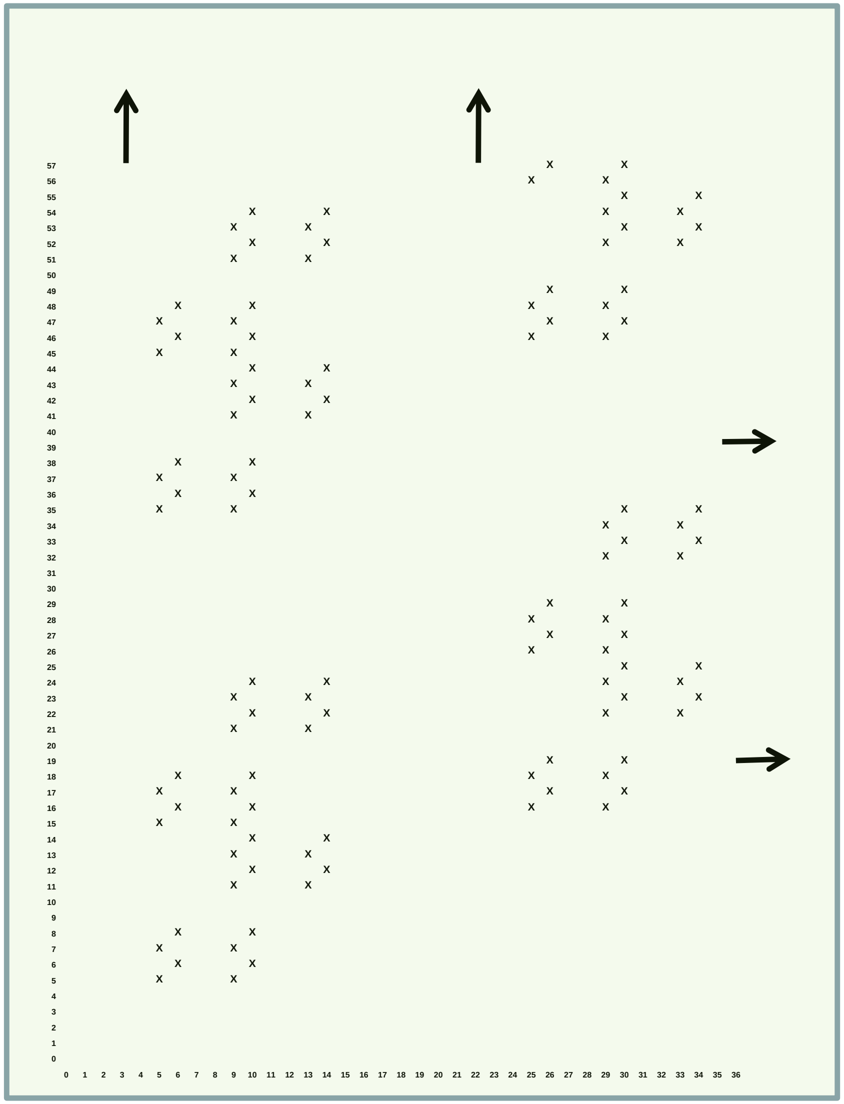
Part II

Comparison across the three ranges

A. Surveys of populations in the east, California, and Hawaii

B. A common-greenhouse experiment : Competitive ability and photosynthesis rate

Part I Methods



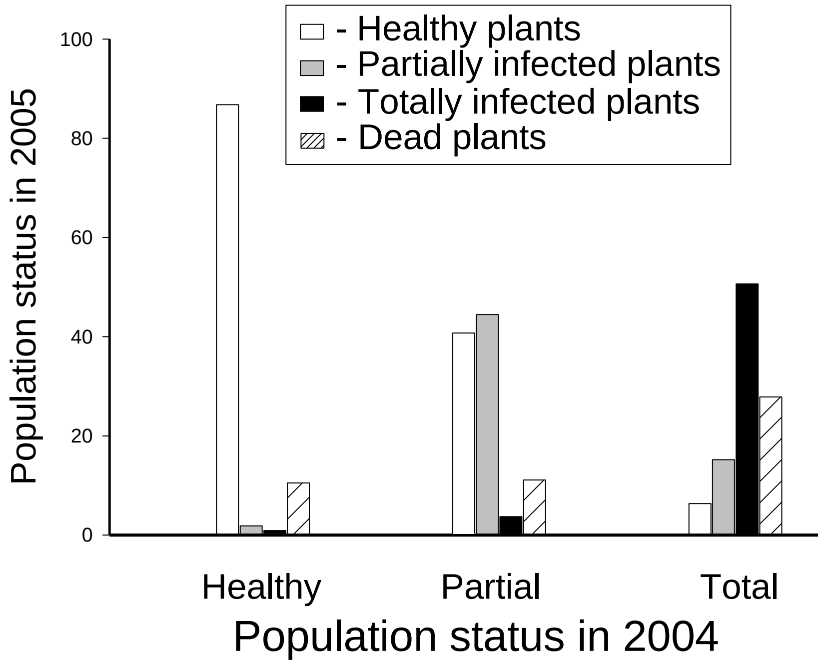
3 yrs. annual field sampling :

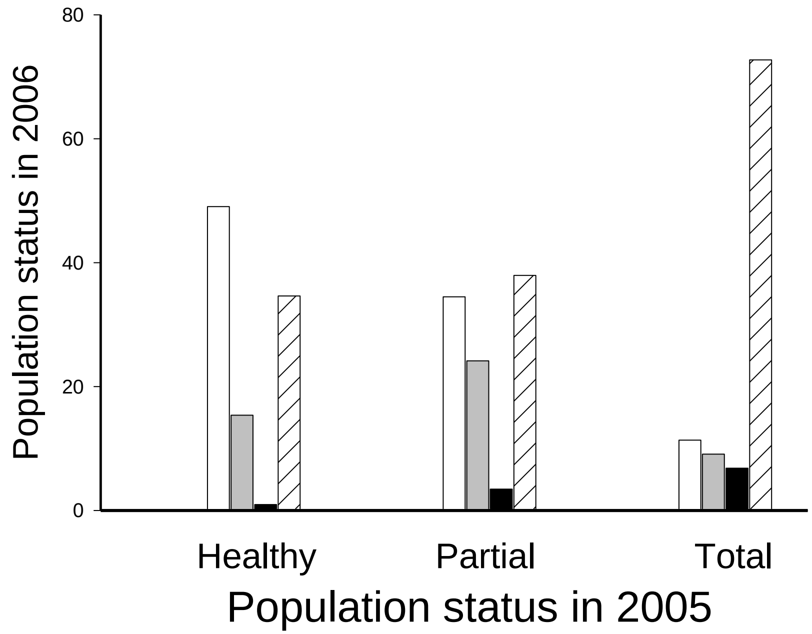
$1m^2$ plots in systematic clustered pattern

Variables :

- host density
- disease frequency
- focal plants:
  - size, disease severity,
  - mortality

Infected focal plants had higher percent mortality

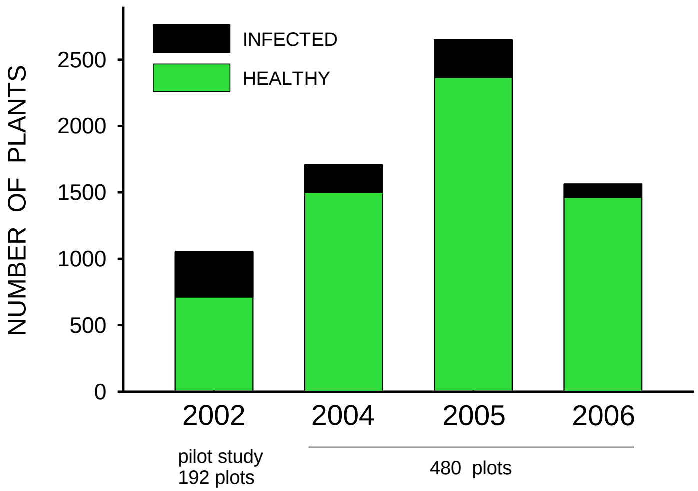


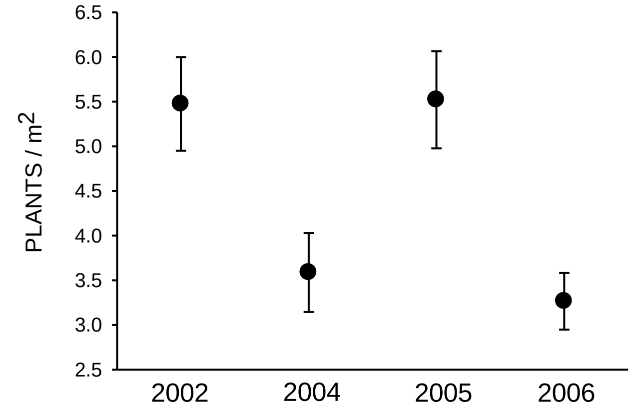


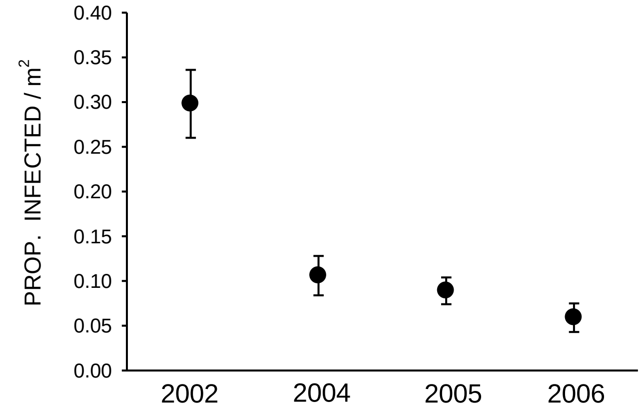
(in addition to lack of reproduction, smaller size, and lower photosynthesis rates)

Do these negative effects of the pathogen on individuals scale up to a negative effect on population growth?

No . . .
host density flucuated independently of infection rate .

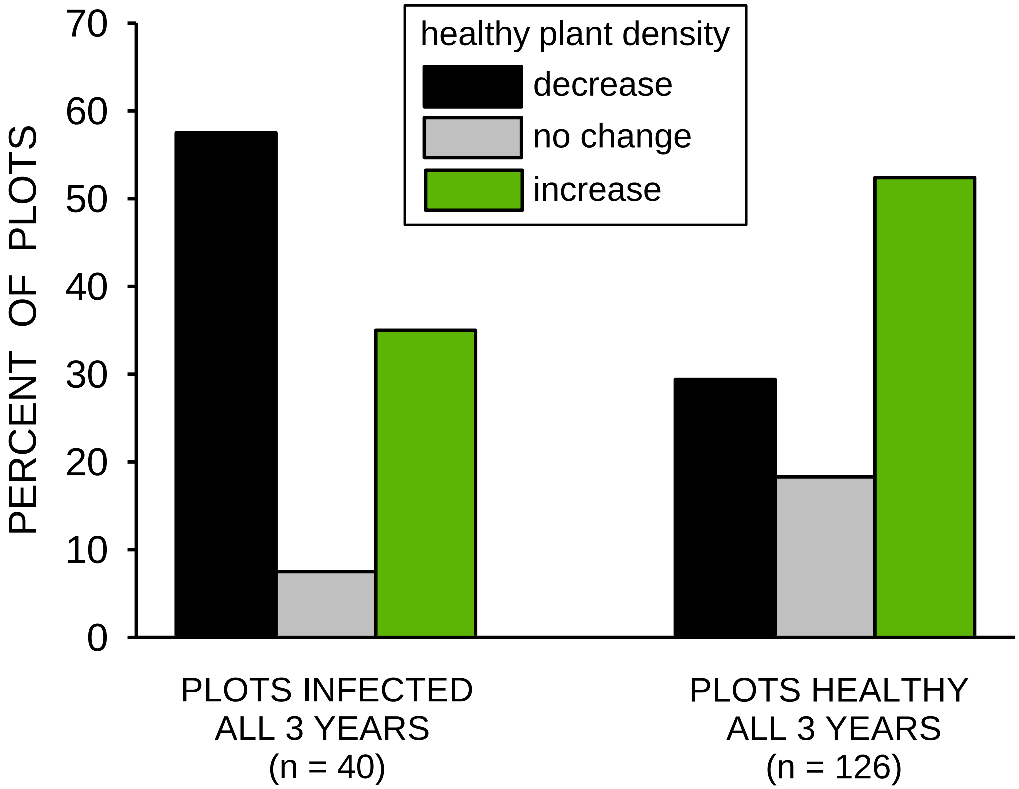




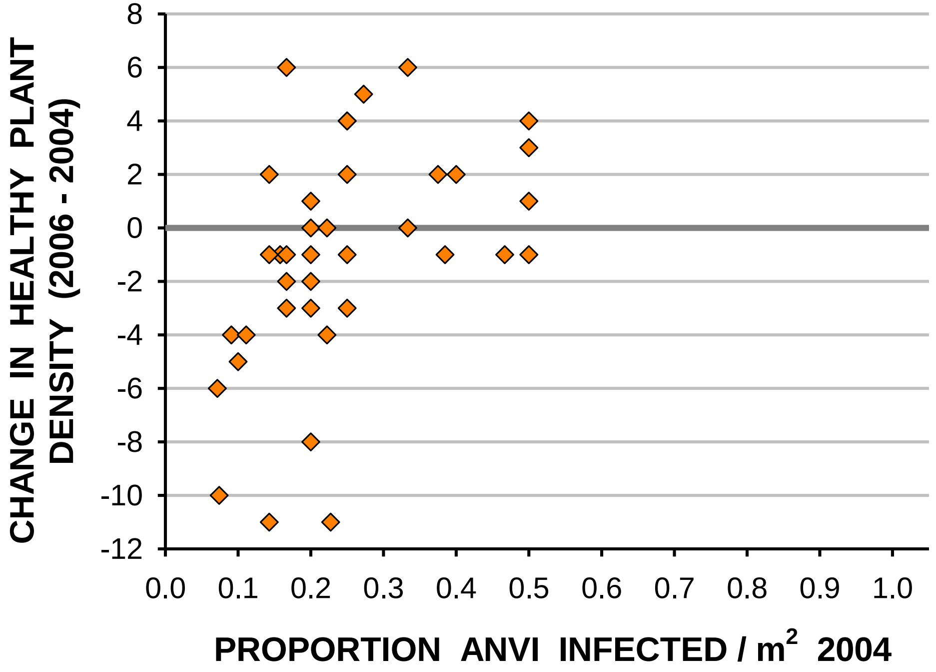


Yes . . .

plots infected all 3 years had greater percentage of plots with decreasing healthy plant density than did plots that were never infected.



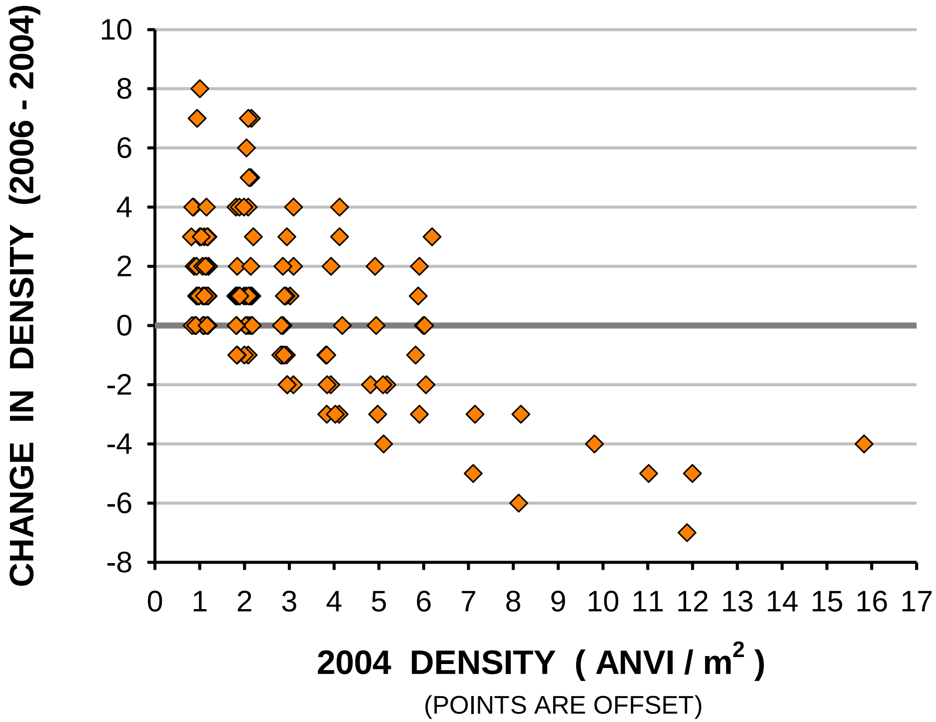
No . . . in the worst-case disease scenario (the plots infected all three years), the more severely infected plots showed greater increases in healthy plant density.



r = 0.58
N = 40
P = 0.0003

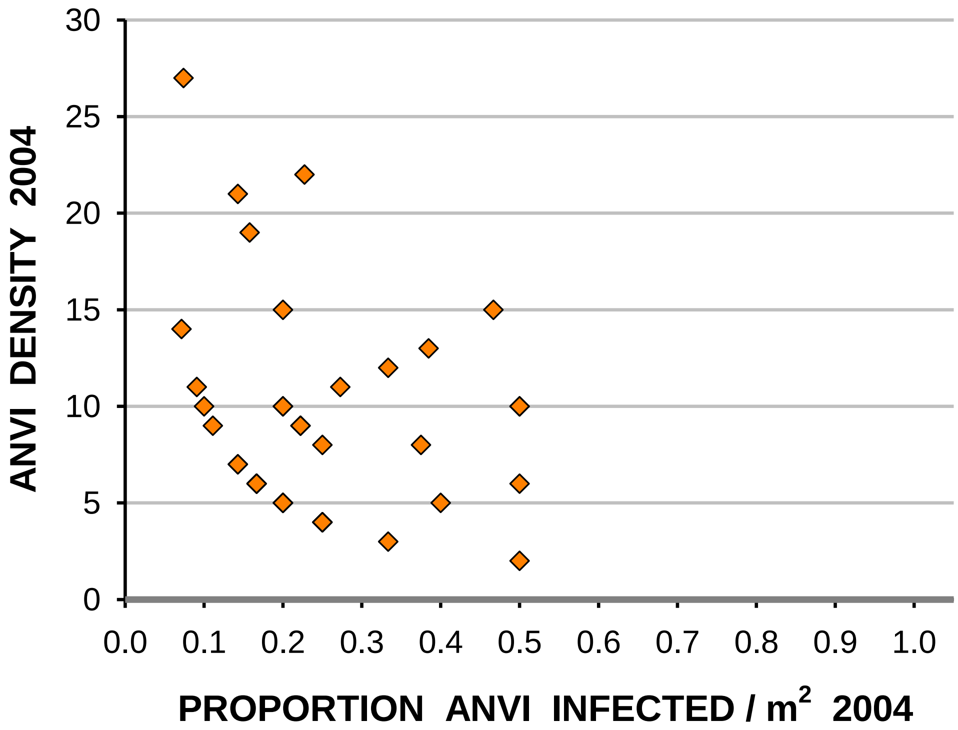
(tested with the Clifford, Richardson, Hemon (CRH) procedure to correct DF due to spatial autocorrelation using Moran's I)

No . . .
in plots never infected there was strong, intraspecific density dependent regulation: denser plots had greater decreases in plant density (self-thinning).



r = -0.63
N = 126
CRH-corrected P < 0.0001

Less dense plots started with more infection; thus the greater increase in healthy plant density seen in severely infected plots is likely due to intraspecific density dependence.



Plots infected all 3 years :
r = -0.39
N = 40
CRH-corrected P = 0.01

The smut fungus negatively affects individuals, but does not strongly affect the host population dynamics as a whole.

Escape from this disease therefore is not predicted to cause accelerated population growth due to loss of negative population regulation.

Still, its strong negative effects on individual survival and reproduction could result in natural selection for resistance to this pathogen at the individual level, in native populations.

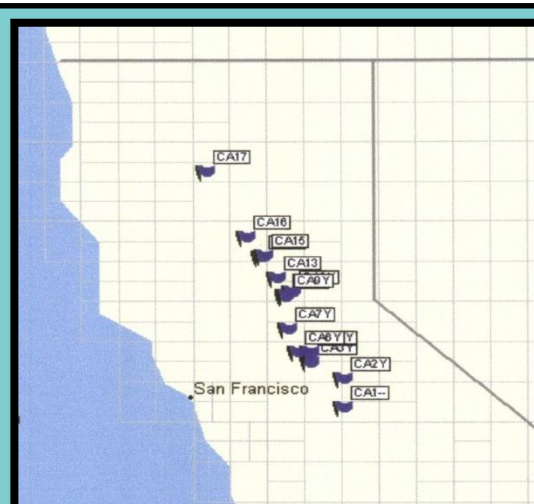
If introduced broomsedge populations no longer experience this agent of selection, they may have evolved increased competitive ability OR they may have originated from less-resistant genotypes in the first place and so may allocate more resources to growth and reproduction than native broomsedge.

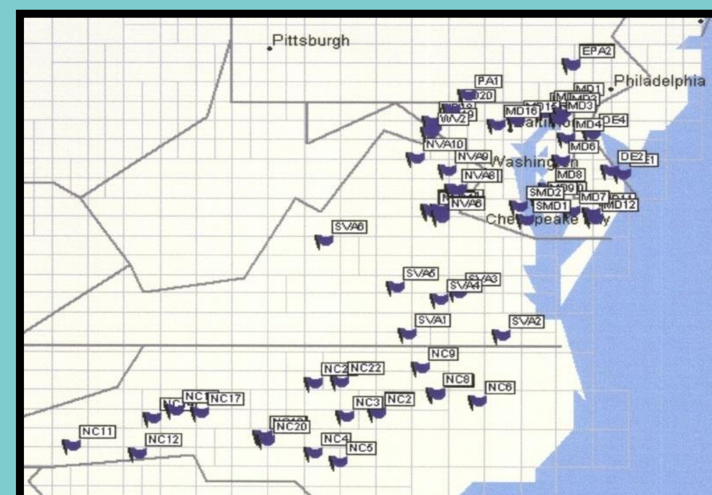
Part IIA Methods

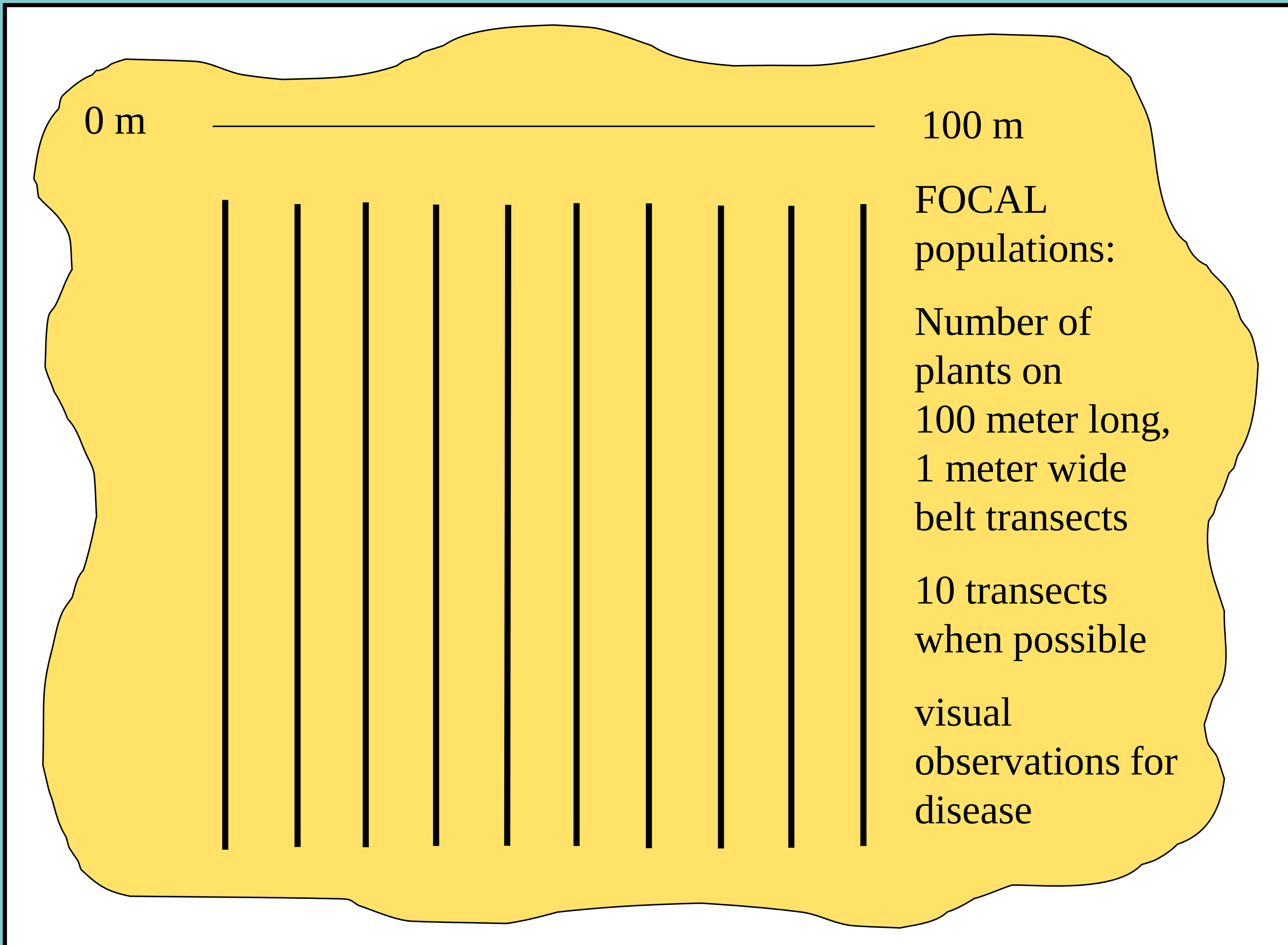
Population comparison across the three ranges :

1. Initial survey to locate populations > 100 populations for possible inclusion

2. Obtained permits, then re-visited to collect data and plant/fungal samples.






0 m
100 m
FOCAL populations:
Number of plants on 100 meter long, 1 meter wide belt transects
10 transects when possible
visual observations for disease

Eastern range:

Included 17 focal and 26 non-focal populations, from PA/NJ to northern SC

Wide range of locations :

coastal plain – QVC property, NC

piedmont – Sky Meadows State Park, VA

higher elevevation pasture – Mt. Research Station, NC (1500 m)

Californian range:

Included 4 focal and 4 non-focal populations

Restricted to water courses, shore lines
(20-350 m elev.)

Rancho Seco, CA

Hawaiian range:

Included 8 focal and 8 non-focal populations, from The Big Island and Maui.

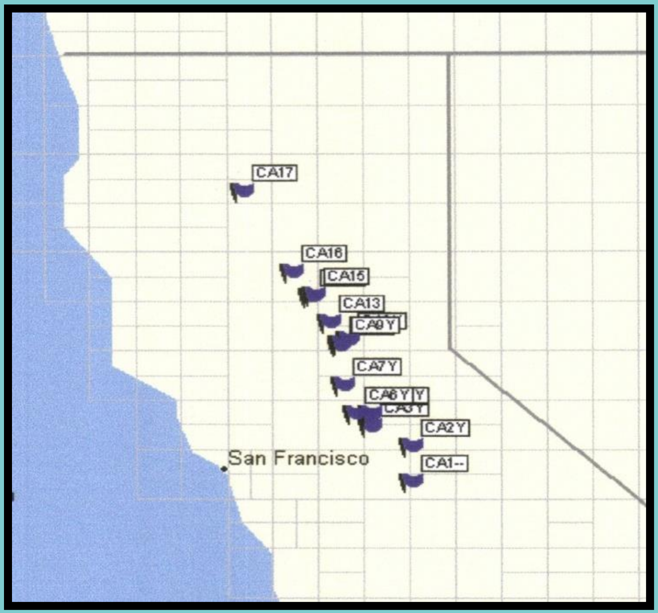
Found on nearly bare lava flows to older volcanic soils with organic matter.

Mostly 50 – 1200 m elev. ; up to 1940 m.

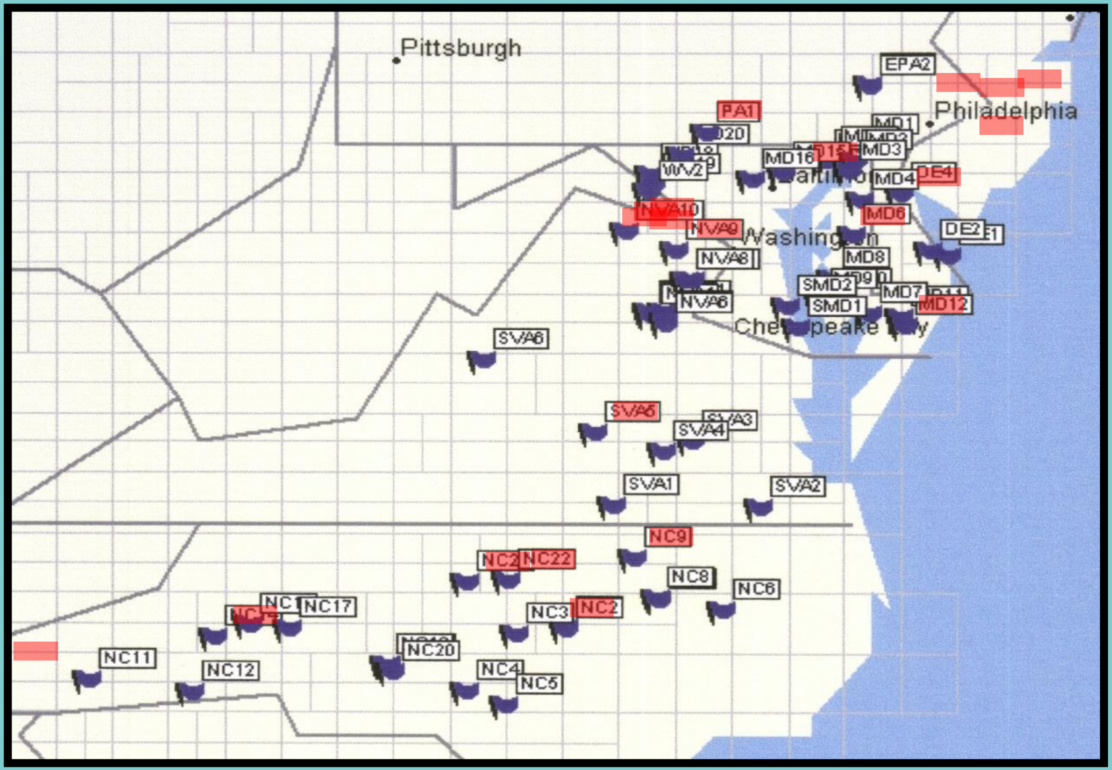
Windward side of islands.

Often remote ridges, crater walls – wind dispersed.

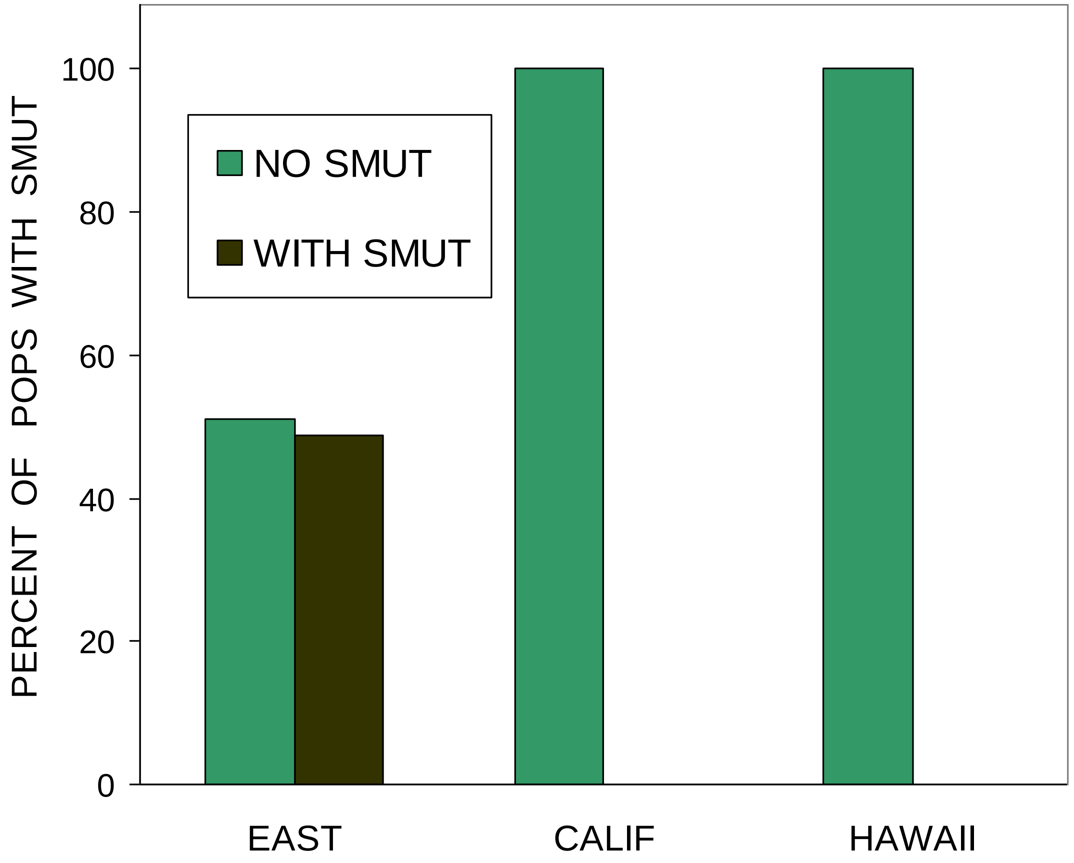
Escape ! No smut fungus disease in Hawaii or California



Populations with disease

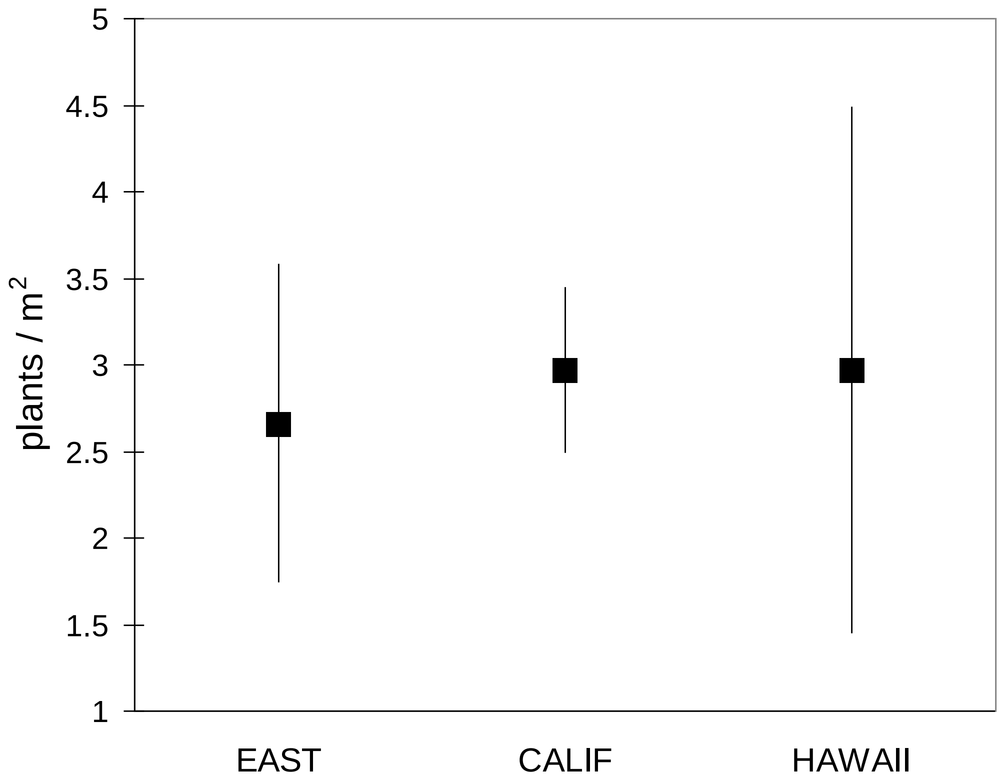


Half of eastern populations have smut fungus



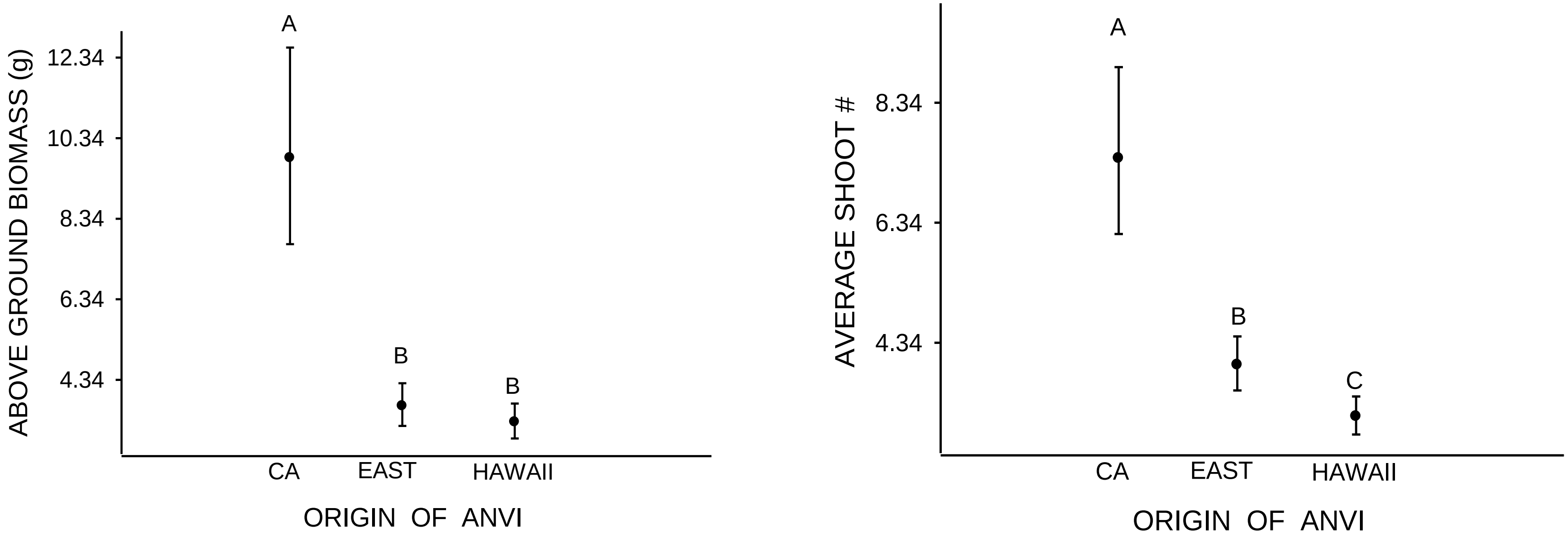
Has escape from this specialist pathogen led to ecological release and increased competitive ability in Hawaiian broomsedge ?

No . . . broomsedge density is similar in the three regions . . .



Means ± 95% CL

No . . . broomsedge is the same size or smaller in Hawaii . . .



Means ± 95% CL. Sample sizes: CA, n=144; East, n=294; Hawaii, n=326.

Part IIB Methods

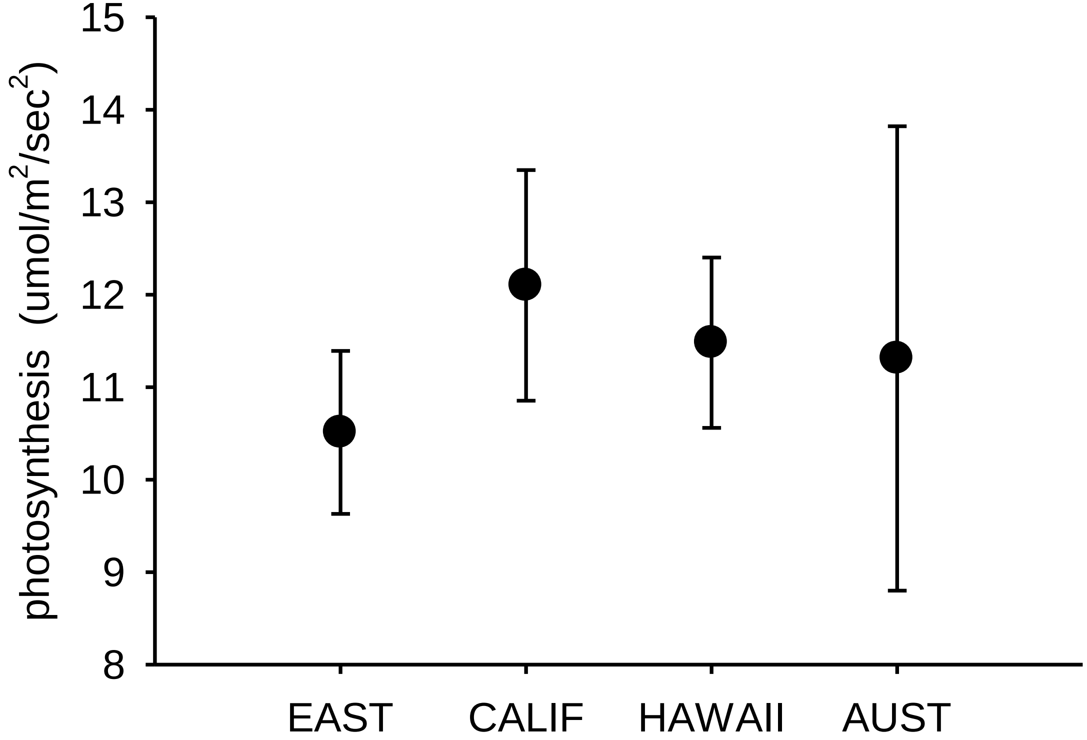
Common-greenhouse competition experiment
One individual of *A. virginicus* grown alone, or with a phytometer (Bermuda grass), for 6 months

A. virginicus grown from seed : EAST (15 pops), HAWAII (10 pops) CALIFORNIA (8 pops), AUSTRALIA (2 pops)

All pops/treatments replicated, randomized into 5 blocks

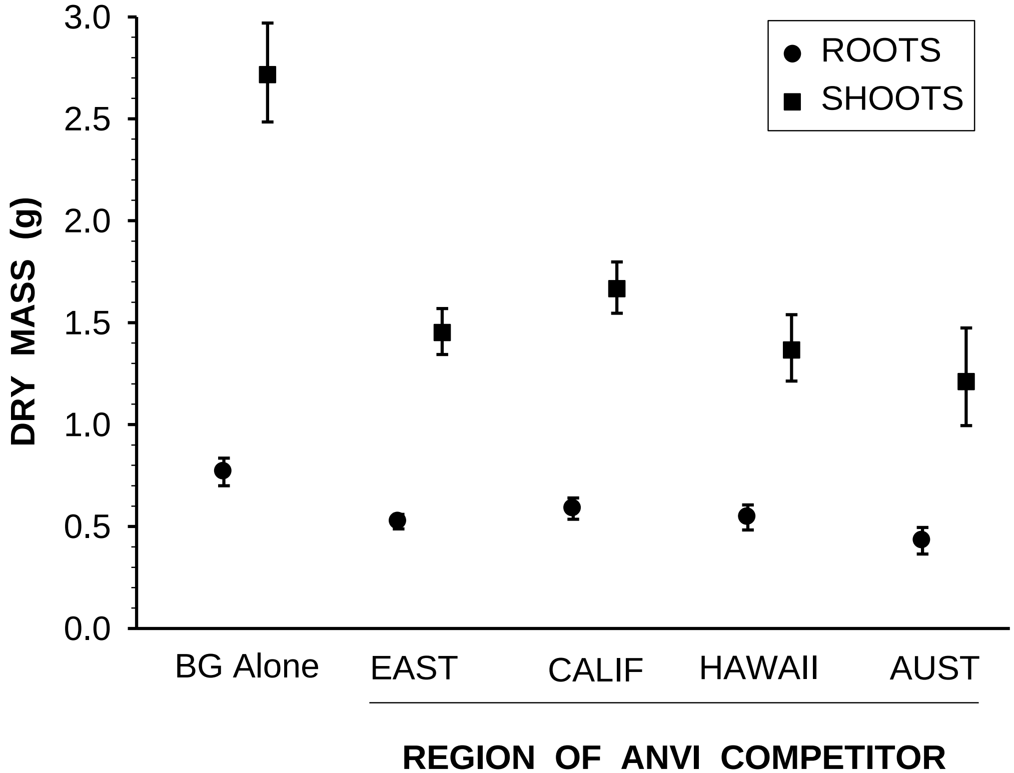
Variables: photosynthesis rate with Li-Cor 6400 root and shoot dry mass at harvest

No . . . broomsedge from all regions have similar photosynthesis rates . . .



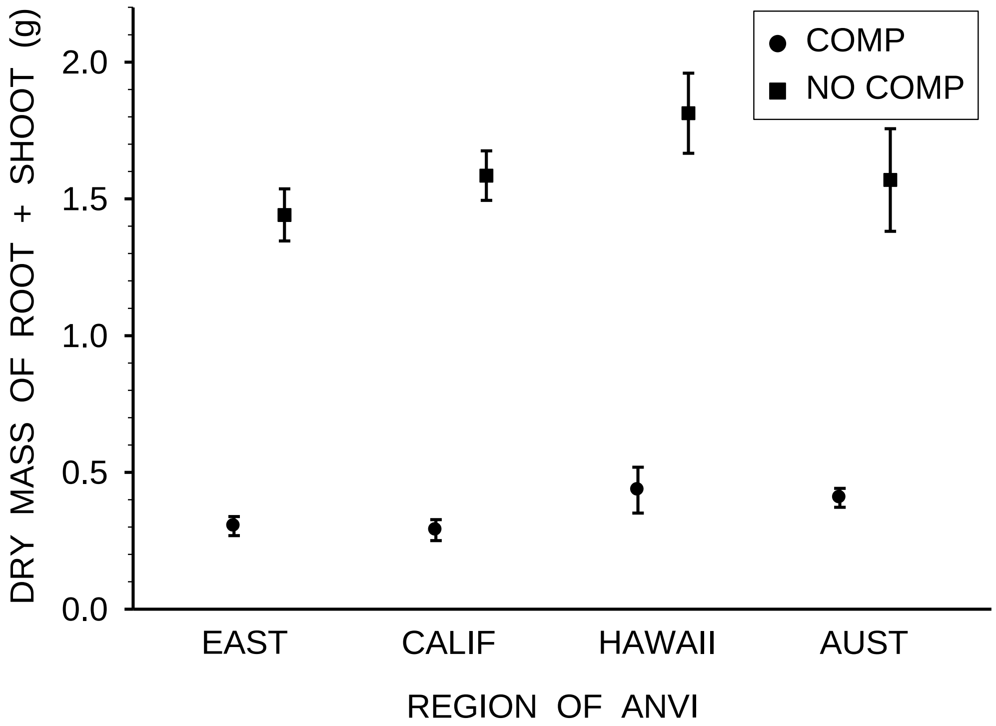
Means ± 95% CL. Sample sizes: East, n=59; CA, n=38; Hawaii, n=47, Australia, n=10

No . . . effect of competition by broomsedge from all regions was similar . . .



Means ± 95% CL. Sample sizes: BG Alone, n=49; East, n=75; California, n=39; Hawaii, n=48; Australia, n=10.

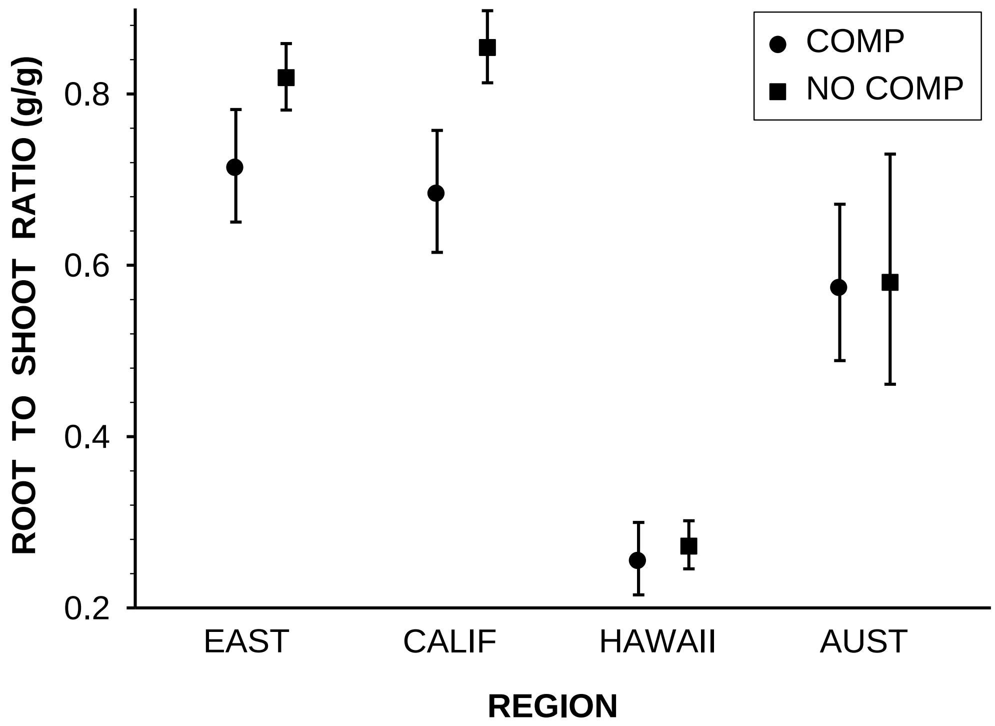
But . . . Hawaiian broomsedge grew significantly larger in the common environment, and . . .



Means + 95% CL. Sample sizes: East, n=75; California, n=39; Hawaii, n=48/47 no comp; Australia, n=10.

Hawaiian broomsedge roots supported MUCH more shoot biomass per root biomass.

Evolution of increased root efficiency (EIRE) ?



Means ± 95% CL. Sample sizes: East, n=75; California, n=39; Hawaii, n=48/47 for no comp; Australia, n=10.

Conclusions

- In the native range smut fungus negatively affects broomsedge individuals but not (or weakly) populations.
- Invasive Hawaiian populations have escaped from the disease, and exhibit increased growth potential and increased root efficiency, but not greater competition or photosynthesis, nor greater in situ size or density.

Next: measure differences in resistance/tolerance and relationship to pattern and amount of resource allocation.

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