Kick'n Grass in Hawaii for Wildfire Management & Restoration

James Leary Dept. of Natural Resources and Environmental Management

A presentation for the Pacific Fire Exchange Webinar Series

November 18, 2018

Objective:

Manage grass fuel loads below risk thresholds

Subjects of interest:

Kikuyu grass (*Pennisetum clandestinum; Cenchrus clandesitnus*)
Fountain grass (*Pennisetum setaceum; Cenchrus setaceus*)

Learning outcomes from research and experience:

- Residual herbicide activities on dormant fountain grass
- Suppressing kikuyu grass pre- and post-plant herbicide
- Accelerating the restoration trajectory of *Acacia koa*
- Hueristic kikuyu grass growth models

C_4 grassy biomes

C_4 grassy biomes are dominant in (sub) tropical climatic zones that also support forests

The C_4 photosynthetic pathway differs from C_3 by the addition of a CO_2-concentrating mechanism at the site of carboxylation; This reduces photorespiration; A competitive advantage of hot, dry environments.

C_4 grassy biomes are hard to predict with global vegetation models based on "Bottom Up" climatic and edaphic conditions (Whittaker 1975)

Grass Fire Cycle

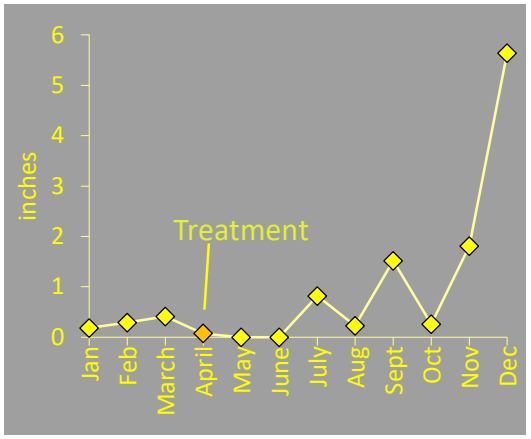
Theoretically, ecosystem physiology should predict woody forest replacement of “early successional” grasslands.

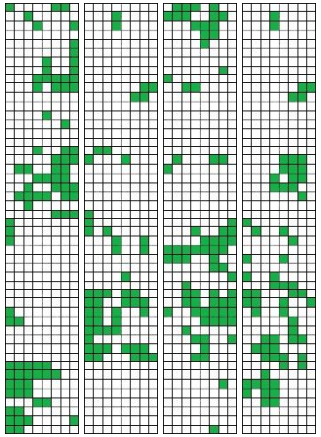
Much of the global mismatch between actual and potential vegetation could be explained by “Top Down” fire (Bond et al. 2005)

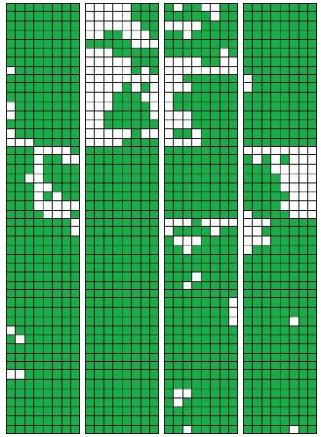
The grass-fire cycle is a species driven positive feedback loop perpetuating “Top Down” fire events followed by competitive response advantages exceeding woody species capabilities

Determine the residual activities of imazapyr and glyphosate on dormant (climax) fountain grass

Approach: Install and monitor a replicated field experiment on dormant fountain grass at Pohakuloa Training Area in 2007







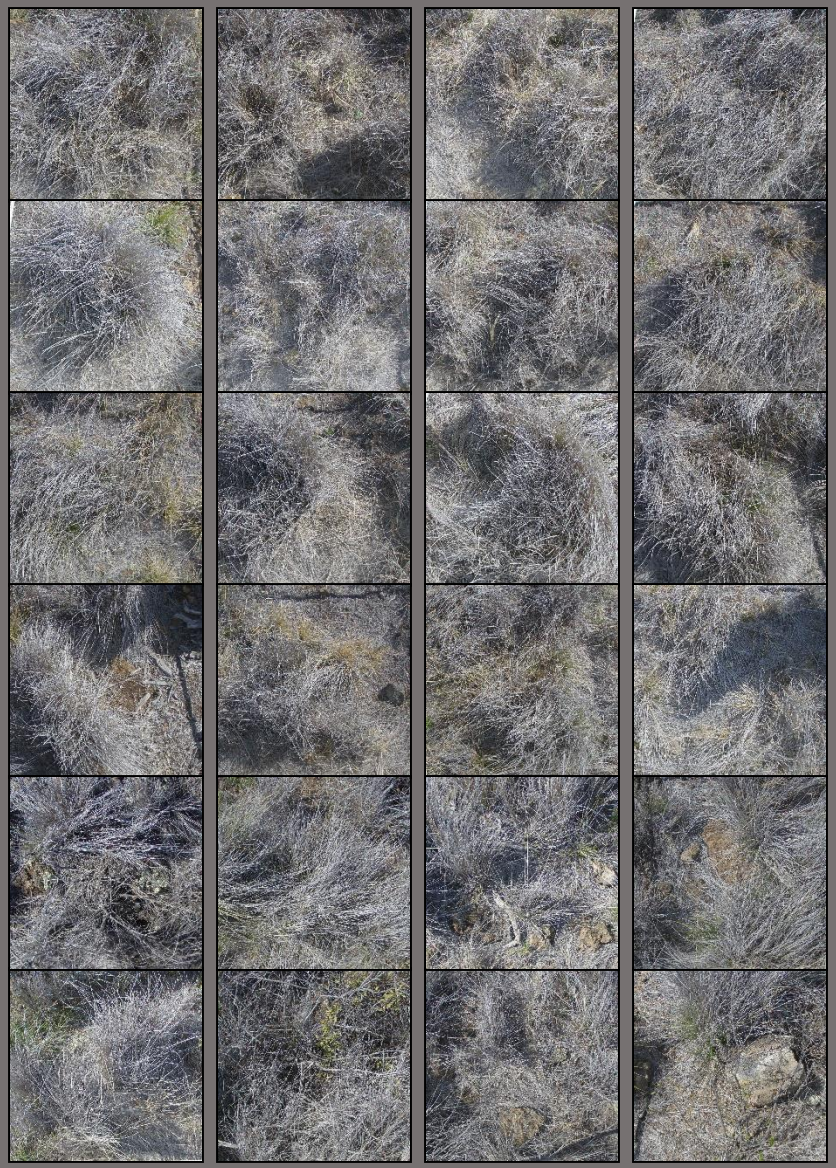
Monthly accumulated precipitation at PTA for 2007 *http://www.met.utah.edu/mesowest/*

- RCBD replicated 4x; Treatments applied in extreme drought conditions
- Imazapyr (IMZ) applied at 0.56 kg a.e. ha^{-1}; Glyphosate (GLY) applied at 1.25 kg a.e. ha^{-1}
- with factorial combinations of adjuvants not significantly effective
- Old-school remote sensing with close range nadir images w/ 1 m^2 FOV plot sampling for visual detection of greenness

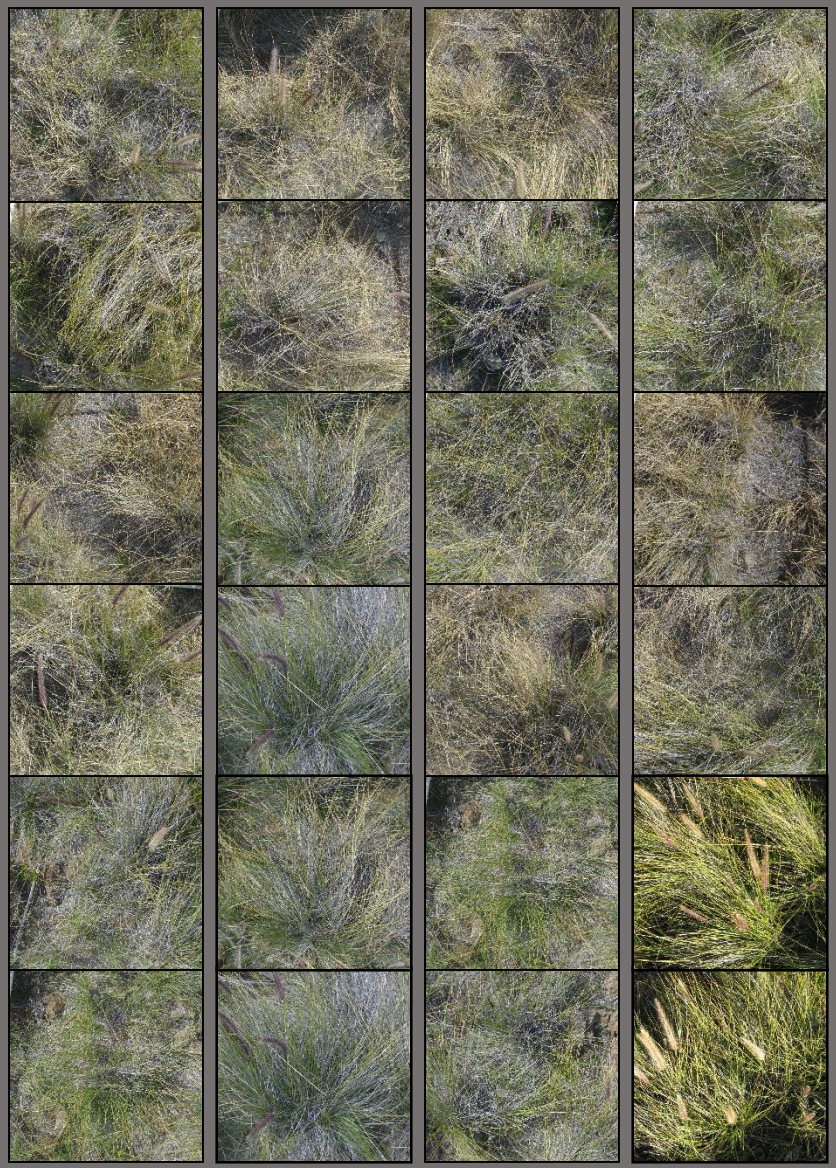
Symptoms observed January 2008 (41 WAT)

Cropped image data set recorded January 2008 (41 WAT)

imazapyr

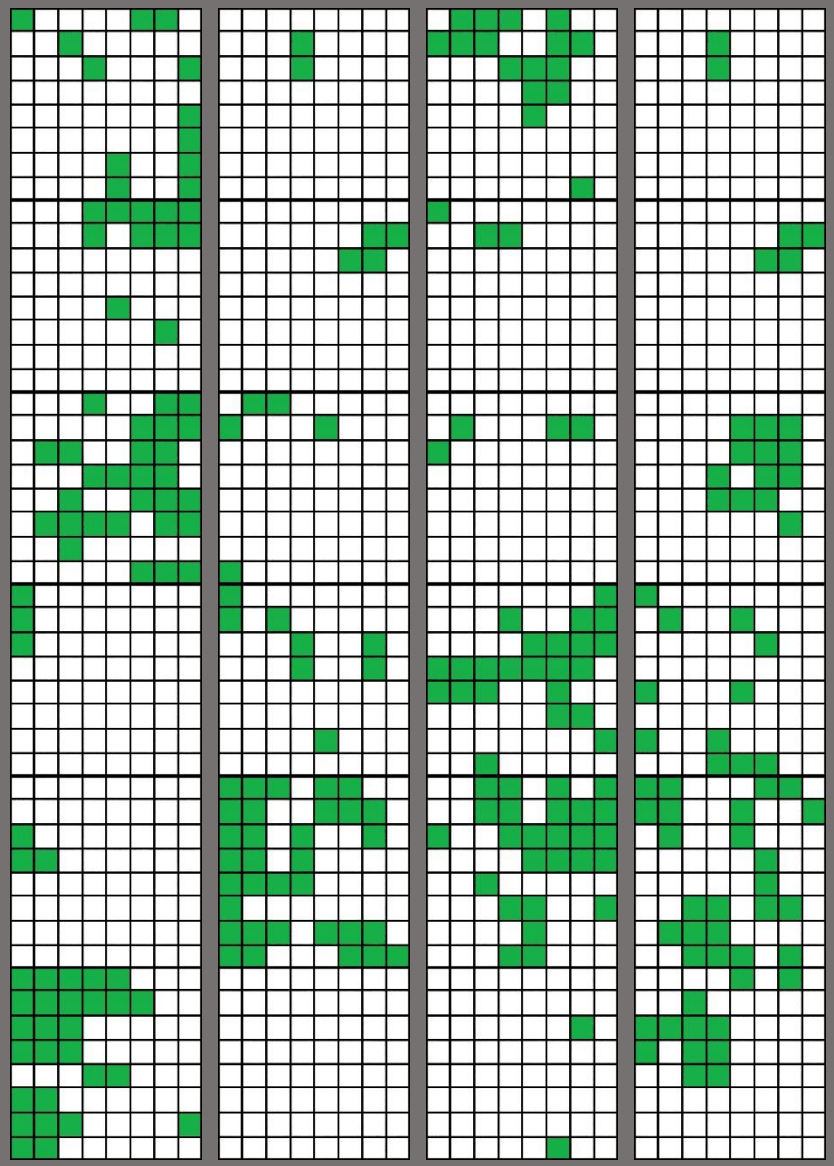


glyphosate

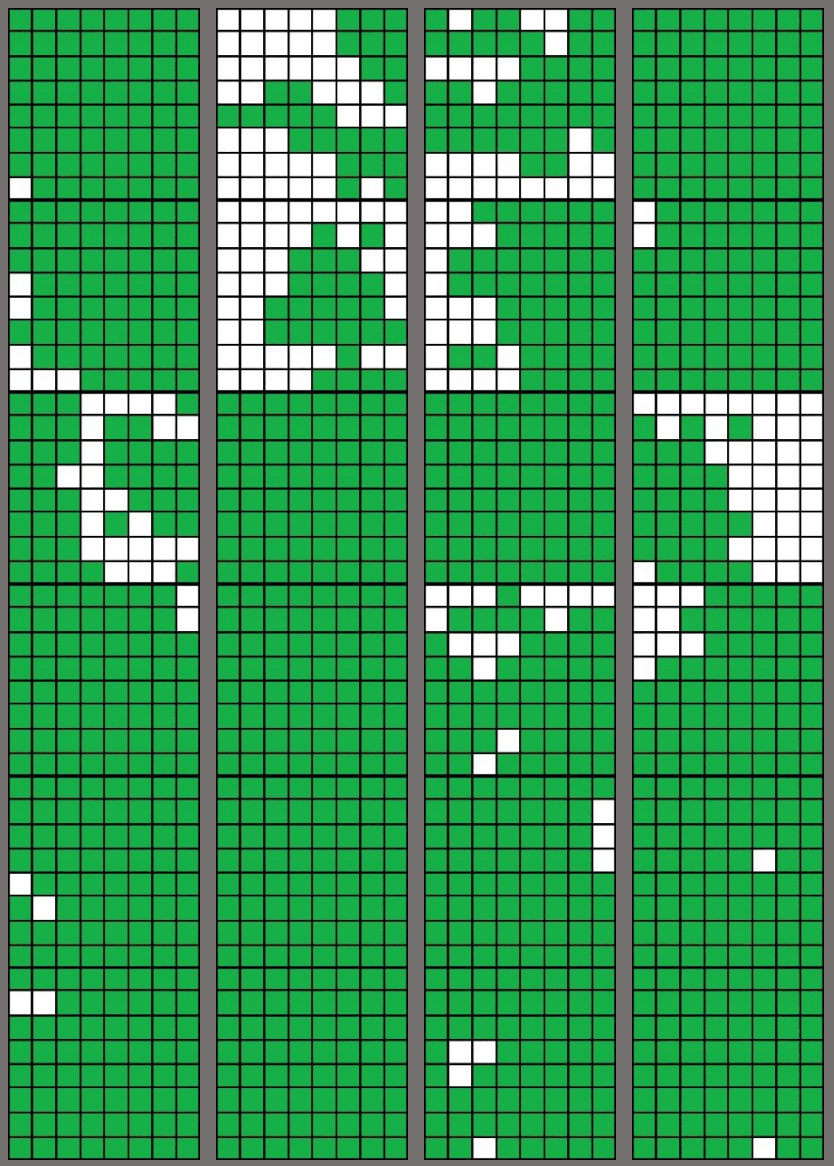


Grid scored by presence (green) or absence (white) of foliage January 2008 (41 WAT)

imazapyr

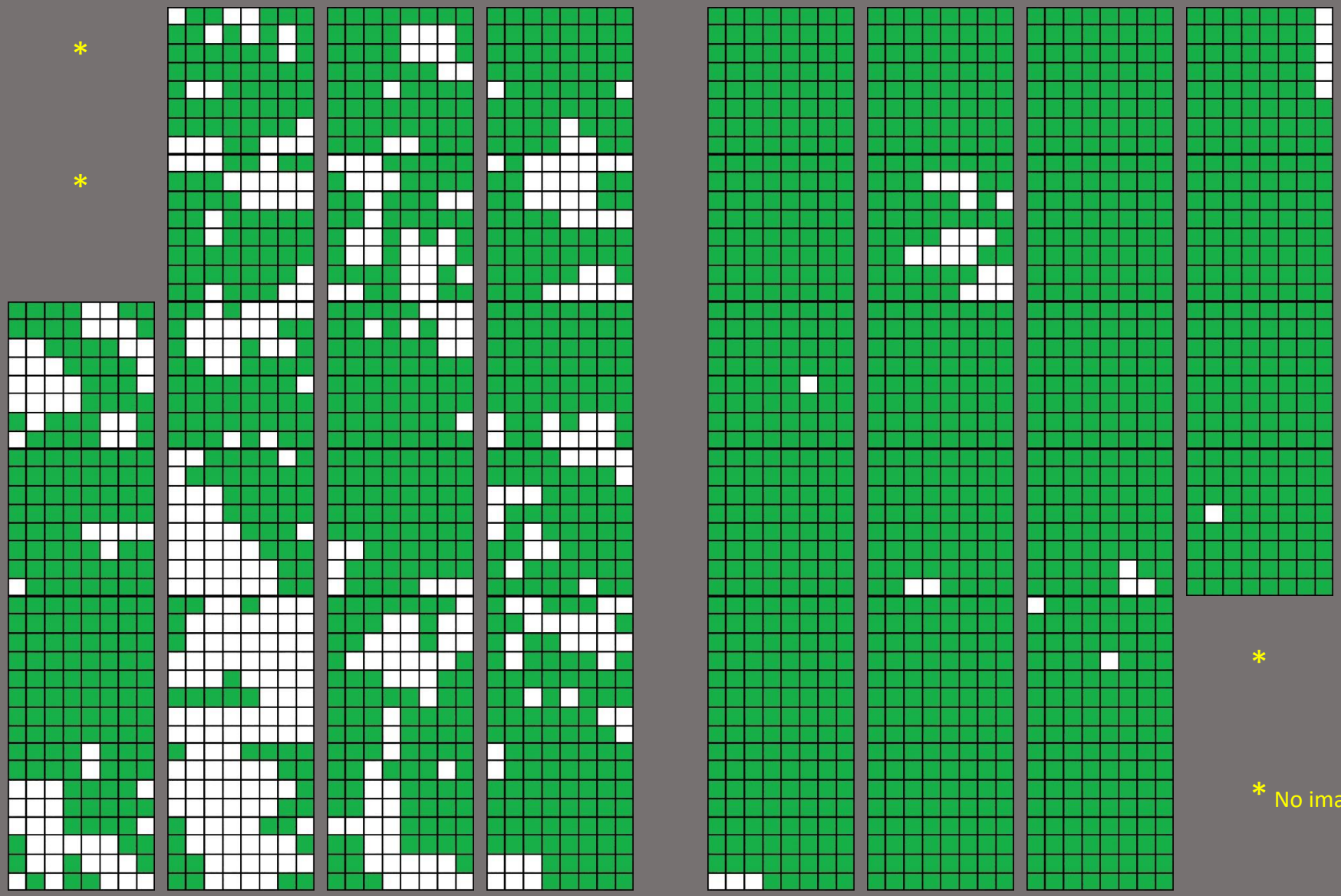


glyphosate



Grid scored by presence (green) or absence (white) of foliage March 2008 (49 WAT)

Grid scored by presence (green) or absence (white) of foliage March 2008 (49 WAT)



Regrowth (greening) observed as ramets sprouting from the edge of the perennial clumps

Determine pre-plant suppression of imazapyr and glyphosate on kikuyu grass, accelerating growth trajectory of outplanted koa

Approach: Install and monitor a replicated field experiment at Ulupalakua Ranch, Maui 2011-2013

- -1 MAT: on May 2011, herbicide combination of glyphosate and imazapyr applied at 1.7 kg ae ha^{-1}, respectively.
- 0 MAT: on June 2011, seedlings (~105 days old) were outplanted in close 1 × 1 m spacing with a total of 20 experimental trees.
- Environmental monitoring with Decagon® 5TM soil sensor recording to EM50G data loggers measuring (hourly) T (^{o}C) and VWC (v_{water}/v_{soil})

Ungulate exclusion is a primary step to site restoration, but inherently leads to dominant occupation of the exotic forages.

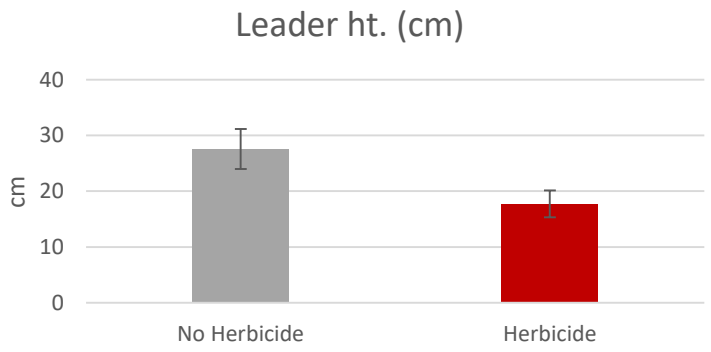
Kikuyu grass (*Pennisetum clandestinum*) is the most prevalent C_4 species and can produce 15-45 Mg ha^{-1} aboveground biomass.

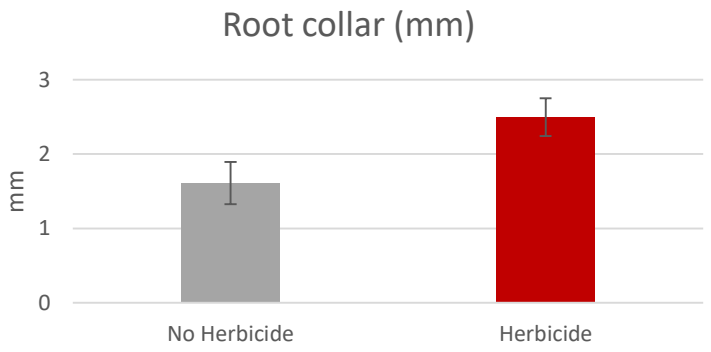
Glyphosate and imazapyr are highly effective short and long-term suppressors of kikuyu grass, respectively.

Glyphosate (left) and imazapyr (right) treatments at 3 MAT. Note how grass is recovering in the clipped area in GLY plot, while IMZ continues to show residual expression.

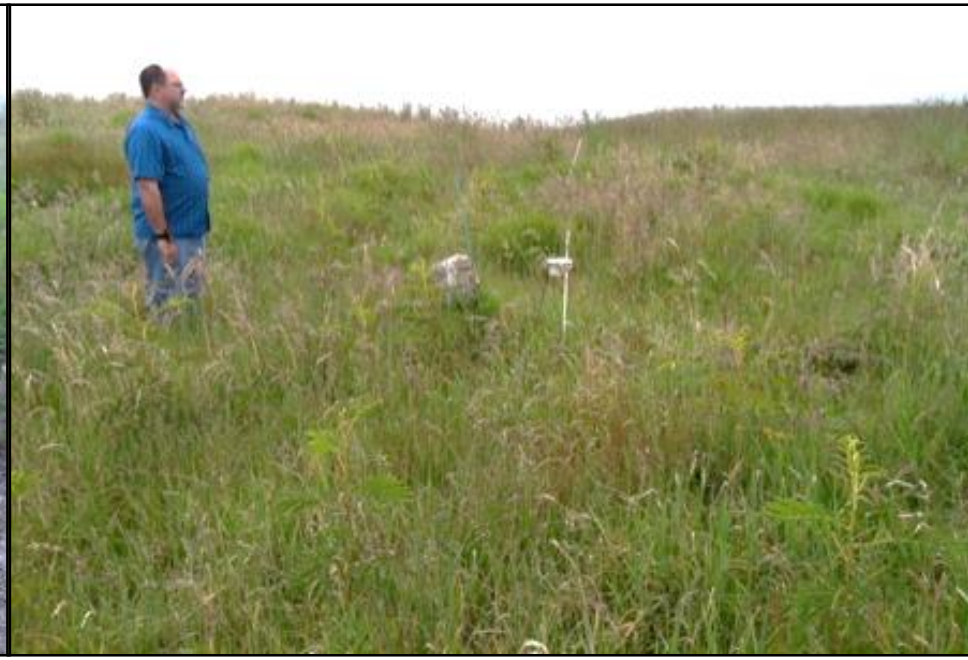
Anecdotal evidence of koa exhibiting imazapyr tolerance.

4 MAT: Strong Grass suppression, but also with collateral injury and koa growth suppression exhibited by residual of IMZ application (30 DAT).





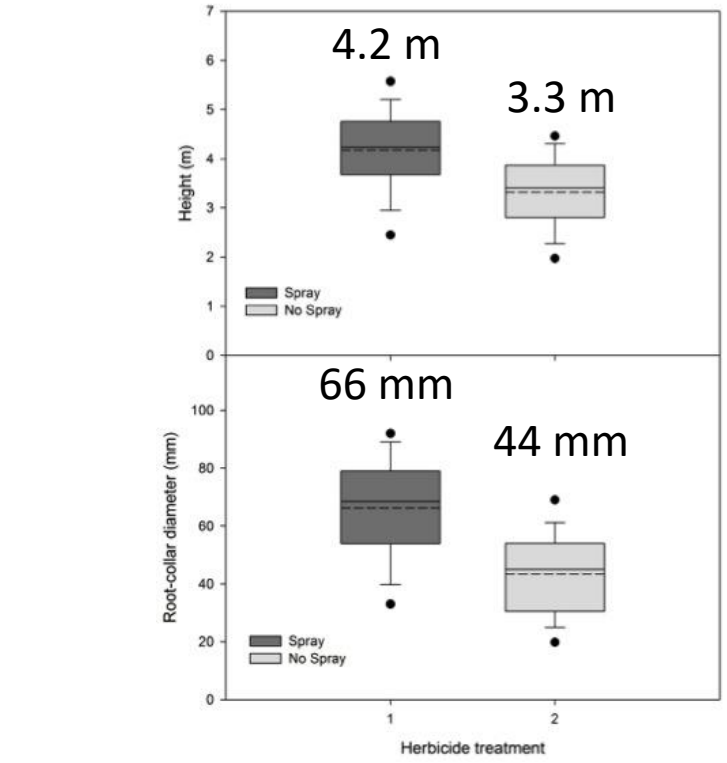
12 MAT: Reversal of fortune with significantly greater koa growth in grass suppression treatment.

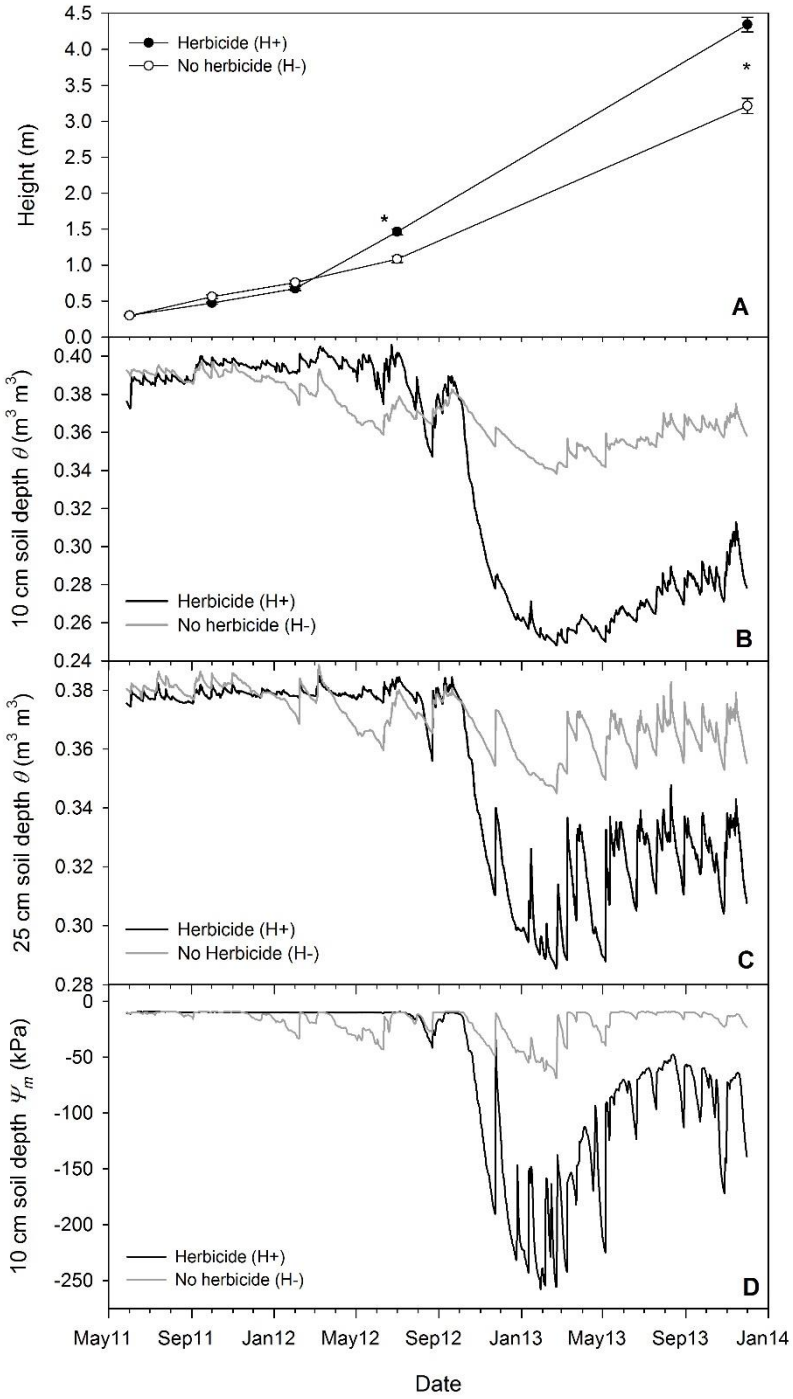


>95% survival for the entire experiment!

Results

36 MAT: Drop in VWC corresponding to log-phase growth enhanced by grass suppression.





Determine Fusilade® DX (a.i. fluazifop-p-butyl) regiment in suppressing kikuyu grass and growth response of Koa

Approach: Install and monitor a replicated field experiments in Humu'ula, Hawaii 2006-2008

h- f-
h- f+

h+ f-
h+ f+

- Treatment design: 2x2 factorial with 5 replications
- Treatments herbicide: fluazifop-p-butyl (0.42 kg a.i. ha^{-1}); fertilizer: 16-16-16 (100 kg N ha^{-1})
- Applications made every 4 months for 16 months (total of 4 treatments)
- Monitored aboveground biomass every 4 months (separated into foliar and stolon fractions)

Sward Structure of kikuyu grass consists of three fractions:

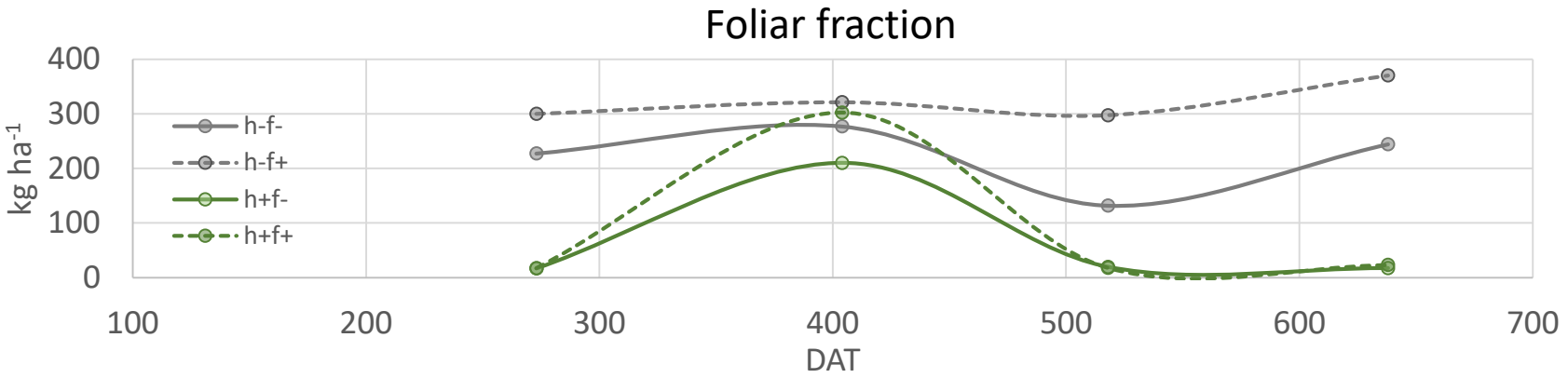
- Foliar fraction- the photosynthetic component
- Stolon fraction- the invasive component
- Thatch fraction- the decay component

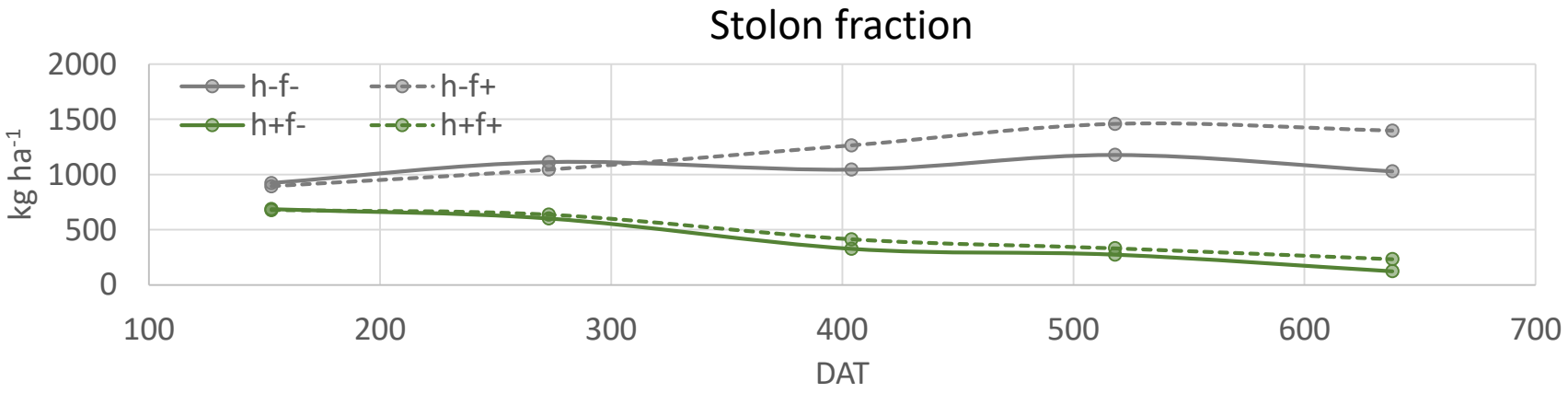
Oscillating suppression and recovery of the foliar fraction leading to stolon bank decline

4MA2nd

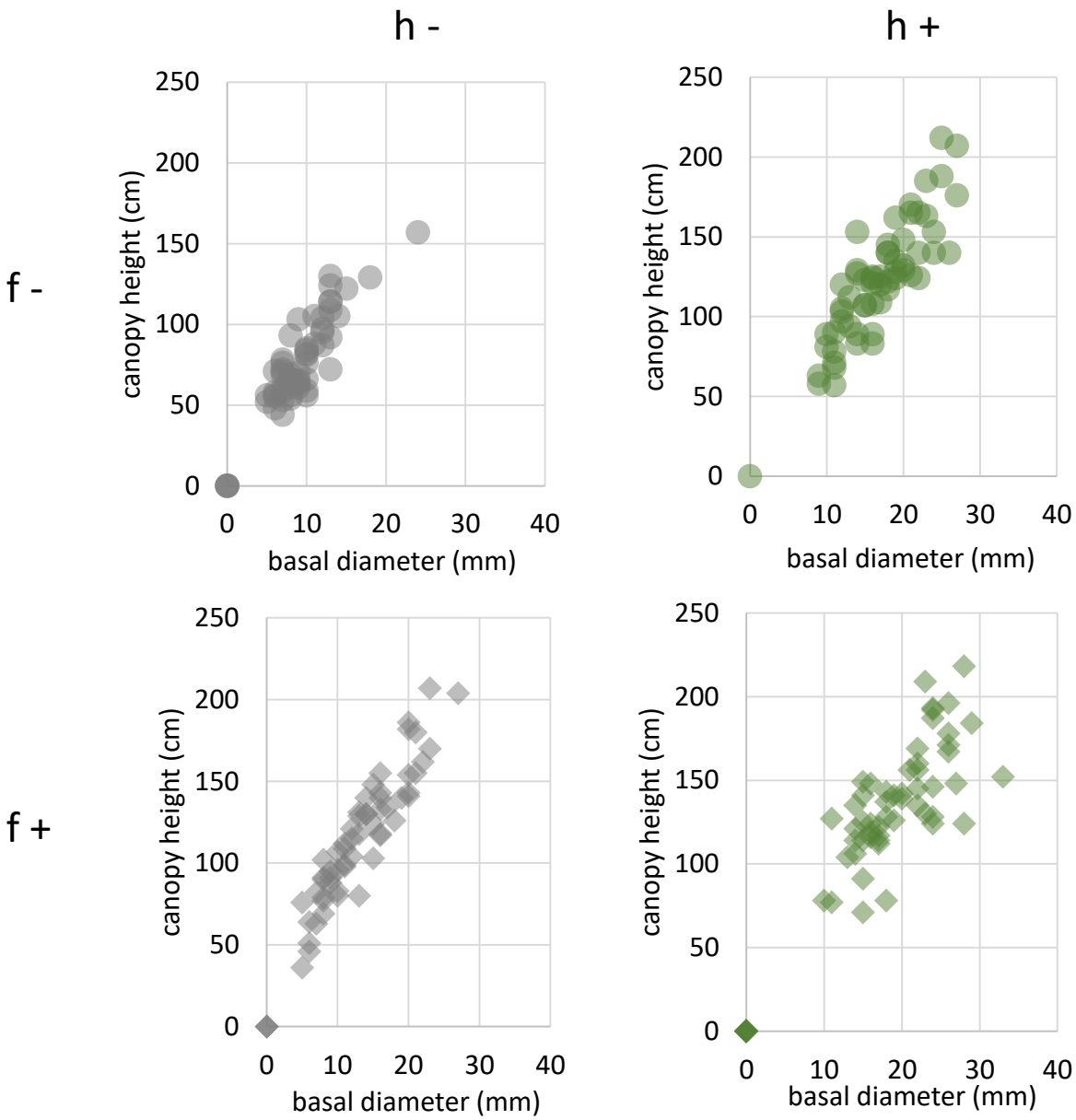
4MA3rd

4MA4th



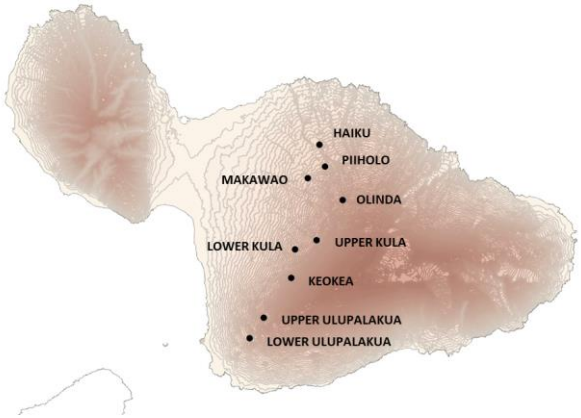


Herbicide and fertilizer effects on koa growth allometry at 12 months after plant



Hueristic kikuyu grass growth models in a mesic montane environment for predicting growth responses to climatic conditions

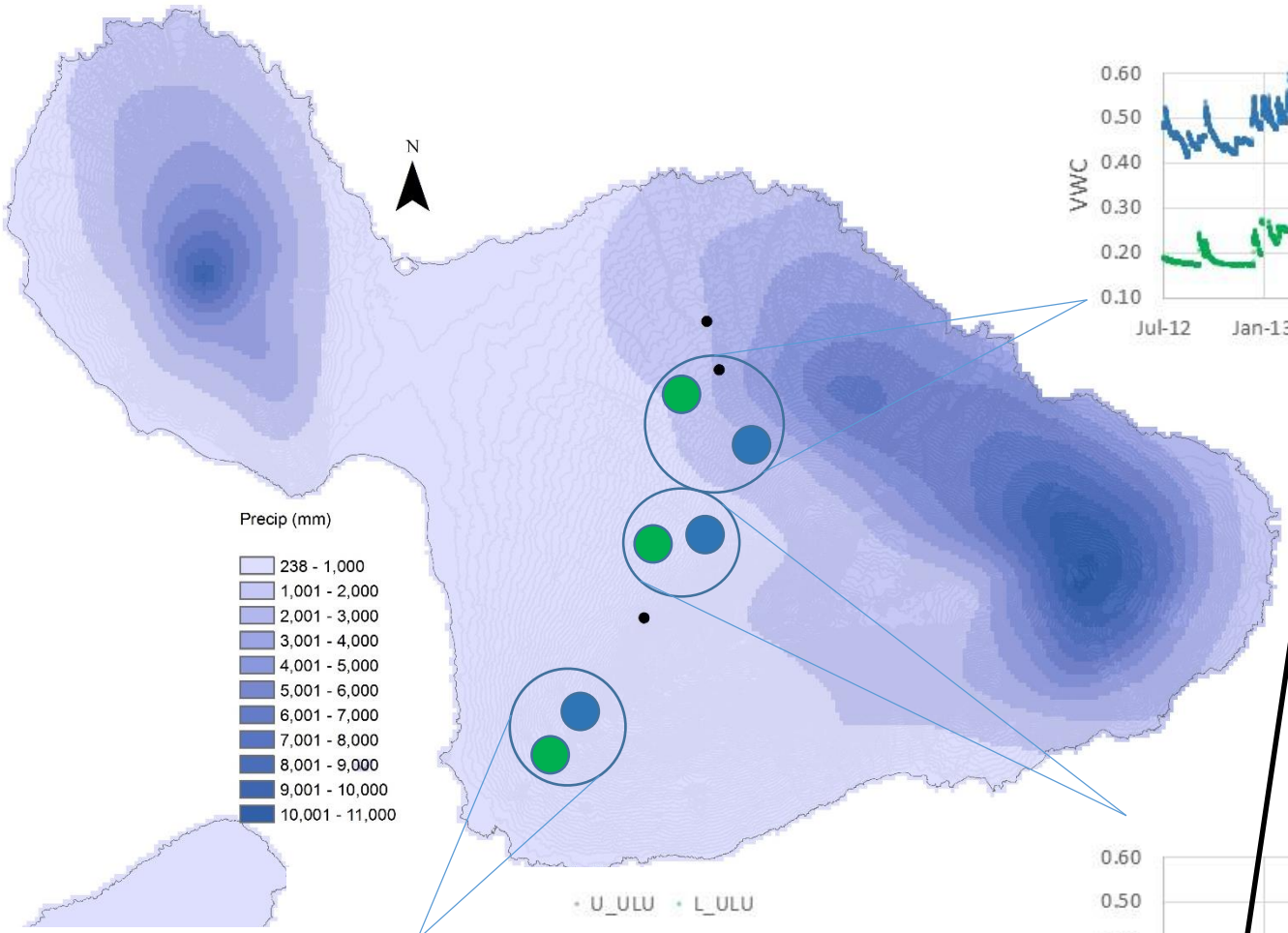
Approach: Install and monitor The Kula Belt Pasture Production Observatory Network 2012-2014

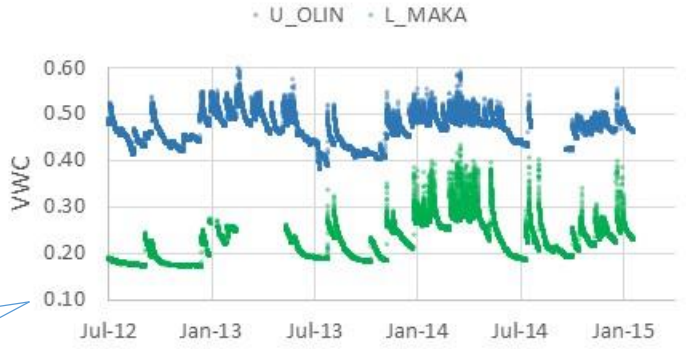


- Nine weather stations installed from Haiku to Ulupalakua, recording PAR, RH, T_{amb}, $T_{soil,}$ and VWC
- Pairs of low (mean 1978 ft. a.s.l) and high (mean 3803 ft. a.s.l) elevation
- Monthly forage samples clipped at 4” (10 cm) stubble height (NRCS recommendation)

RESULTS

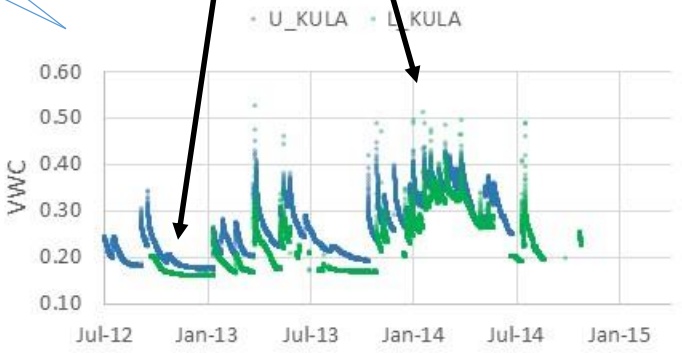
Volumetric Water Content Flux Jul 2012 – Nov 2014

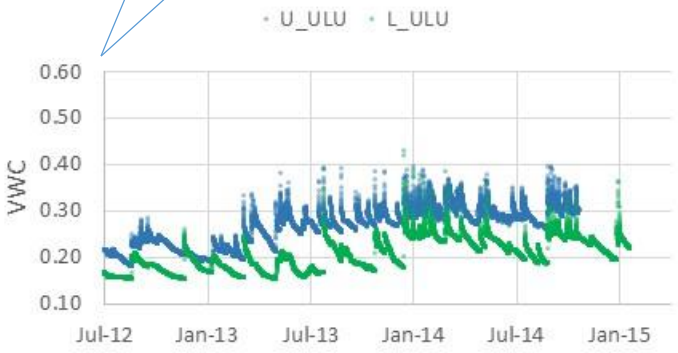




Water content <20% WC flatline during drought

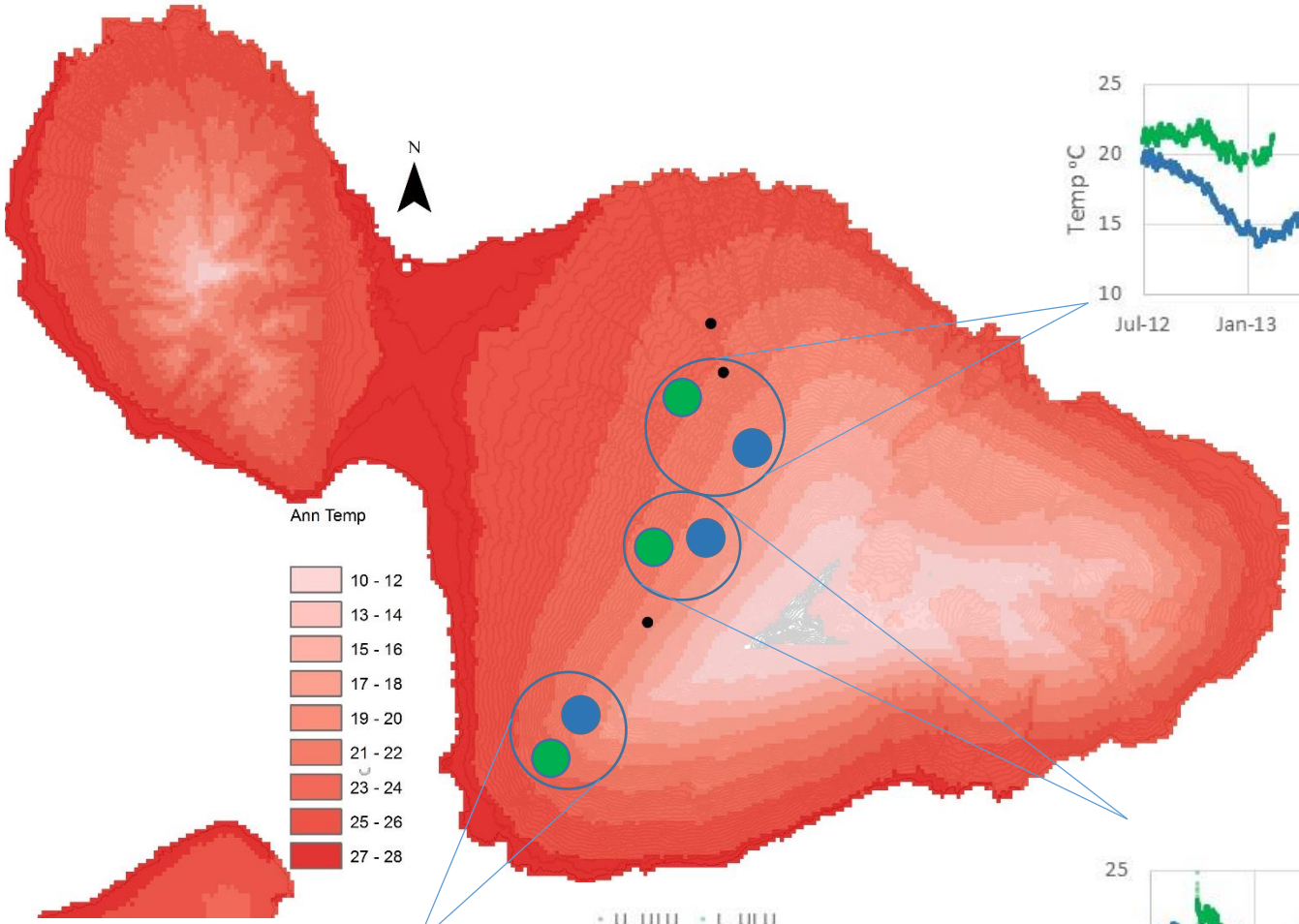
Recovery with frequent precip spikes and WC >30%





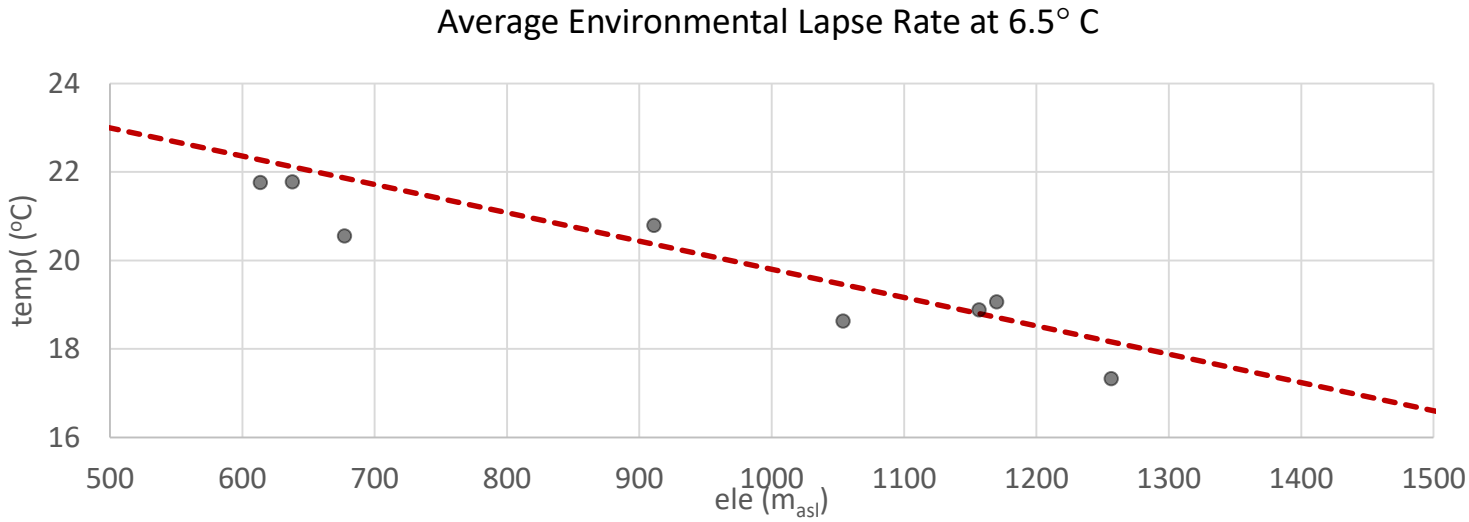
RESULTS

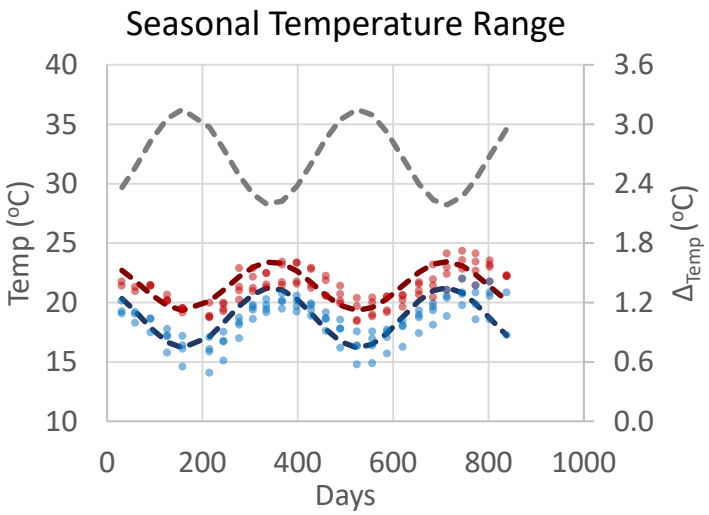
Seasonal Soil Temperature Flux Jul 2012 – Nov 2014

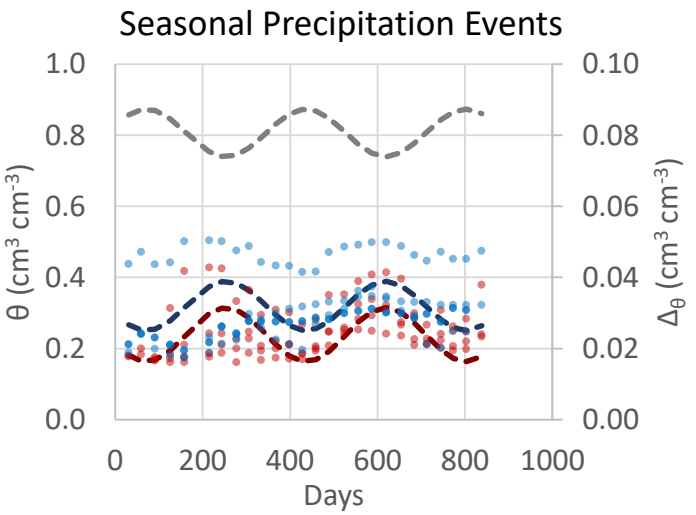


Seasonal T^{o} fluctuation with lower (green) sites always higher by several ^{o}C.

Trigonometric functions to Model Climate

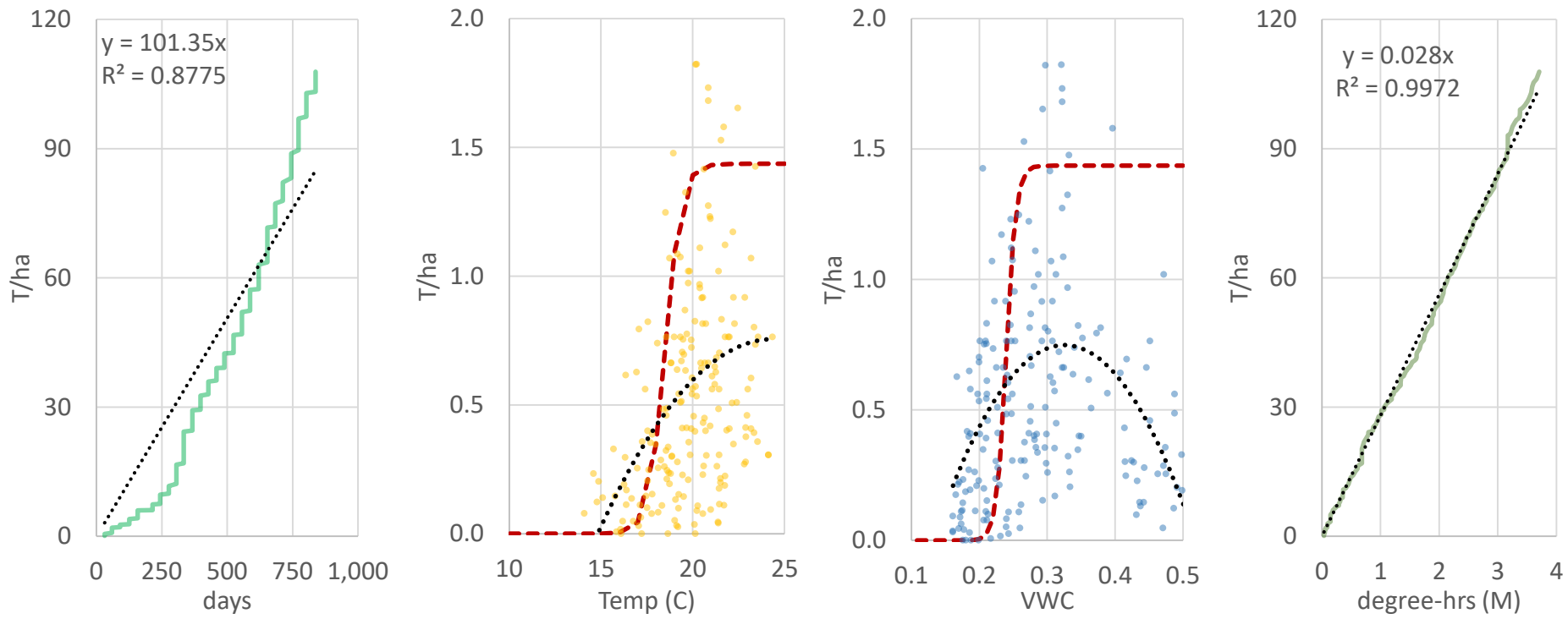






Exploratory research to develop heuristic growth models

Production / (Temperature + Moisture) = Prediction



Identify optimum and threshold climate parameters with 2nd order polynomials and logistic growth functions

Linearize grass production against degree-hours for reliable interpretation as a response to climate

Determine the residual activities of imazapyr and glyphosate on dormant (climax) fountain grass

Conclusion: Imazapyr exhibits residual activity in low moisture conditions offering some flexibility in fuel load reduction, but inferior to timing interventions with green up events, particularly post-fire.

Determine pre- and post-plant suppression of imazapyr, glyphosate and fluazifop-p-butyl on kikuyu grass

Conclusion: These three herbicide options are effective in reducing the regenerative stolon bank and consequently enhances growth performance of outplanted koa overstory.

Hueristic kikuyu grass growth models in a mesic montane environment for predicting growth responses to climatic conditions

Conclusion: Growing degree-day models could facilitate better monitoring of fuel loading events dictating by elevational and orographic microclimates

Mahalo to my partners and collaborators!
Jeremy Pinto, USFS
Anthony Davis, Oregon State Univ.
Matthew Aghai, Univ of Washington Seattle
Diana Crow, Ulupalakua Ranch
Nick Dudley, HARC
Mike Robinson, DHHL
Doug Jacobs, Purdue Univ.
Kas Dumroese, USFS
Olga Kildisheva, Univ. of Idaho
Paul Scowcroft, USFS
Creighton Litton Univ. of Hawaii Manoa
Alyssa Cho, Univ. of Hawaii Manoa

Support provided in part by the USDA TSTAR Grant Program, USDA NRCS Conservation Innovation Grant Program, the USDA Urural Resources Extension Act