

What limits natural regeneration in koa restoration forests, and how do we get around it?

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Collaborators



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Remnant/planted trees

- US Fish and Wildlife planted over 390,000 *Acacia koa* in 1980's
- Jumpstart succession
 - Increase shade/compete with pasture grass
 - Create microhabitats for native germination
 - Perching/nest sites for birds
 - Increase seed rain from birds

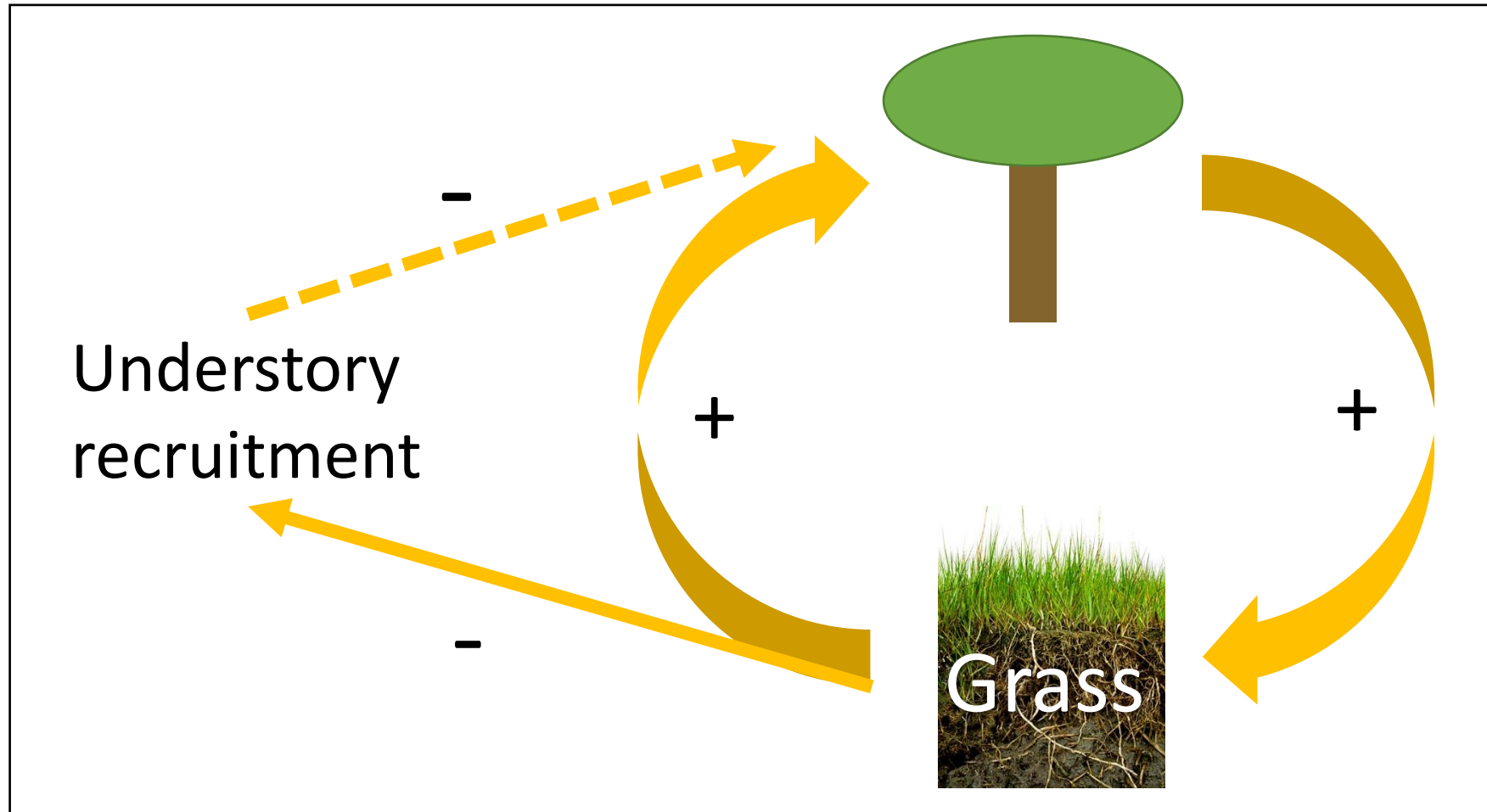


Metrosideros polymorpha ('Ōhi'a)



- Slow growing tree
- Common understory species:
 - 'Ākala (*Rubus hawaiiensis*)
 - Hāpu'u (*Cibotium glaucum*, *C. menziesii*)
 - Kōlea (*Myrsine lessertiana*)
 - 'Ōhelo (*Vaccinium calycinum*)
 - 'Ōlapa (*Cheirodendron trigynum*)
 - Pukiawe (*Leptecophylla tameiameia*)
 - Pilo (*Coprosma rhynchocarpa*)
- Thick litter layers, lower grass cover
- More bird visitation?

Koa stands have higher light and soil nitrogen than 'Ōhi'a

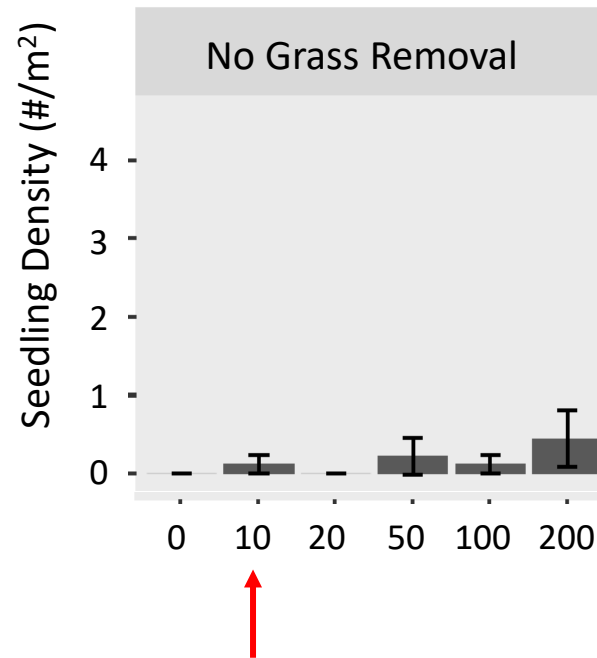


Hypotheses around lack of secondary succession under koa

- ~~• No seed dispersing birds in koa corridors~~
- ~~• Birds do not use koa trees -> no seed rain~~
- Too much grass, even if there is seed

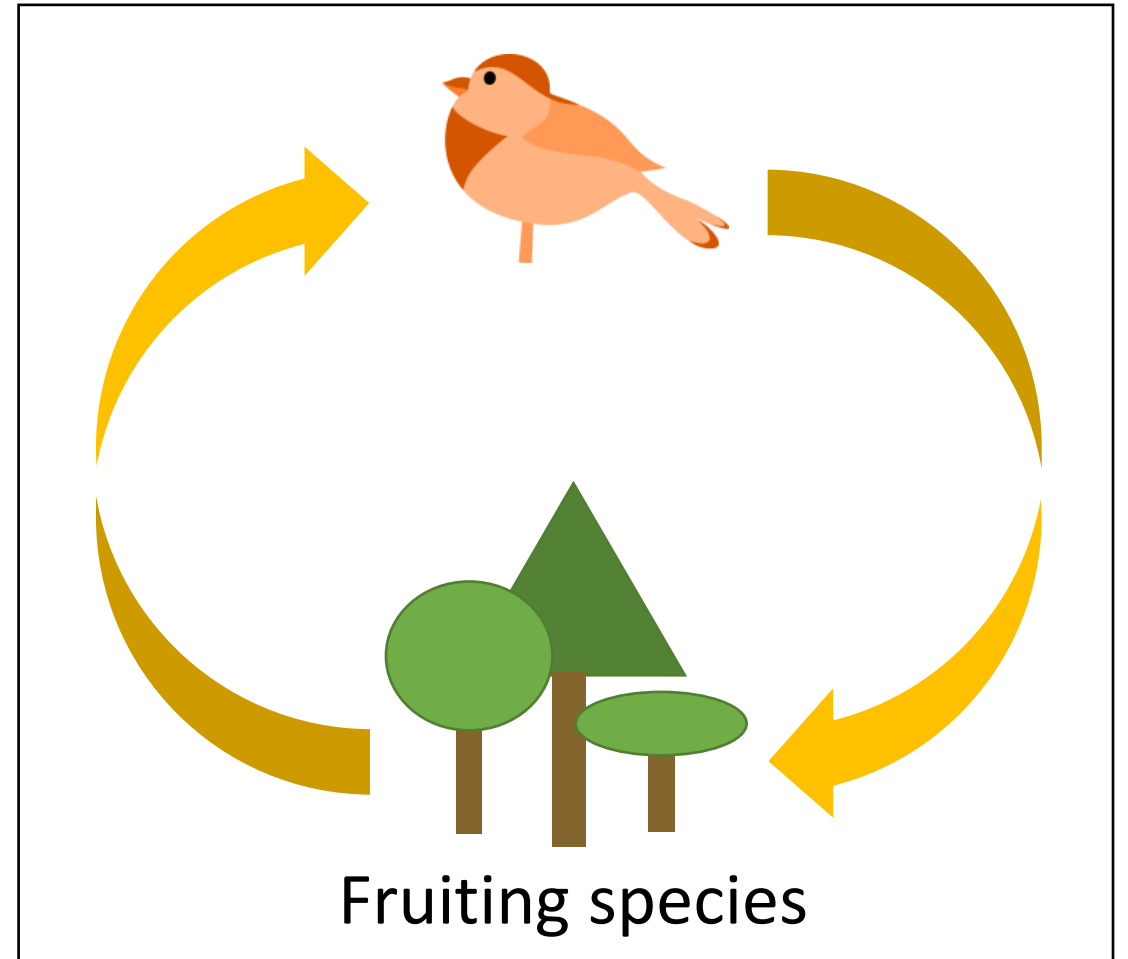
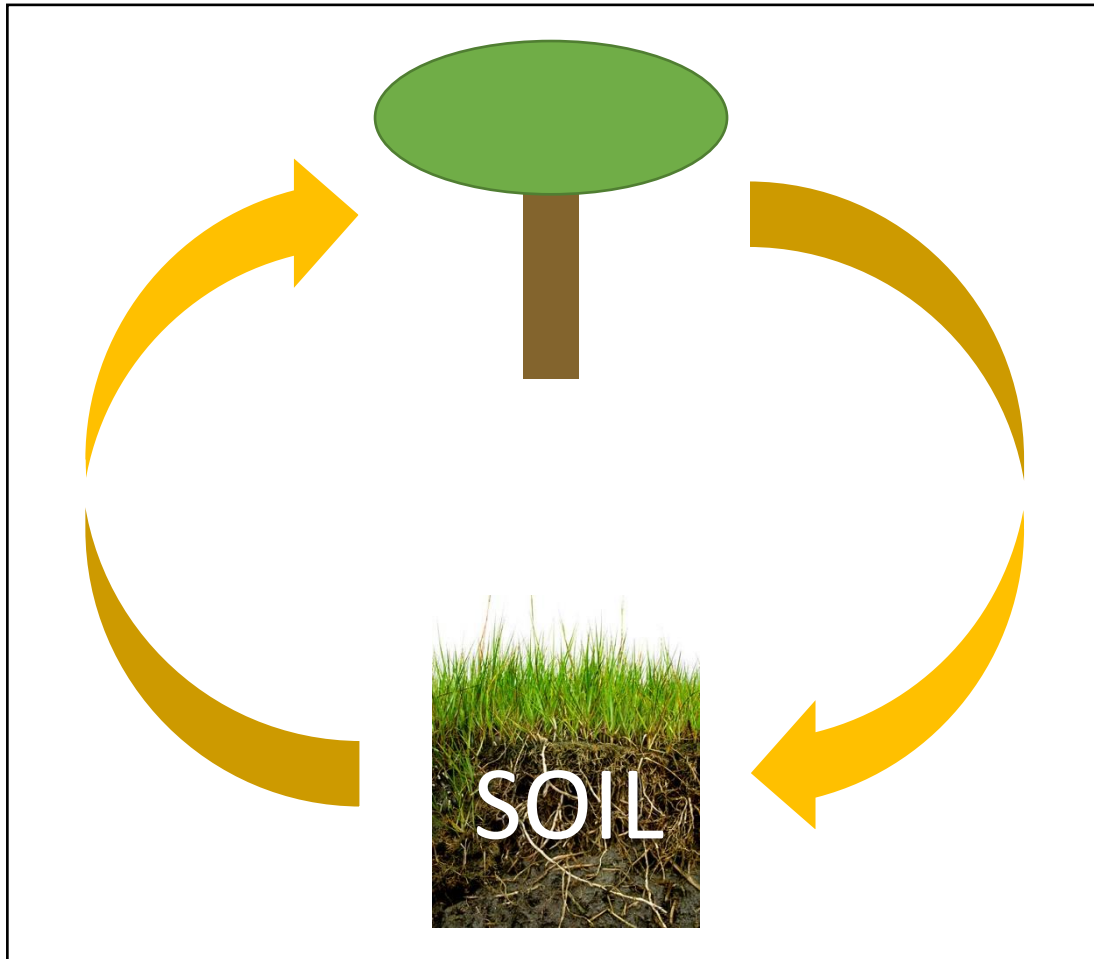


How little grass/many seeds do we need to get understory regeneration?



Seed Density

Resilience in koa-grass state





Litter addition experiment

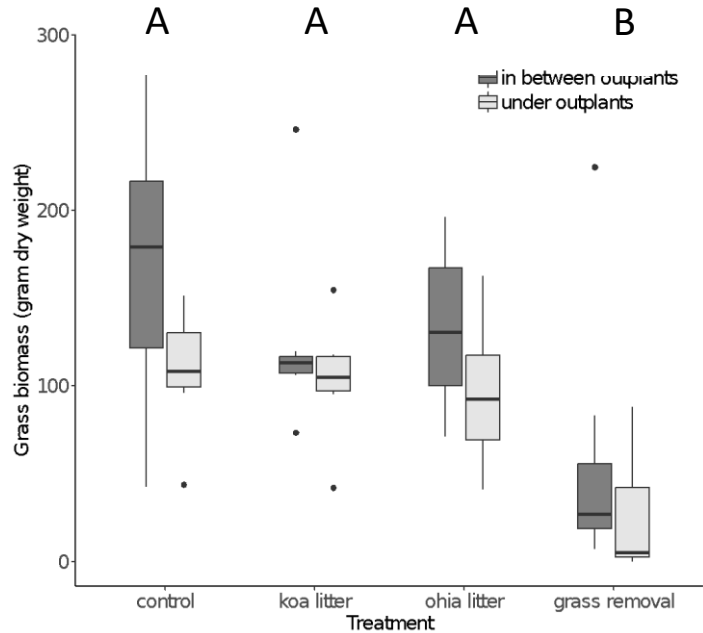
- Can we add enough 'ōhi'a litter under koa to...
 - lower the high soil N?
 - lower grass biomass?
 - increase success of planting?
- Treatments (**The Plan**)
 - Add 'ōhi'a litter, koa litter, control (no litter)
 - Herbicide, control (no herbicide)
 - Fully factorial
 - Plant understory species



Litter addition experiment

- Can we add enough 'ōhi'a litter under koa to...
 - lower the high soil N?
 - lower grass biomass?
 - increase success of planting?
- Treatments (**The Reality**)
 - Add 'ōhi'a litter, koa litter, herbicide (no litter), control (no litter, no herbicide)
 - Plant understory species

Litter addition experiment



- Added 4.7 times the amount of naturally falling 'ōhi'a litter over 2.5 years.
- Did soil N decrease with 'ōhi'a litter? NO
- Did grass biomass decrease? NO
- Did it help plantings? NO (because they had great survival either which way!)

Herbicide experiment



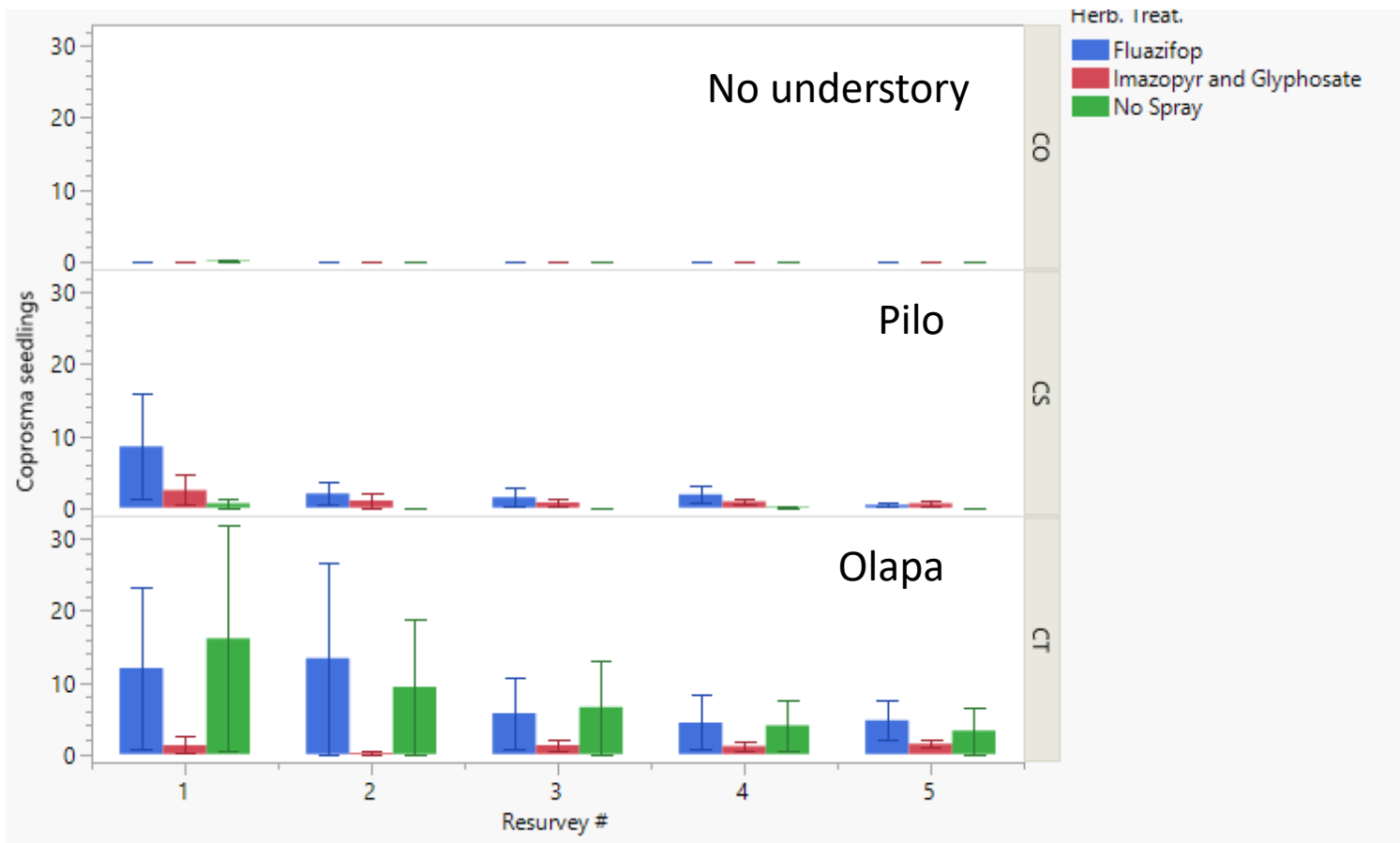
- Can we facilitate natural regeneration via herbicide?
- Is bird-mediated seed enough, or need extra from existing understory?

Herbicide experiment



- Can we facilitate natural regeneration via herbicide?
- Is bird-mediated seed enough, or need extra from existing understory?
- Herbicide
 - Grass specific (Fluazifop)
 - Nuclear option (Imazopyr + Glyphosate)
 - Control (none)
- Koa corridors
 - With planted understory
 - With none

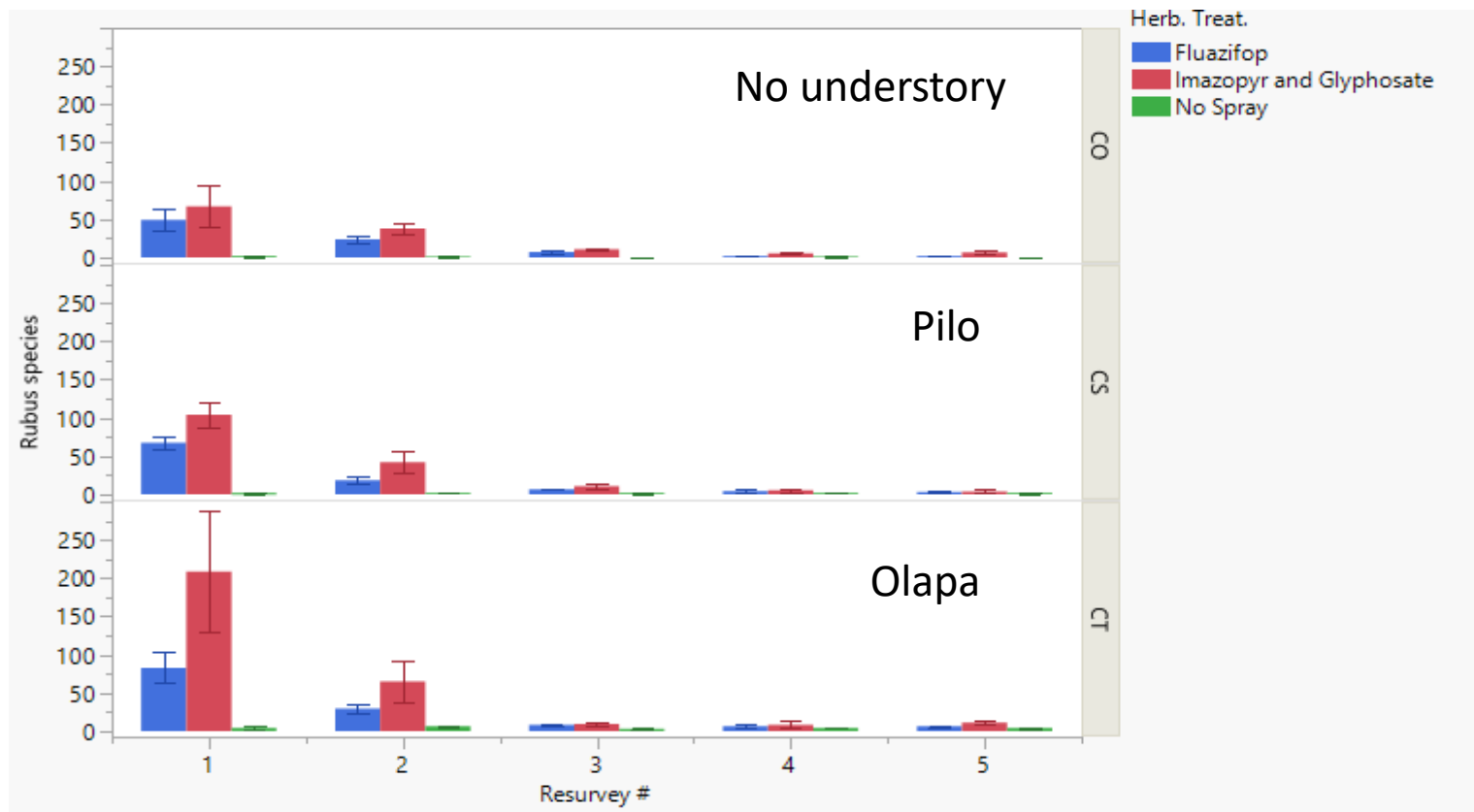
Herbicide experiment: Pilo seedlings



Did we facilitate regeneration by killing grass?

- No pilo seedlings in koa corridors without understory
- Very small gains under established understory

Herbicide experiment: Rubus seedlings



- Rubus spp are everywhere – with and without understory
- More Rubus in Imazopyr + Glyphosate than Fluazifop
- **Herbicide may lead to secondary invasion by unwanted BLACKBERRY**

Planting experiment



- How does the density of plantings affect grass biomass over time
- Does herbicide help with survival and growth of plantings

Planting experiment: 2016



- How does the density of plantings affect grass biomass over time
- Does herbicide help with survival and growth of plantings
- Single density
- Single density after herbicide
- Double density

Planting experiment: 2020



Planting experiment: 2020



Single density



Double density

Did the double density treatment lead to greater mortality?

Not within 4 years

Planting experiment: 2020



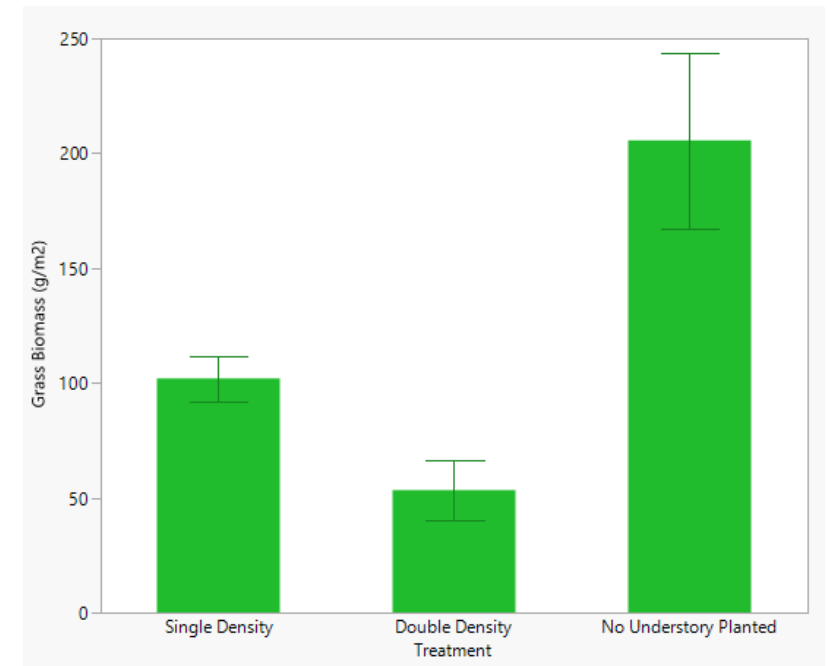
Single density



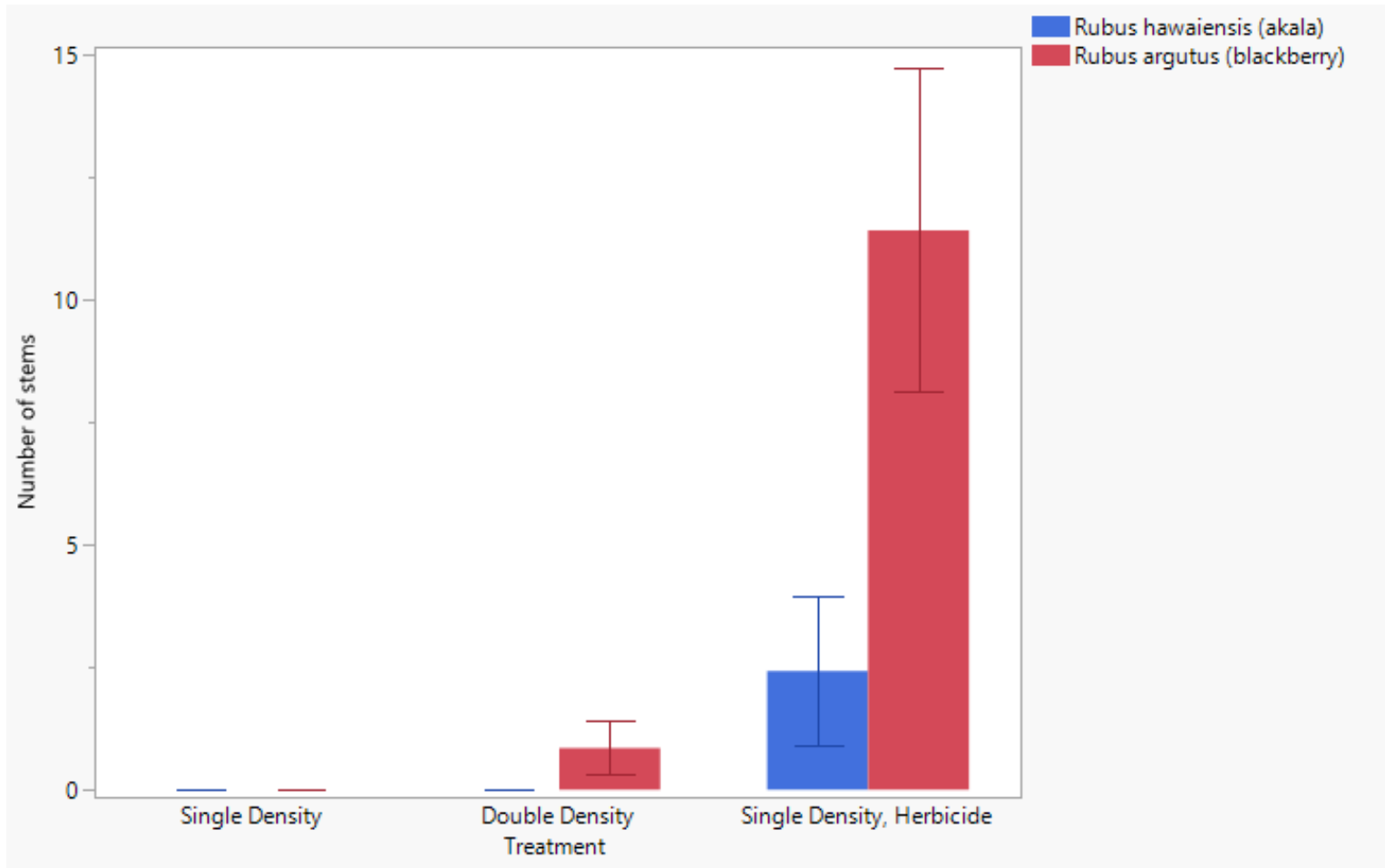
Double density

Did the double density treatment lead to less grass?

Yes



Planting experiment: 2020



Did the herbicide treatment lead to *Rubus* invasion?

YES

Management implications

- Cannot rely on birds for secondary succession
- Start with a more diverse canopy
- Need to actively outplant, add seed, and/or remove grass
- Herbicide can lead to secondary invasion
- Herbicide does not lead to greater survival for most species
- Planting at high densities can help reduce grass/increase recruitment



“Failure to Launch and Lessons Learned”

- The only way to figure out if something works is to try
- Often it does not work, but gives clues to next steps, or saves money down the line
- **Having strong partner relationships is key to allowing this process to play out**



Mahalo!

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