The effect of restoration treatments on seed dispersal and seedling establishment limitation in a tropical agricultural landscape

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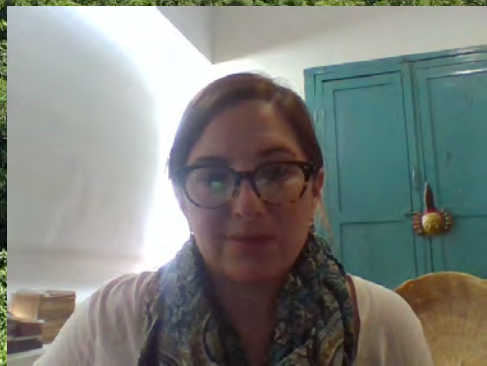
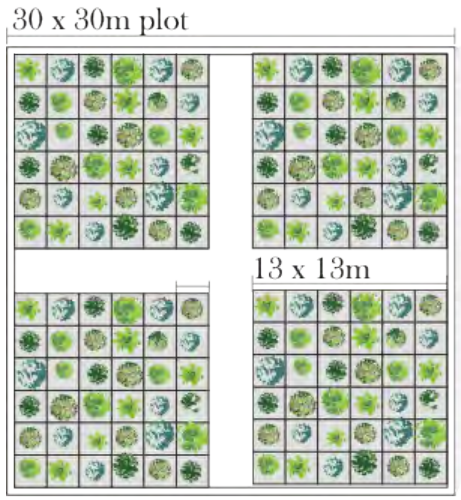
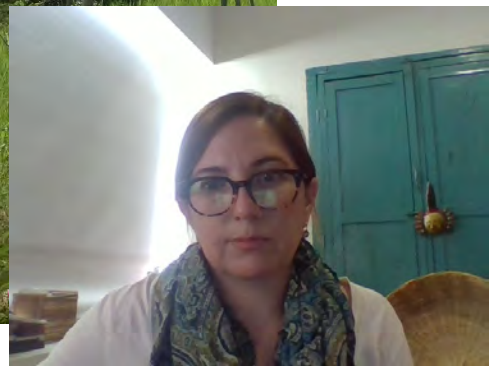


Los Tuxtlas

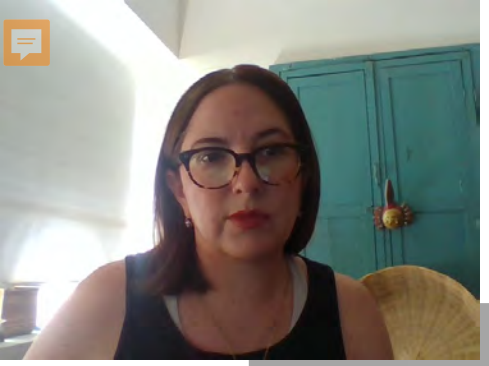
- Tropical Rainforest
- Open pastures for cattlegrazing
- Fragmentad landscape
- Restoration plantings in 2006
- Oj. Restoring ecological interactions
  - -seed dispersal processes
  - - movement of plants and animals

12 species per planting treatment





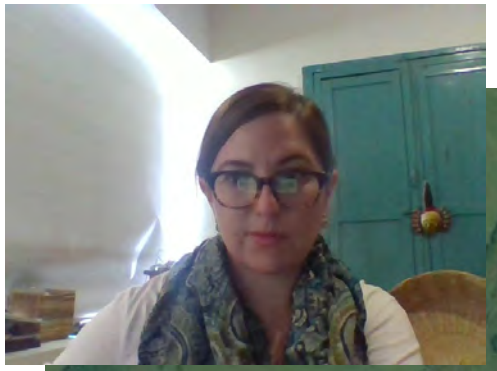
Los Tuxtlas



Density index

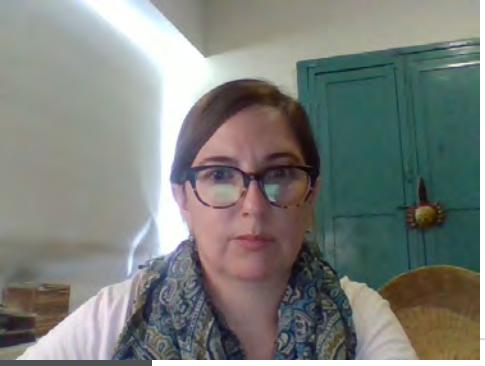
Dispersal limitation	$1 - \frac{\left(\frac{s_i}{S}\right)+\left(\frac{a^*}{n^*}\right)}{2}$	S = Total number of seeds in the seed pool s_i = number of seeds of *sp.* 1 a = number of seed traps with *sp.* 1 n = total number of seed traps *Total seed traps 96 (4 per plot)*
Establishment limitation	$1 - \frac{\left(\frac{p_i}{P}\right)+\left(\frac{r}{a^*}\right)}{2}$	P = Total number of seedlings p_i = number of seeds of *sp.* 1 r = number of stations with both seeds and seedlings of *sp.* 1 n = total area sampled for seedlings *Total seedling area 16,224 m^2 (676 per plot)*

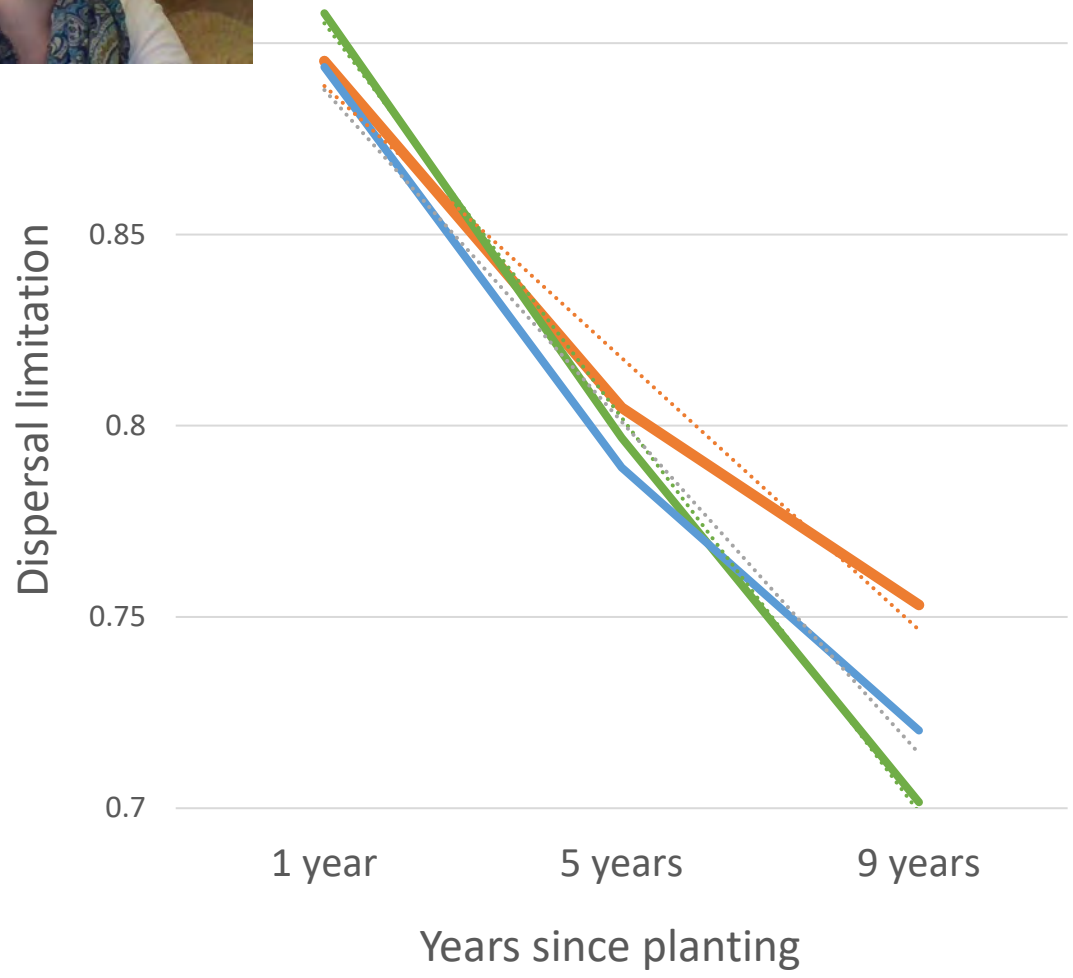
De la Peña-Domene *et al.* 2018

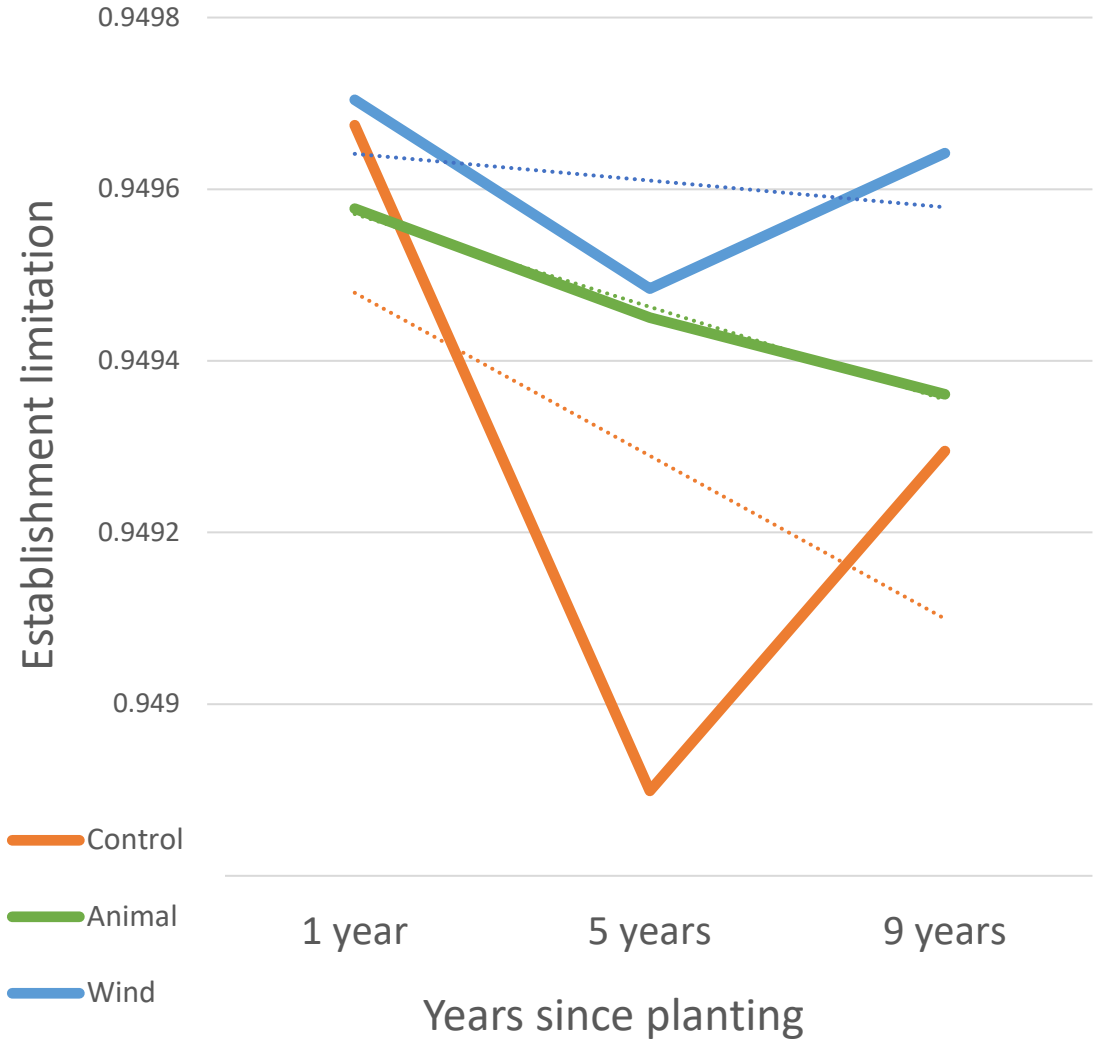


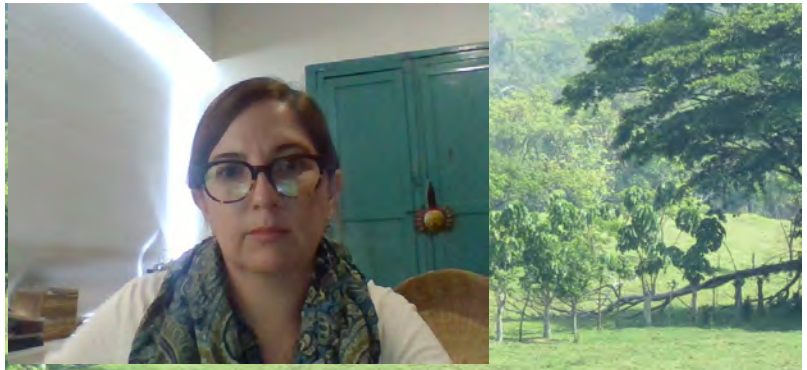
2005

2021




Dispersal limitation
0.85
0.8
0.75
0.7
1 year
5 years
9 years
Years since planting

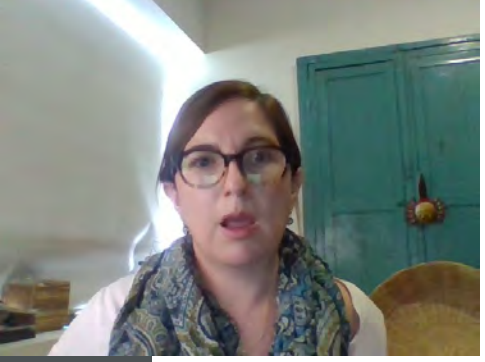

Establishment limitation
0.9498
0.9496
0.9494
0.9492
0.949
Control
Animal
Wind
1 year
5 years
9 years
Years since planting

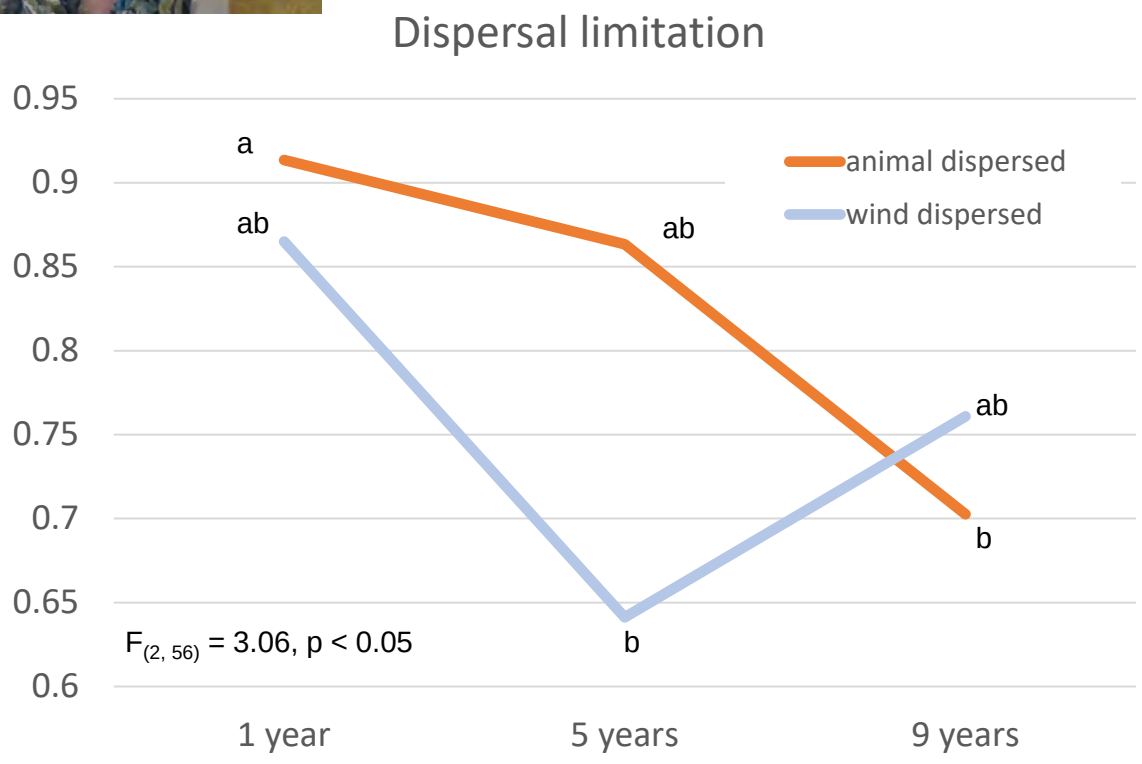


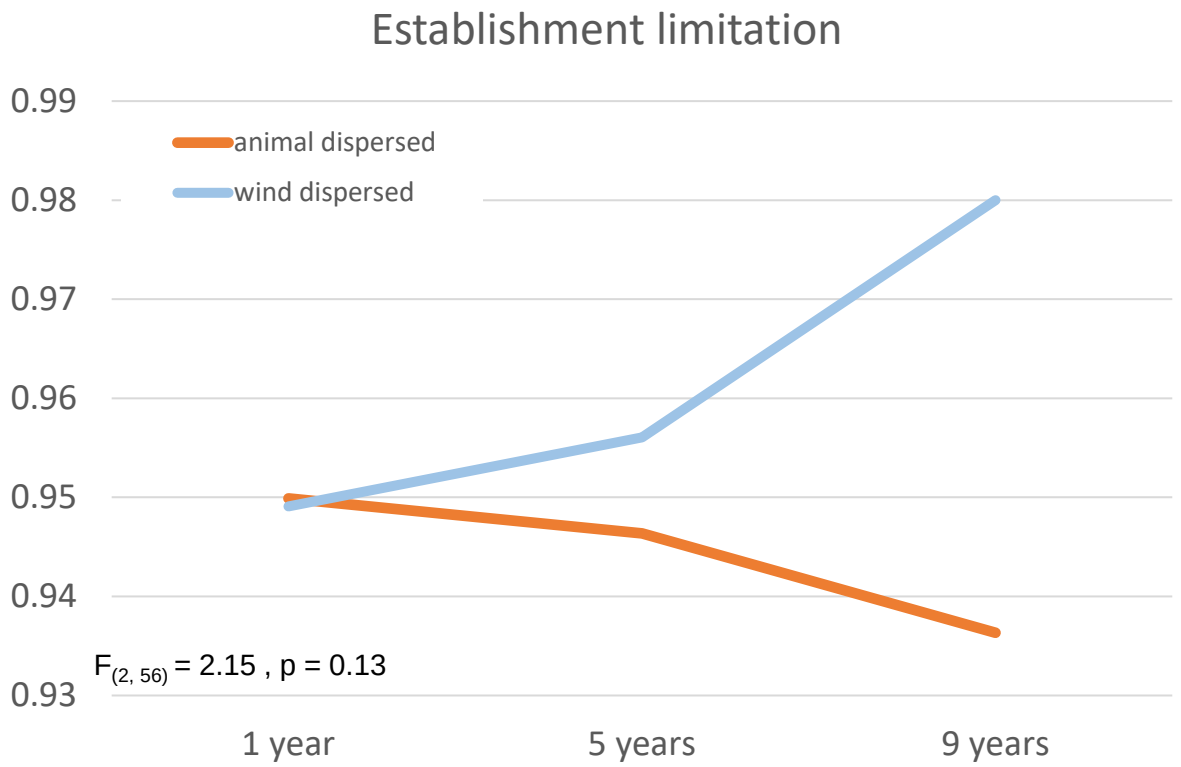
Control

Wind

Animal




Dispersal limitation
0.95
0.9
0.85
0.8
0.75
0.7
0.65
0.6
a
ab
ab
ab
b
b
animal dispersed
wind dispersed
$F_{(2, 56)} = 3.06, p < 0.05$
1 year
5 years
9 years


Establishment limitation
0.99
0.98
0.97
0.96
0.95
0.94
0.93
animal dispersed
wind dispersed
$F_{(2, 56)} = 2.15 , p = 0.13$
1 year
5 years
9 years

2007

2013

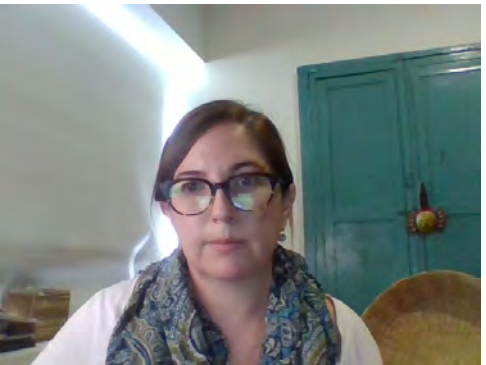
Very few animals crossing

High wind currents

More animals crossing

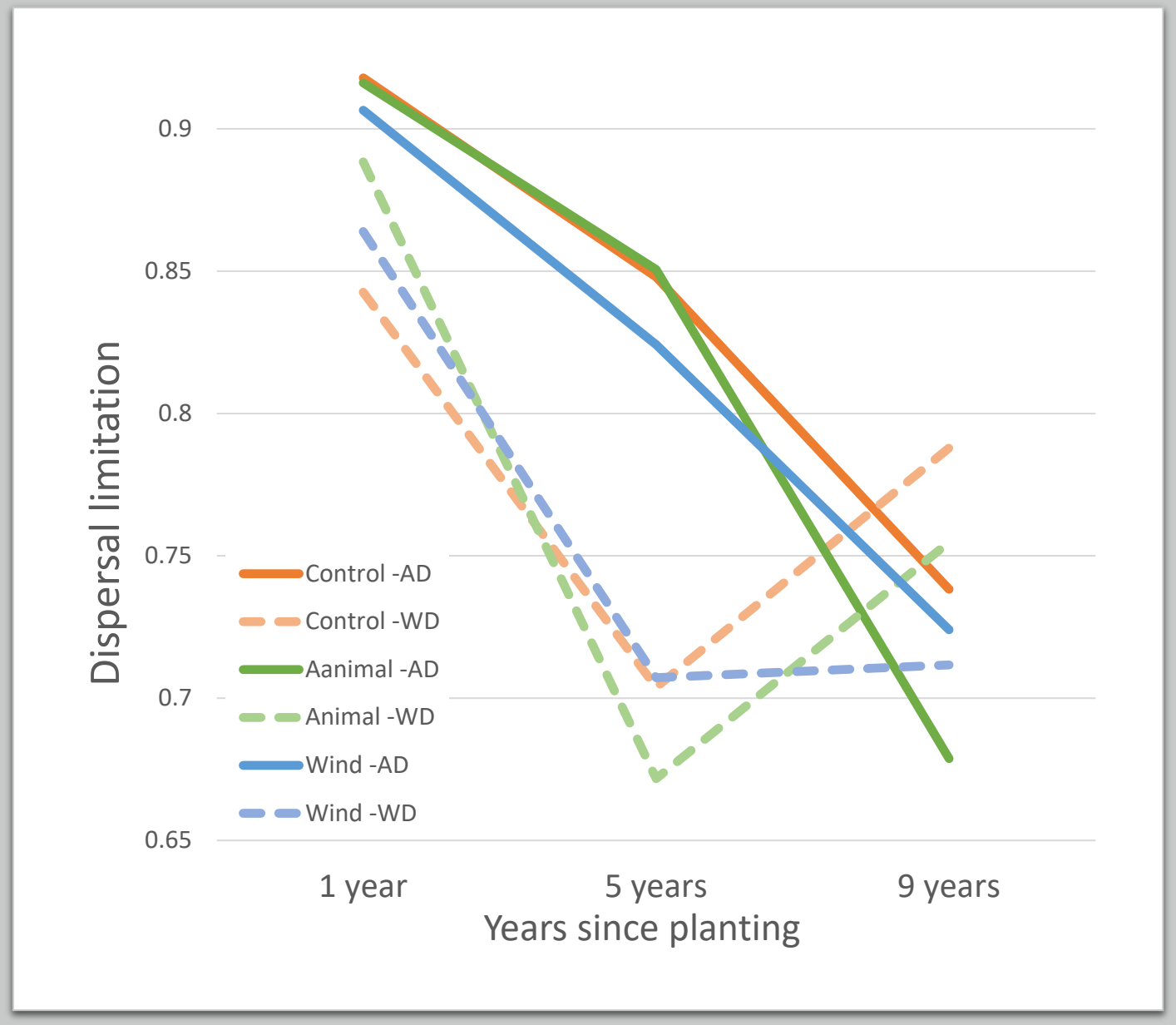
Wind currents stopped by plantings

Over time dispersal and establishment limitations shifted from animal-dispersed species wind-dispersed species

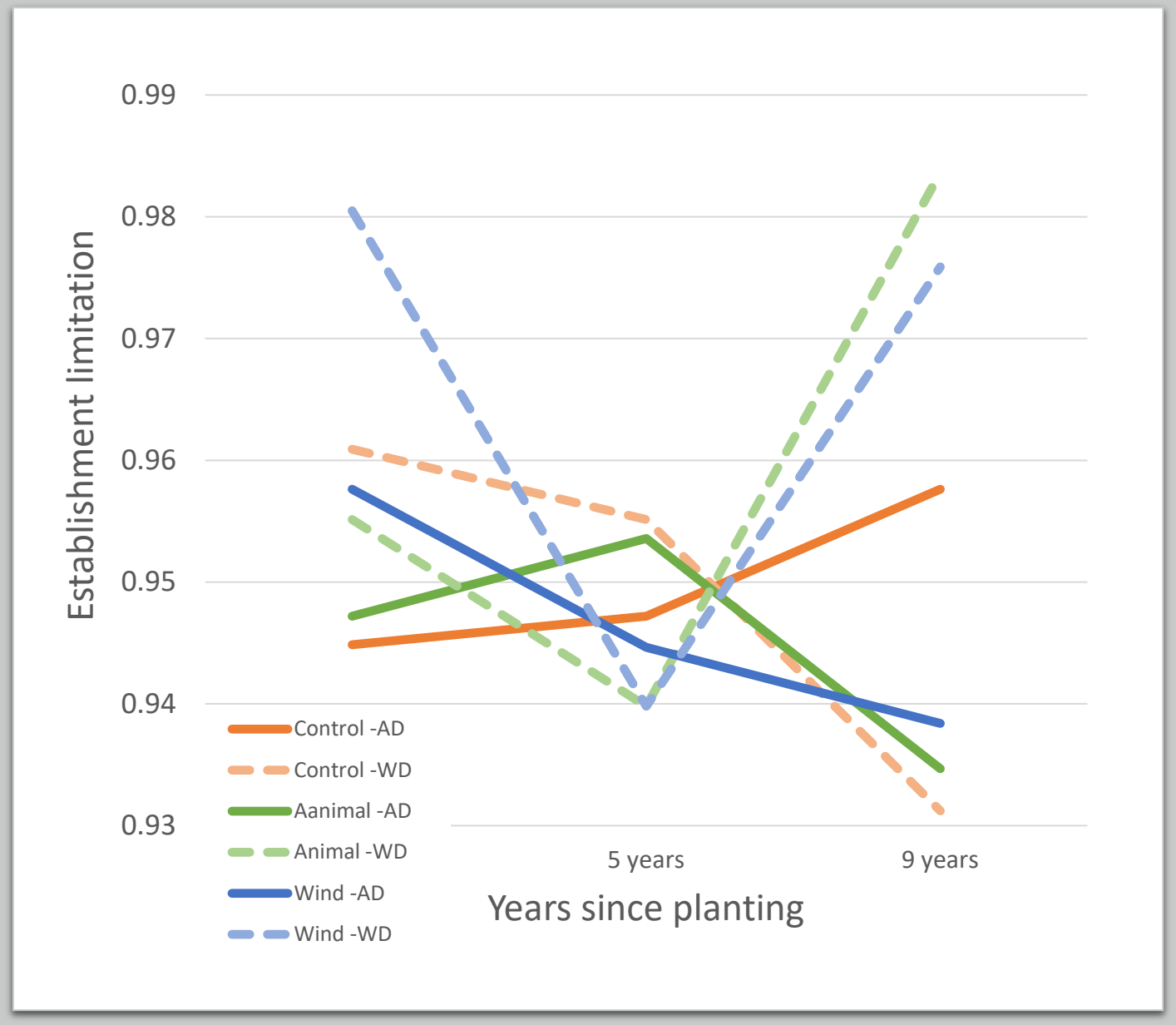


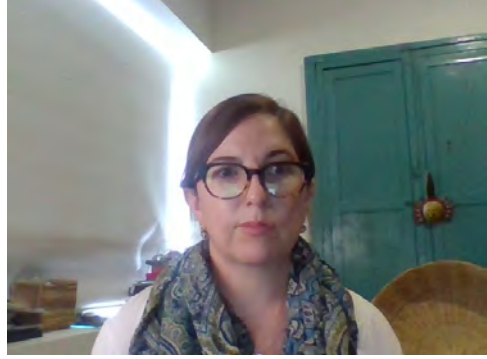
- Dispersal limitations was reduced the most in animal-dispersed plantings from animal-dispersed species

- Limitation for wind-dispersed species greatly decreased, but then increased again in control and animal-dispersed plantings, but not in wind dispersed plantings

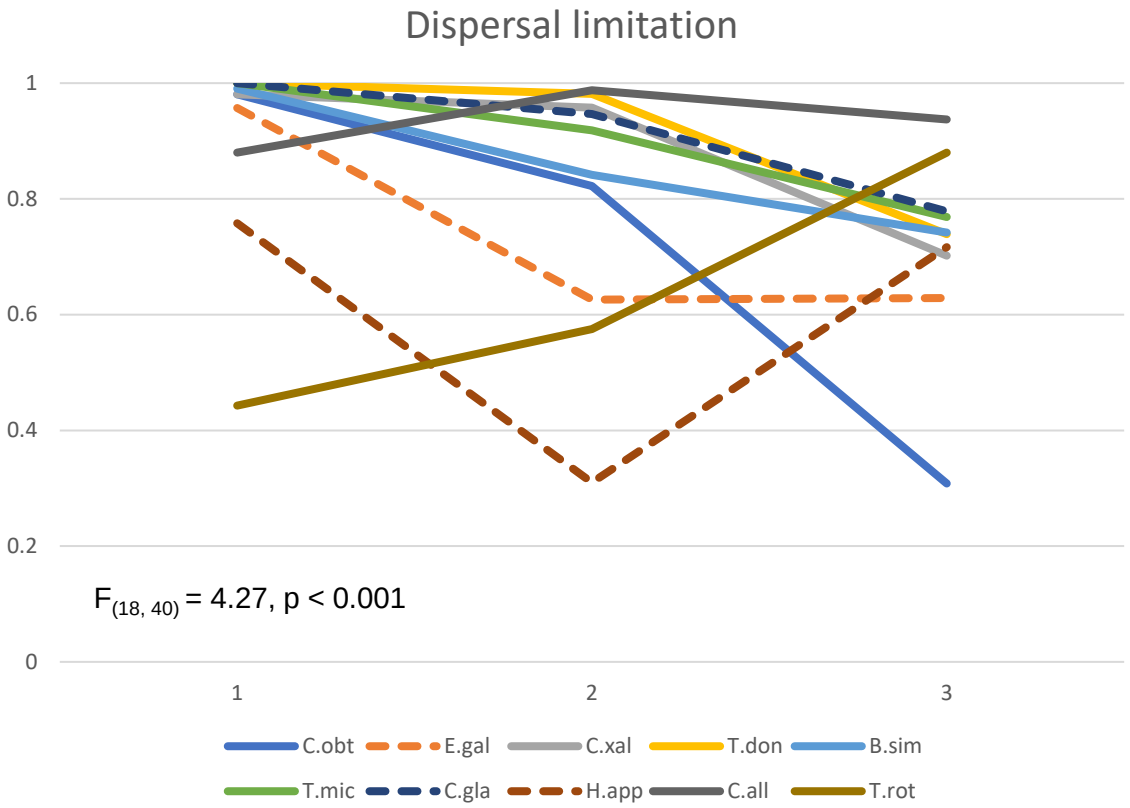


- Establishment limitations showed opposite patterns for control plots and plantings.
- In both planting treatments, limitation was reduced for animal-dispersed species and increased for wind-dispersed species

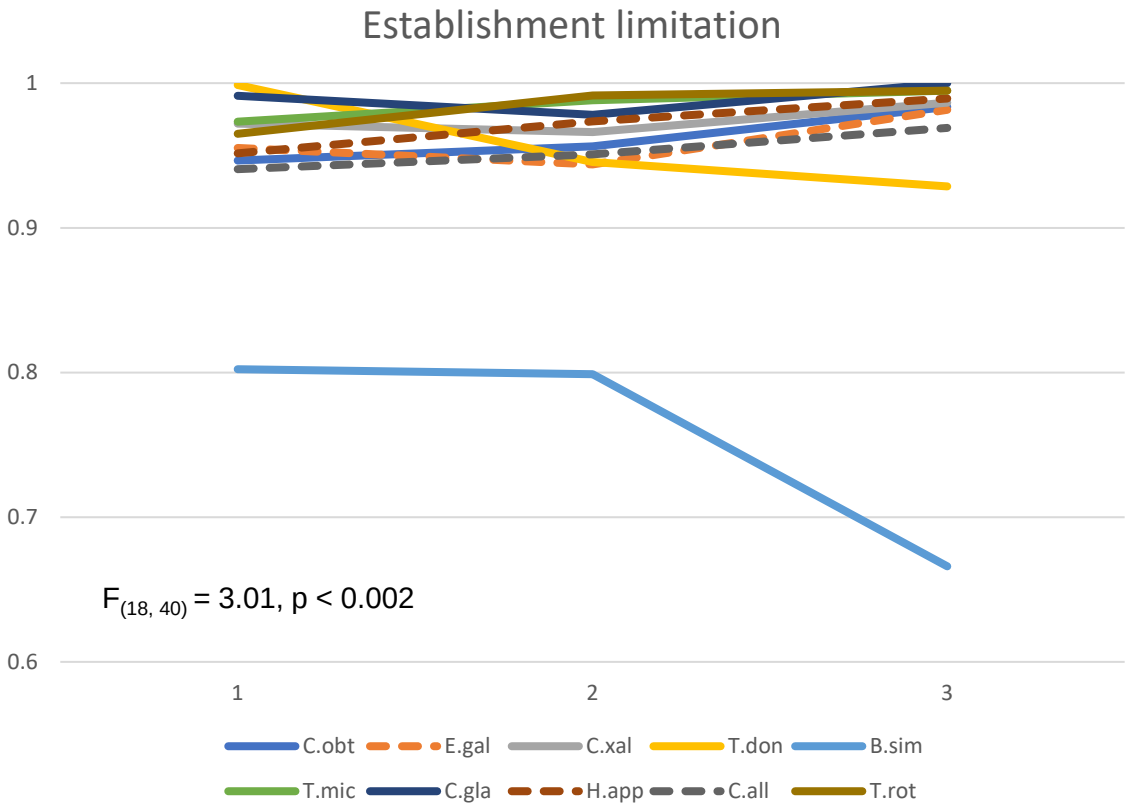




- Dispersal and establishment limitations varied significantly among species over time
- Overall, most species were less limited, but most species are still highly establishment limited.

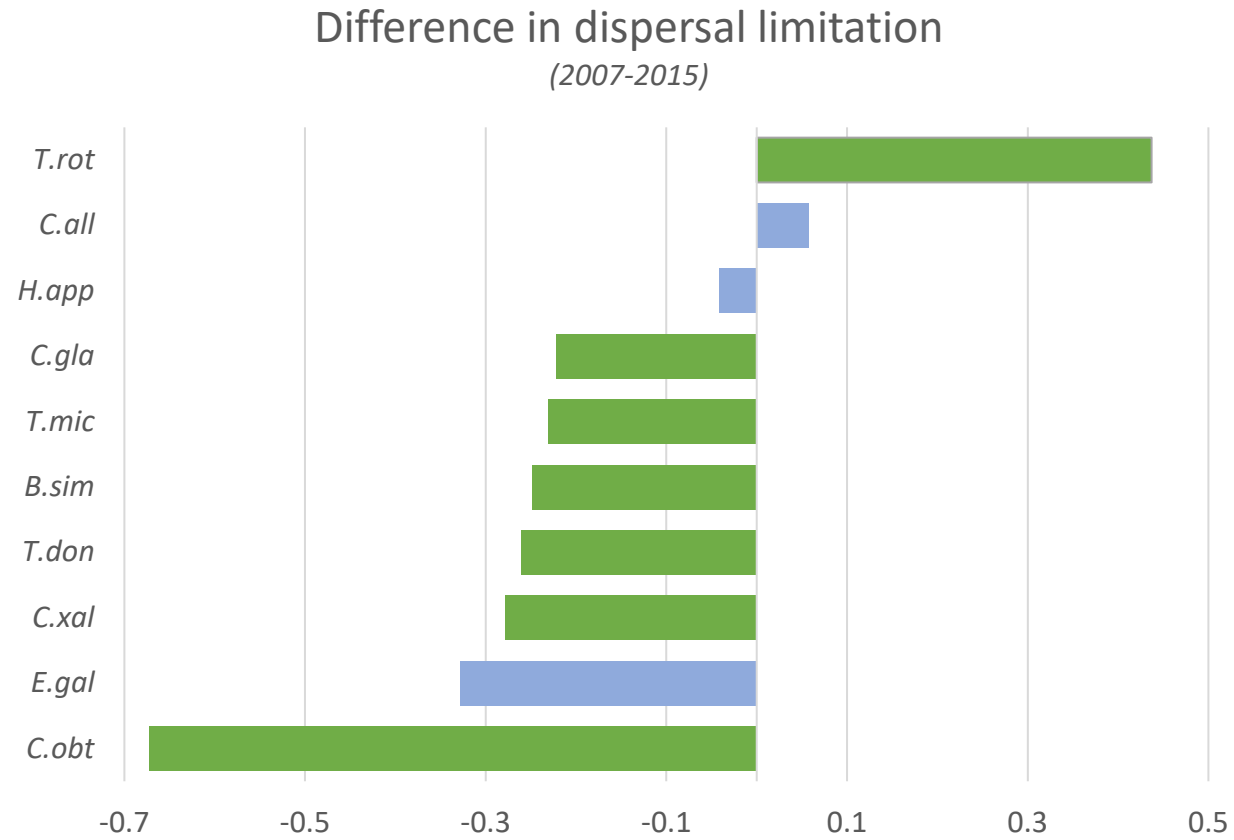


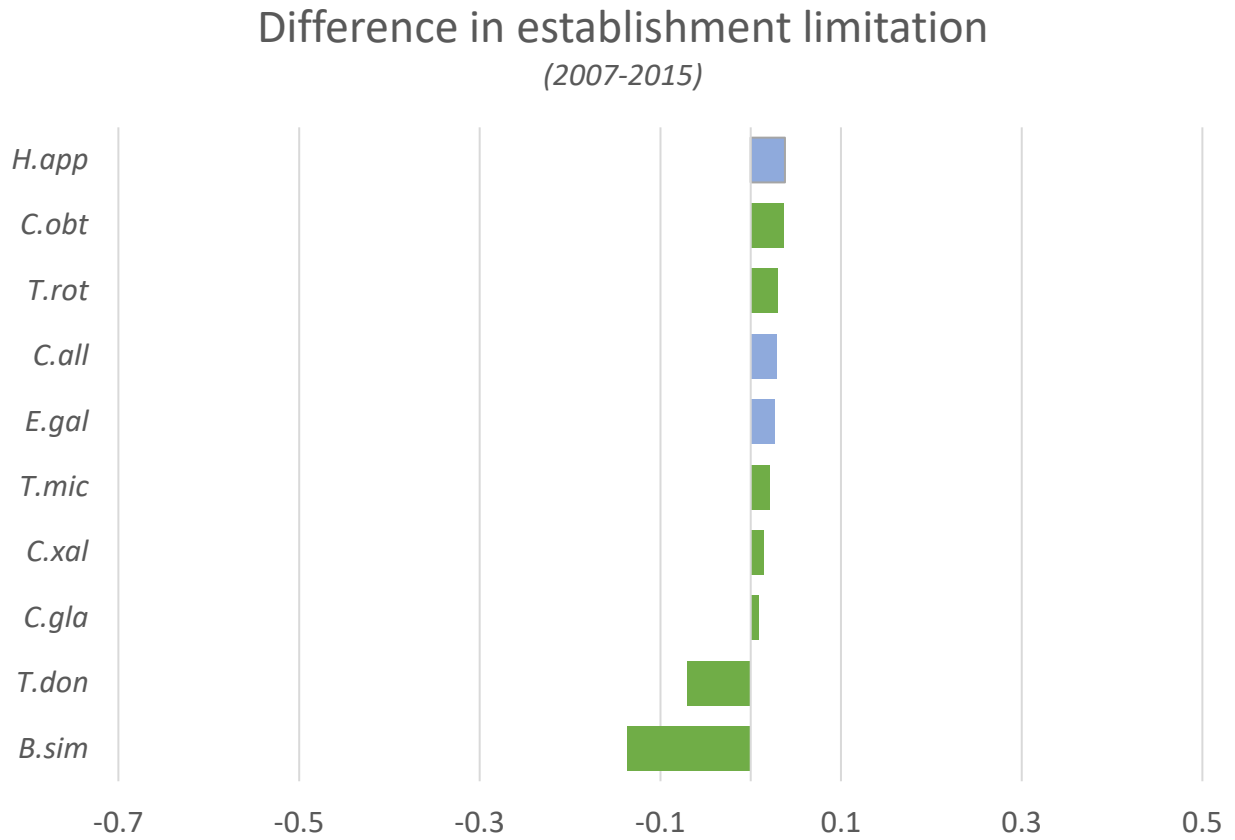
$F_{(18, 40)} = 4.27, p < 0.001$



$F_{(18, 40)} = 3.01, p < 0.002$

Establishment limitations was only reduced for two non-pioneer animal-dispersed species





General conclusions

- Planting treatments reduced dispersal and establishment limitations for animal-dispersed species
- After 9 years, under natural succession (controls), dispersal and establishment limitations have not shifted from animal- to wind-dispersed species
- Although in a broad context of restoration, natural succession is the most cost-effective strategy, many sites with long periods of intensive management, such as cattle pastures, do not recover species composition and densities easily
- Strategically designed plantings can both restore ecological interactions and species diversity, specifically if these planting include rare species or those that are most unlikely to arrive by themselves