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Society for Ecological Restoration at Ohio State University

Vanguards of restoration: Tracking first year survivorship and growth of native tree and shrub seedlings planted after *Lonicera maackii* and *Pyrus calleryana* removal

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INTRODUCTION

Ecological restoration projects often involve both invasive species removal and subsequent planting of native species. Short-term success is measured by survivorship of planted seedlings, but long-term success depends on the competitive ability of planted native species to exclude recolonization by invasives. Here, we studied the first-summer survivorship and growth of bareroot seedlings of 16 native species of tree and shrubs in a riparian forest restoration project.

METHODS

SER-OSU planted 1,060 bareroot tree and shrub seedlings in April 2019 along ~200m of the Olentangy River in Columbus, Ohio. In September 2019, we censused planted seedlings in a 120 x 40m subregion of the restoration site. We recorded site characteristics: (X,Y) location, qualitative canopy cover (shade/gap/open). We measured the percent cover of herbaceous vegetation taller than the seedling, as well as the percent cover of *Lonicera maackii* and *Pyrus calleryana,* within a 1m^2 quadrat surrounding the seedling (n= 570). We measured the total height and current-year's growth for each living seedling (n=442), and damage from herbivory, insects, and pathogens.

QUMA #731 in SER-OSU Restoration site, April 2021

Bur oak (Quercus macrocarpa) flag # 731 in 100% cover of dogbane (*Apocynum cannibinium*). Bur oaks grew better in dense herbaceous cover.

Seedling location and growth

Fig. 2

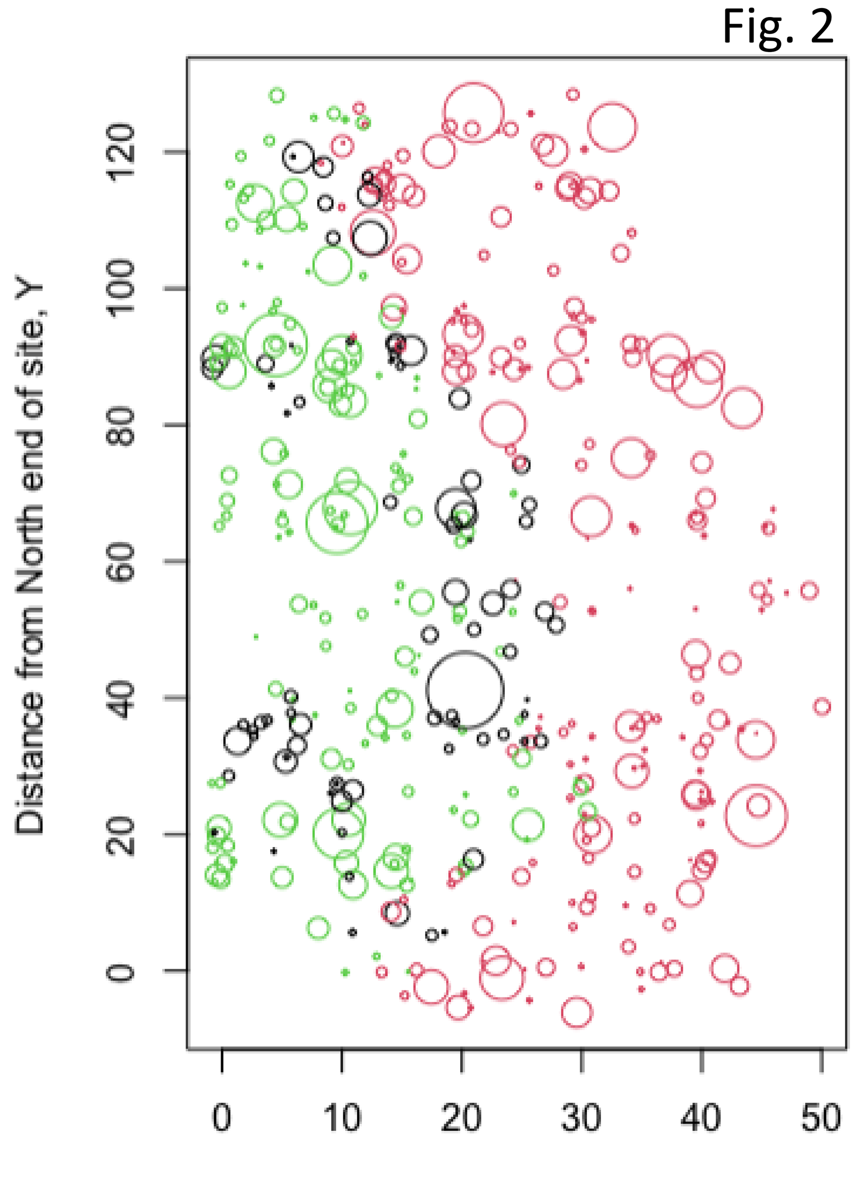


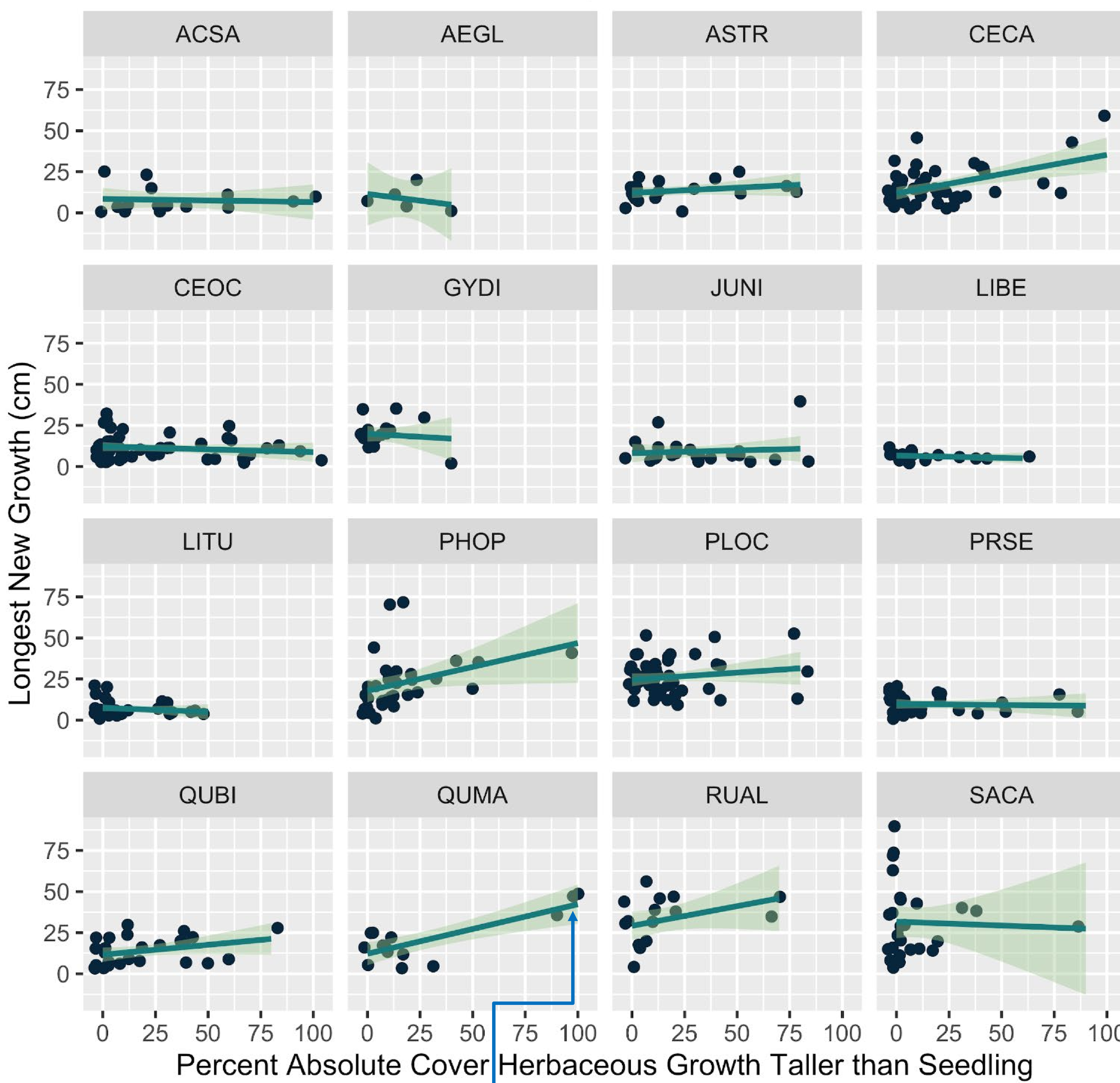
Figure 2 (l) Plot of the locations and growth rates of each of 442 surviving seedlings. Points are scaled proportionate to the growth rate of the seedlings. Color indicates site conditions: Red, full sun; green, full shade of mature tree canopy; black, partial shade in canopy gaps or edge of tree cover.

Figure 3 (r) Bar plot of survivorship and violin-plot of the distribution of growth rates for each species. The species with the fastest growth rate (*Platanus occidentalis*, *Sambucus canadensis*, *Rubus allegheniensis)* had lower rates of survival than the slower-growing *Gymnocladus dioicus*, *Juglans nigra*, and *Lindera benzoin*.

RESULTS

Herbaceous Cover and Seedling Growth

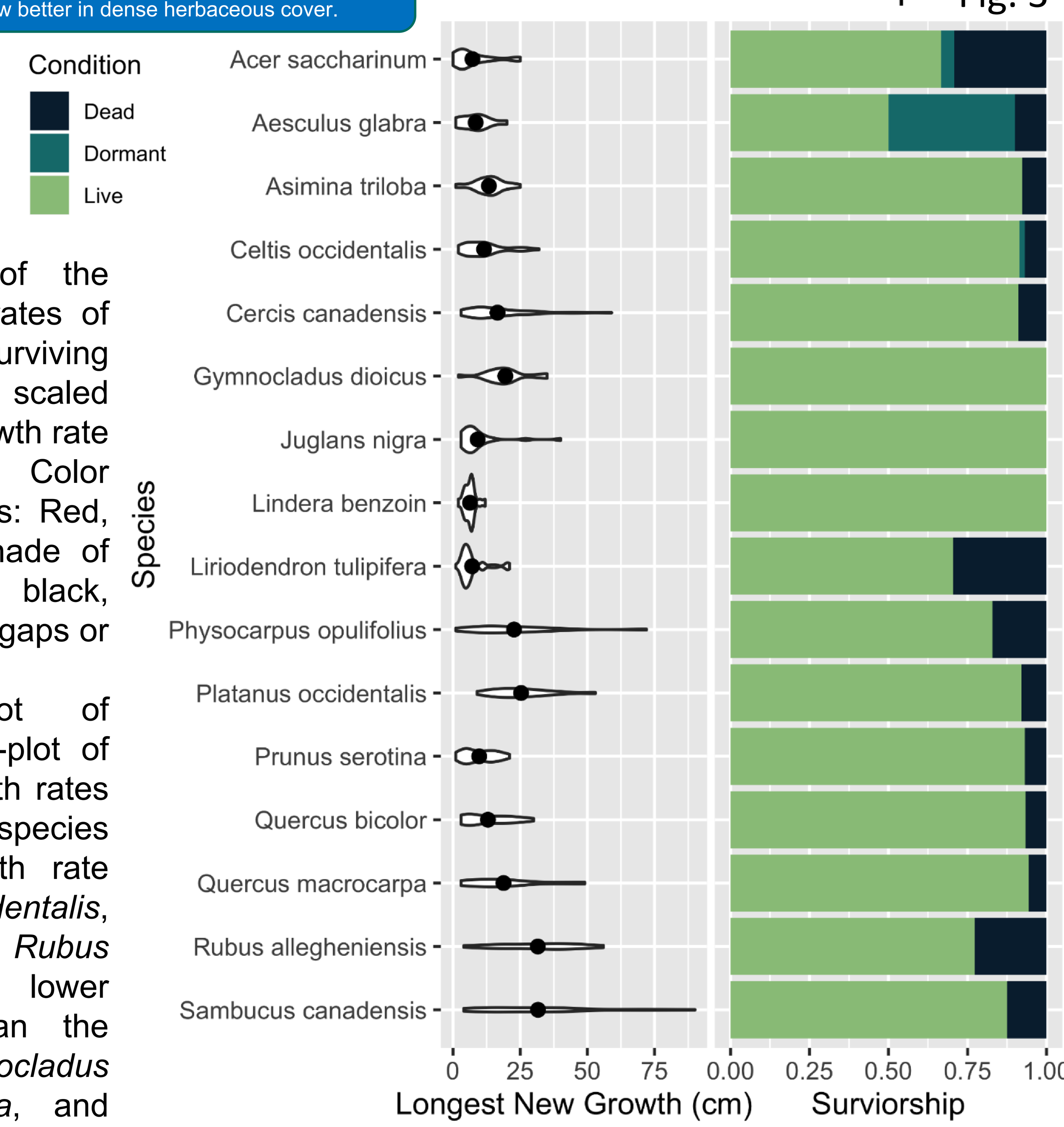
Fig. 1a



New Growth

Survivorship

Fig. 3



We ran a spatial autoregressive (SAR) model (R package spatialreg) to account for the confounding effect of local soil conditions on seedling growth: Growth ~ Species*HerbCover + PYCA + LOMA + Tree Tube, where *PYCA* and *LOMA* are the % cover of *Pyrus calleryana* and *Lonicera maackii.*

- There was a marginally significant negative effect of *Pyrus calleryana* on woody seedling growth, a reduction of 0.11 cm per percent-cover increase of PYCA (p=0.058).
- Honeysuckle, LOMA, had no effect (p=0.36).
- Tree tubes had a marginal benefit of +2.6 cm of growth (p=0.07).
- **Herb cover benefitted certain species: Table 1b**

Figure 1a, Table 1b. Responses to density of herbaceous cover for 12 species of tree and 4 species of shrubs. Figure 1a shows the correlation between percent herbaceous cover and post-planting growth of each species (Species are abbreviated, e.g. AEsculus GLabra =AEGL). Table 1b presents the average growth of each seedling (cm), and the effect of herbaceous cover on seedling growth (in cm of seedling growth per herbaceous % cover increase) from the spatial autoregressive model. Three species significantly (p<0.01) benefit from herbaceous cover: Bur oak, redbud, and ninebark, and a fourth species, blackberry, experienced a marginally significant (p=0.052) benefit. No species of tree or shrub experienced a significant negative impact on growth from herbaceous competition.

Table 1b

Species	Common name	*n*	Growth (cm)	Herb Effect (cm / %cov)	p value
Platanus occidentalis	Sycamore	58	26.05	0.116	0.27
Quercus macrocarpa	**Bur oak**	**17**	**20.79**	**0.329**	**0.002**
Gymnocladus dioicus	Kentucky coffeetree	18	19.46	-0.047	0.83
Cercis canadensis	**Redbud**	**56**	**16.41**	**0.262**	**0.007**
Quercus bicolor	Swamp w oak	28	13.96	0.148	0.20
Asimina triloba	Pawpaw	24	13.29	0.091	0.44
Celtis occidentalis	Hackberry	54	11.34	-0.006	0.94
Prunus serotina	Black cherry	27	9.65	0.015	0.89
Juglans nigra	Black walnut	26	9.21	0.059	0.60
Aesculus glabra	Ohio buckeye	9	8.45	-0.017	0.94
Acer saccharinum	Silver maple	27	7.06	-0.028	0.71
Liriodendron tulipifera	Tuliptree	38	6.94	-0.019	0.89
Rubus allegheniensis	***Blackberry***	***17***	***32.64***	***0.267***	***0.052***
Sambucus canadensis	Elderberry	28	31.28	-0.019	0.88
Physocarpus opulifolius	**Ninebark**	**34**	**22.32**	**0.319**	**0.006**
Lindera benzoin	Spicebush	19	6.26	0.001	0.99

CONCLUSIONS

Contrary to expectations of competition from herbaceous vegetation reducing growth of the bareroot tree and shrub seedlings, three woody species exhibited significantly (p<0.05) higher growth rates in dense herbaceous cover, and no species were negatively affected. The effect size of the benefit from full herbaceous cover was an order of magnitude larger than that of tree tubes. Qualitatively, seedlings, particularly oaks, were not only taller, but more vigorous in herbaceous cover; increased height growth is not explainable by stem etiolation from low light.

This benefit of herbaceous vegetation may be due to enhanced shade and soil moisture during drought and protection from herbivory. This site has abundant whitetail deer which are a substantial source of herbivory pressure, and these seedlings were measured after a dry summer (PDSI for September 2019 was D0-D1 moderate drought) . This is consistent with the Stress Gradient Hypothesis (Bertness and Callaway 1994), which holds that positive interactions in communities are more common in stressful conditions. Therefore, the benefits of herbaceous cover in reducing drought-stress and herbivory may be outweighed by light and nutrient competition by herbaceous vegetation on a wetter site or a wetter year.

The benefits of herbaceous cover for some species of woody seedlings can be utilized as a restoration technique, as has been recognized for semi-arid systems (Gómez-Aparicio, 2009). For sites with high drought stress or herbivory pressure, preserving as much herbaceous cover around woody plantings may improve bareroot seedling survivorship and growth.

SER-OSU Restoration site, April 2021

References

Bertness, M. D., & Callaway, R. (1994). Positive interactions in communities. *Trends in Ecology & Evolution*, *9*(5), 191–193.

Gómez-Aparicio, L. (2009). The role of plant interactions in the restoration of degraded ecosystems: A meta-analysis across life-forms and ecosystems. *Journal of Ecology*, *97*(6), 1202–1214.

Acknowledgements

Ryan McCarthy, Ashley Keesling, and John Ballas designed the study; John Ballas, Ashley Keesling, Isaac Knowles, Kali Mattingly, Ryan McCarthy, and Dave Tomaschefski measured seedling growth; John Ballas and Ryan McCarthy analyzed the data; Katie Gaffney, Grace Gutierrez, Jo Moretina, Darienne Purtz and Ryan McCarthy designed the poster.

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Herbaceous community benefits from removal of woody invasive species

Gaffney, Katie*, Ryan McCarthy, John Ballas, Ashley Keesling, Kali Mattingly, Dave Tomashefski, Grace Gutierrez, Logan Rance, Darienne Purtz, Jo Moretina

INTRODUCTION

Forest restoration efforts that focus on the woody plant community will impact the rest of the ecosystem. Removal of woody invasive species has the potential to positively impact the ecosystem by 1) increasing the percent cover of native herbaceous species via release from competition, or 2) increasing the species richness and diversity of the native herbaceous community through germination from the soil seedbank. Conversely, negative impacts to ecosystems can occur if 3) existing exotic species outcompete natives for the newly opened space, or 4) results in colonization of new invasive species from dispersal into the site from surrounding areas.

METHODS

- In September of 2019 and 2020, the herbaceous community was surveyed in the northern 300m of our restoration site.
- The 2019 survey consisted of both restored and unrestored areas, while the 2020 survey captures the responses of vegetation across 1 and 2 growing seasons post-removal.
- We surveyed the herbaceous community composition in 130 1m^2 quadrats spaced on a regular grid covering ~300x40m, with sampling points spaced at 5m intervals perpendicular to the river, and 20m intervals parallel to the river.
- We estimated the absolute percent cover of each forb and woody species whose stem was within the quadrat, but for graminoids estimated the total cover without attempting to distinguish species. Estimating percent cover for individual species allows the total percent cover to sum to more or less than 100%, due to species overlap and bare ground.
- Data analysis was performed in R. We fit multiple linear regression models to determine impact of different vegetation categories on ne=ative herbaceous vegetation:

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NativeHerbaceous ~ WoodyExotic +
HerbExotic + WoodyNative + Graminoid
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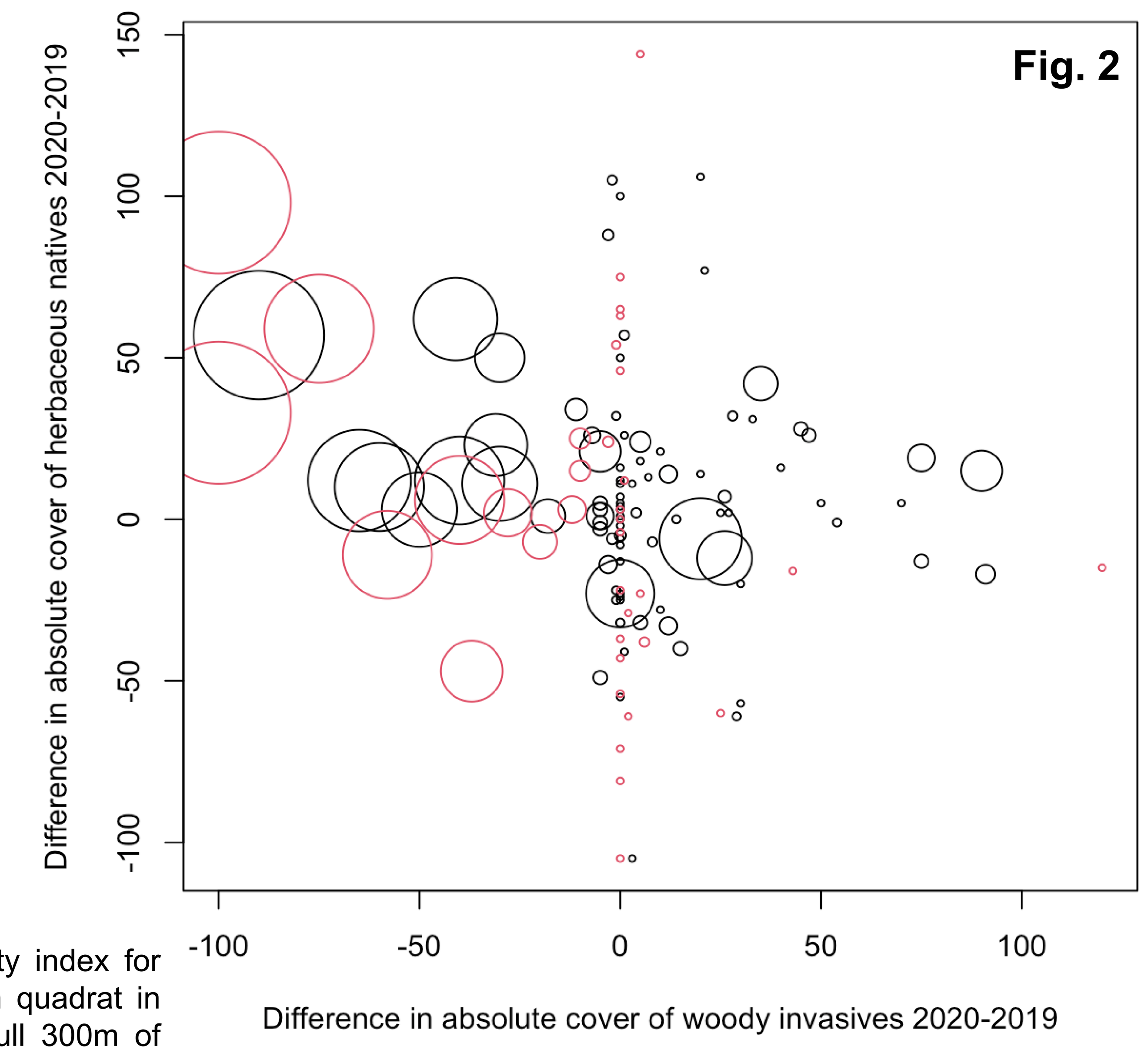
  where each model term is the sum of percent covers of that category of vegetation. We fit models for 2019, 2020, and the change between the years.
- We used canonical correspondence analysis (R package *vegan*) to assess species associations in the herbaceous community with *Lonicera maackii and Pyrus calleryana*.

RESULTS

Aggregated native and exotic species abundances were used to track temporal changes in the herbaceous community of restored and unrestored parts of the site. We found that % cover of native herbaceous species increased in response to woody invasive removal. We found a significant negative relationship between the percent cover of woody invasive species and native herbaceous species, in both 2019 and 2020 vegetation surveys. Native woody vegetation did not affect native herbaceous vegetation. Additionally, cover of exotic herbaceous vegetation and grasses did not affect native herbaceous cover in 2019, but significantly negatively affected native herbaceous vegetation in 2020.There was no significant difference between 2019 and 2020 from 0-200m, but from 200-300m the % cover of woody exotics and grasses had a significant negative effect on native herbaceous cover.



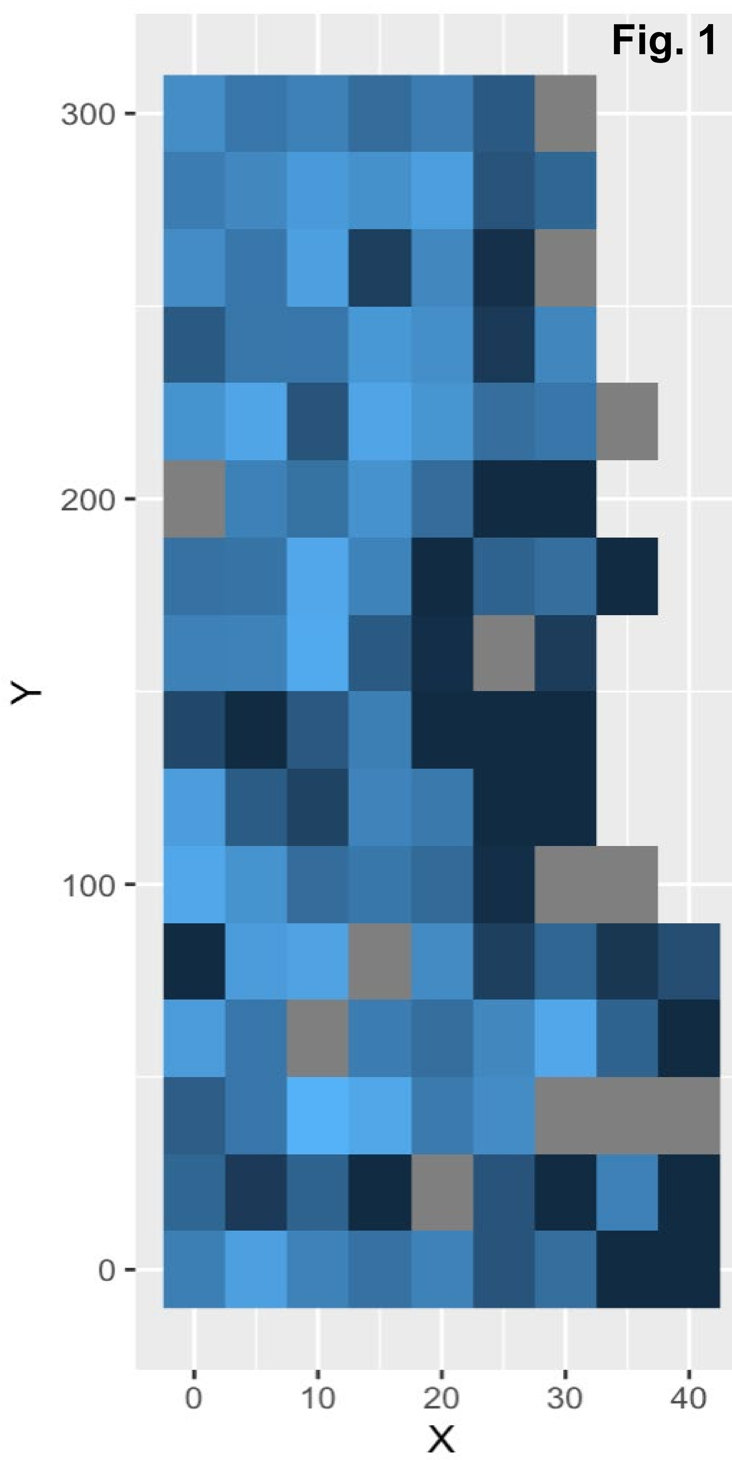


Fig. 1. Map of the Simpson's diversity index for native herbaceous vegetation at each quadrat in 2020, following removal across the full 300m of the site. Brighter colors of blue indicate higher diversity. Gray indicates quadrats with no diversity (e.g. only one herbaceous species present, excepting grass). Diversity was higher in the region of richer soil and large tree cover near the river, but not significantly different between the regions of 2019 (Y <200) and 2020 (200<Y<300m) woody invasive removal.

Fig. 2. Scatterplot showing change in the herbaceous natives (Y) and woody invasives (X). Circle size indicates the absolute cover of woody invasive species in 2019. Circle size corresponds to total % cover of woody invasive species pre-removal. On average, the plots previously containing highest total percent cover of invasives also had the largest post-removal increases in absolute cover of native herbaceous species. Quadrats with large % cover of invasives had post-removal increases in native herbaceous % cover. Black= 0-200m, Red=200-300m

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Fig. 3. Graph depicting the relative abundance of each species present at the site as a function of distance from of the Olentangy river. The set of species toward the top of the graph reflects a plant community growing in high light conditions, whereas the bottommost set reflect the community growing in shade. Additionally, the soil far from the river (roughly 20-30m) is poor quality (construction backfill), so the species with high abundances at these distances may posses a higher tolerance for poor soil

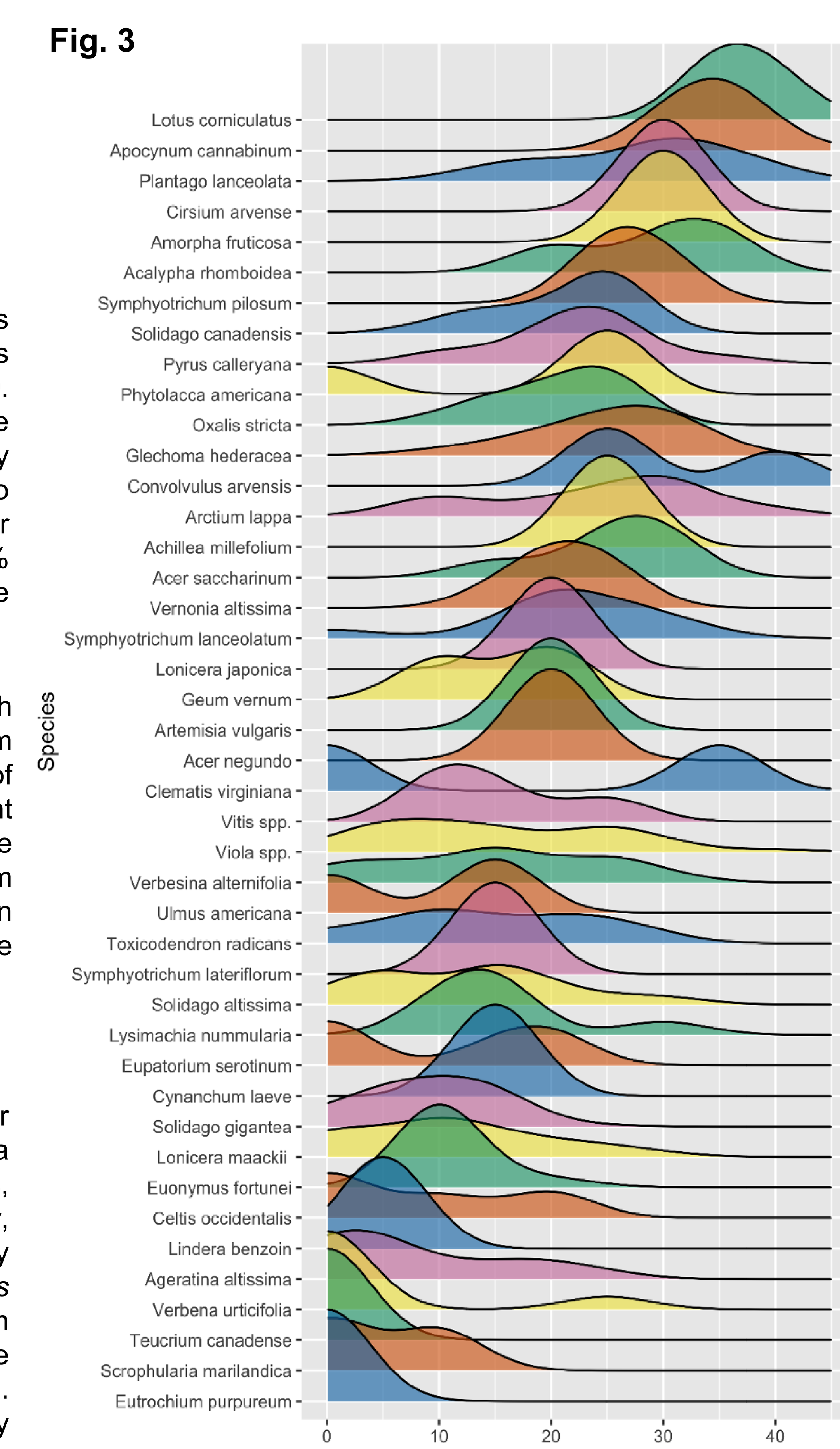

Table 1.	Effect size 2019	p-val 2019	Effect size 2020	p-val 2020
Woody exotics	-0.435	**0.001**	-0.232	**0.046**
Woody natives	-0.093	0.82	-0.02	0.86
Herb. exotics	-0.225	0.10	-0.225	0.04
Grass, sedges	-0.132	0.09	-0.221	**0.005**

Table 1. Parameter estimates and p-values for changes in the native herbaceous cover as a function of exotic woody, exotic herbaceous, native woody, and graminoid percent cover, for 2019 and 2020. Woody exotics, principally the invasive *Lonicera maackii* and *Pyrus calleryana* that we have been removing from our restoration site, had significant negative effects on native herbaceous vegetation. Notably, there was no effect from woody native vegetation in either year, suggesting coexistence within the native community.

CONCLUSIONS

- We found that the percent cover and richness of native herbaceous species increased in response to woody invasive removal.
- These findings demonstrate that, even in a heavily degraded urban site, woody invasive removal can have positive effects on the herbaceous community, even without direct seeding of herbaceous species.
- The percent cover of the native herbaceous community increased in response to removal of *Lonicera maackii* and *Pyrus calleryana*. This is consistent with release from the strong competitive effect that woody invasives with extended leaf phenologies have on the native community.
- Notably, there was no effect of native woody species on the native herbaceous community; that is consistent with coevolution and niche partitioning between members of the native plant community.
- Two growing seasons post woody invasive removal, exotic herbaceous cover negatively impacted the native herbaceous community. The removal of woody exotics may have facilitated the increase in exotic herbaceous cover.
- The species richness of the entire plant community increased from 81 to 133 species between 2019 and 2020. This is an increase in both the native and exotic species.

This study was possible with funding from the SER-MWGL student restoration grant. The study design was developed by John Ballas and Ryan McCarthy. John, Kali, Dave, Ashley, Katie, Ryan, and Logan surveyed vegetation. Ryan and John performed the data analysis; Katie, Grace, and Ryan made the poster. Grace entered data and edited the poster and abstract.

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