Native *Echinacea angustifolia* has depressed viability relative to non-native *E. pallida* and reciprocal hybrids (*E. angustifolia x E. pallida*) in a fragmented prairie habitat

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Background

- Non-native plants can negatively affect population growth of native congeners, especially when they form hybrids.[1]
- Invasive plants tend to have higher physiological rates than non-invasives.[2]
- On average, inbred *E. angustifolia* have lower physiological values and lower fitness.[3]

Study System

- *Echinacea* are long-lived, vector pollinated, self-incompatible prairie forbs that flower after 3-7 years.
- Fragmented prairie in Douglas County, Minnesota.
- Less than 1% of native prairie remains as roadside ditches or small restorations.
- Remnant *E. angustifolia* are subject to genetic isolation and inbreeding depression.[4]
- *Echinacea pallida* (4n) was introduced to the system and has been observed to hybridize with native *E. angustifolia* (2n).[5]

Methods

Hand-crossed *E. angustifolia* and *E. pallida* from prairie remnants (maternal x paternal):

- *ang* x *ang*
- *pal* x *pal*
- *ang* x *pal*
- *pal* x *ang*

Seedlings planted in fall 2013 in 10m x 30m grid 1m apart. Locations and ID of plants randomized.

Each year 2014-2018, members of Team Echinacea recorded leaf number, leaf length, and survival of each plant.

In 2018, I measured photosynthetic rate (A_{max}), water use efficiency (WUE), and leaf thickness of surviving plants.

- Relative survival of cross types with at least one *E. pallida* parent compared to *ang:ang* crosses using logistic regression with log link.
- Ecophysiology (A_{max}, WUE, and leaf thickness) compared across cross types using a permutated MANOVA.
- Longest leaf length and leaf number each year 2014-2018 compared among cross types using PERMANOVA.
- Missing data imputed using predictive mean matching.

Results

Ecophysiological traits of the *ang:ang* cross type were lower than that of all other cross types (Fig 1) *E. angustifolia x angustifolia* cross types on average displayed lower above-ground biomass and survival than all other cross types across all five study years (Fig 2, Table).

Table. Relative survival since seed stage of *E. angustifolia* intraspecific crosses to cross types with at least one *E. pallida* parent, fit using logistic regression with a log link.

Cross type	Coefficient (±SE)	Survival relative to ang:ang (95% CI)	Overall survival	p-value
Intercept (ang:ang)	-1.63 (±0.19)	-	0.196	**<0.001**
ang:pal	0.41 (±0.28)	1.51 (0.85-2.62)	0.296	0.150
pal:ang	0.87 (±0.21)	2.38 (1.60-3.73)	0.469	**<0.001**
pal:pal	0.97 (±0.21)	2.64 (1.80-4.09)	0.529	**<0.001**

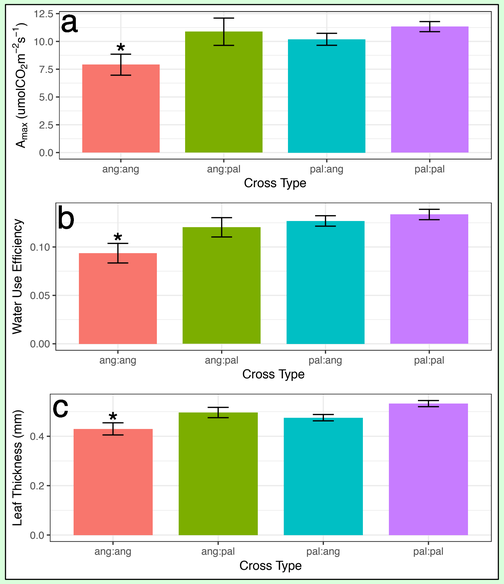

Fig 1. Comparison of ecophysiological traits a) A_{max}, b) WUE, and c) leaf thickness (±SE) across four *E. angustifolia* and *E.pallida* intraspecific and interspecific cross types in summer 2018. Conspecific *E. angustifolia* crosses had significantly decreased ecophysiology compared to all other cross types (PERMANOVA, overall p = 0.0012; *ang*:*ang* compared to: *ang*:*pal*, F = 4.439, p = 0.030; *pal*:*ang*, F = 5.930, p = 0.012; *pal*:*pal*, F = 16.437, p < 0.001). There were no significant differences between any other cross types.

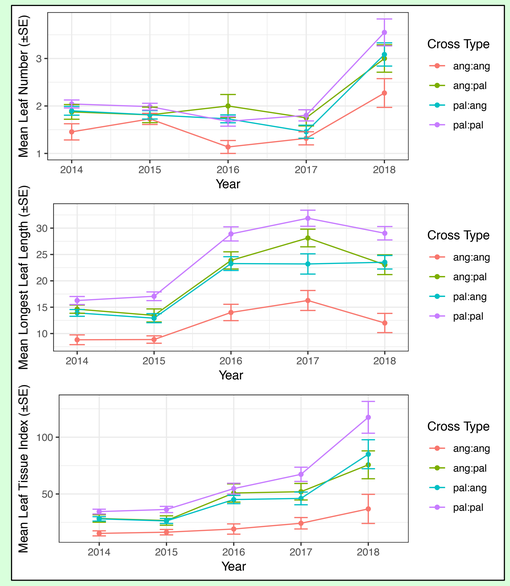

Fig 2. Vegetative plant size displayed as leaf number, longest leaf length, and leaf tissue index (leaff # x long leaff length) over time, between cross types. *E. angustifolia* conspecific crosses had significantly lower above-ground biomass compared to all other cross types over the five study years (PERMANOVA, overall p < 0.001; *ang*:*ang* compared to: *ang*:*pal*, F = 11.8, p < 0.001; *pal*:*ang*, F = 14.3, p < 0.001; *pal*:*pal*, F = 25.2, p < 0.001). *E. pallida* conspecific crosses also had significantly greater above ground biomass over five measuring seasons than the *E. pallida* x *angustifolia* cross type (PERMANOVA, F = 7.32, p < 0.001).

Discussion

- All cross types with at least one non-native *E. pallida* parent on average had higher survival, ecophysiology, and above-ground biomass than the native *E. angustifolia* conspecific cross types, suggesting the introduced non-natives may threaten the native population.
- Introduced congeners can reduce pollinator visitation and seed set of native congeners.[6] Because increased ecophysiology and vegetative size is correlated with increased fecundity and flower size[7,8] and non-natives had higher survivorship, the pollinator visitation, seed set, and λ of native *E. angustifolia* may be drastically reduced.
- Management of *E. pallida* and should be undertaken to reduce hybridization and to save the already diminishing native coneflower population.

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