

Establishment and Early Productivity of Perennial Biomass Alley Cropping Systems in Minnesota, U.S.A.

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Introduction

Agroforestry has been proposed for sustainable biomass cropping

- Potential to utilize “marginal”, depositional, or lowland sites
 - Strategic niches to minimize competition with food crops
- Potential for increased ecosystem services
 - Wildlife / pollinator habitat
 - Carbon sequestration
 - NPS pollution reduction / water quality
- Landscape and feedstock diversity



Introduction

- Limited information on biomass crop potential in agroforestry systems in U.S. Midwest
- Successful crop establishment is critical to stand longevity and maximizing productive potential
- We need to develop systems before farmers can adopt!



Methods: objectives

Therefore, our short-term objectives were to:

- To evaluate establishment and yields of biomass crops in an alley cropping system
- To evaluate the effects of tree-crop interactions on productivity and establishment



Methods: crops

- Fish Creek willow cultivar (*Salix purpurea* x *S. purpurea*)
- NM6 poplar hybrid (*Populus nigra* x *P. maximowiczii*)



Methods: crops



**Willow planted in “twin
row” system**

14,332 trees ha⁻¹



**Poplar planted at 1.2 m
grid spacing**

6,670 trees ha⁻¹



Methods: crops

- **Switchgrass**

(*Panicum virgatum* L.)

- Local ecotype broadcast at 18.2 kg ha⁻¹ (193 seeds m⁻²)



- **Prairie Cordgrass**

(*Spartina pectina* Bosc ex Link)

- Local ecotype propagated at 107,593 plants ha⁻¹ (10.8 plants m⁻²)



Methods: crops

- **Native tallgrass polyculture**

- 4 forbs, 4 legumes, 3 grasses broadcast at 17.1 kg ha^{-1} (384 seeds m^{-2})



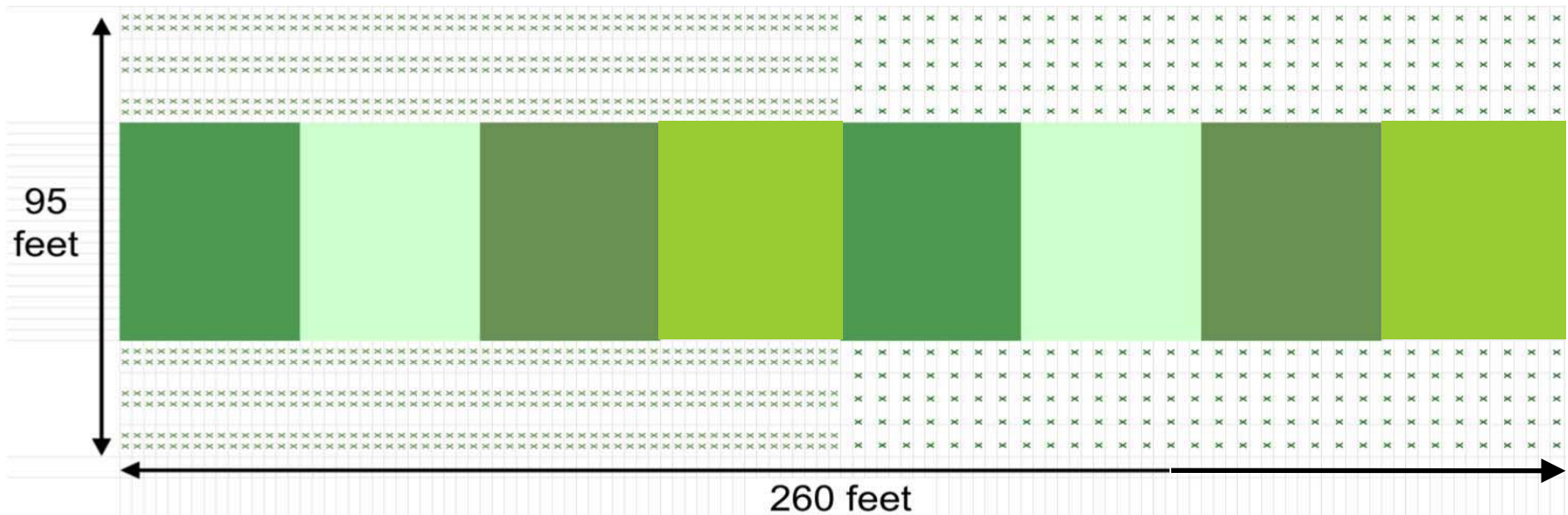
- **Alfalfa - intermediate wheatgrass mixture**

- Alfalfa (*Medicago sativa* L.) Pioneer '54V48' at 5.7 kg ha^{-1}
- 'Rush' intermediate wheatgrass (*Thinopyrum intermedium* [Host] Barkworth and Dewey) at 9.1 kg ha^{-1}



Methods: design

- RCBD in split plot arrangement
- 3 on-farm sites: Fairmont, Empire, and Granada, MN
 - 2 floodplain, 1 stream terrace
- 3 years (2010 - 2012)
- 2 woody crops, 4 herbaceous crops
- 15.2 m alley



Methods: design

Alley orientation

Empire



Fairmont



Granada

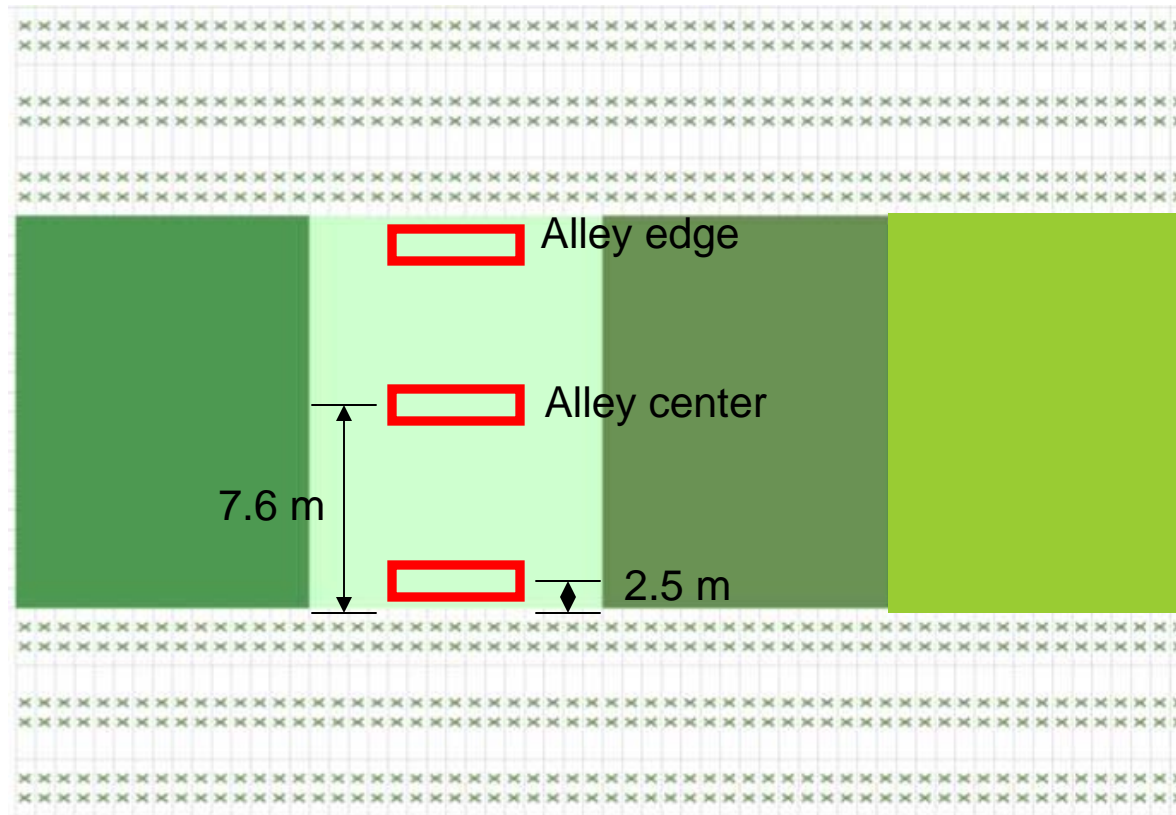


Methods



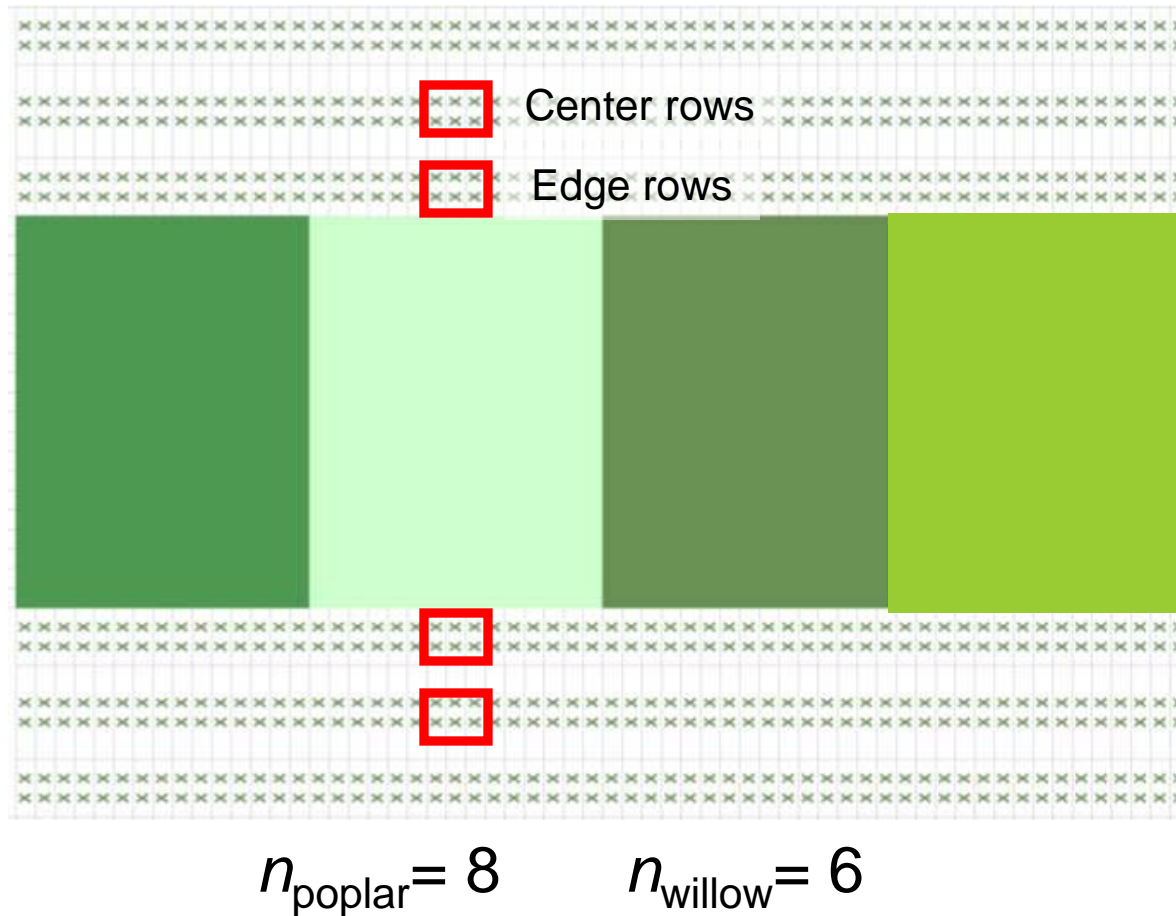
Methods: sampling

Herbaceous crop sampling



Methods: sampling

Tree sampling



Results & discussion

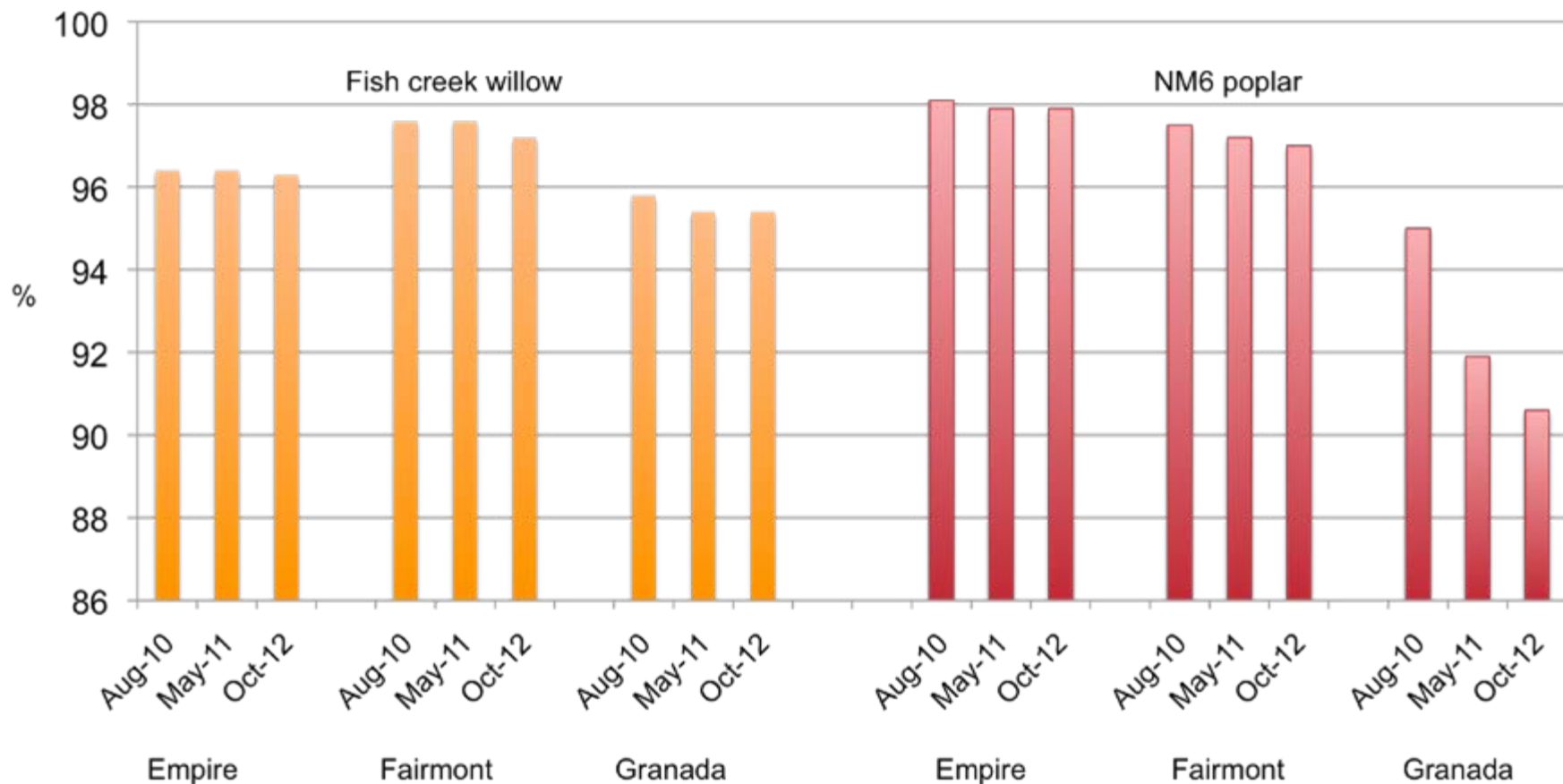


Figure 2: Short rotation willow and poplar survival 3, 12, and 30 months after establishment in alley cropping systems at three Minnesota sites

Results & discussion

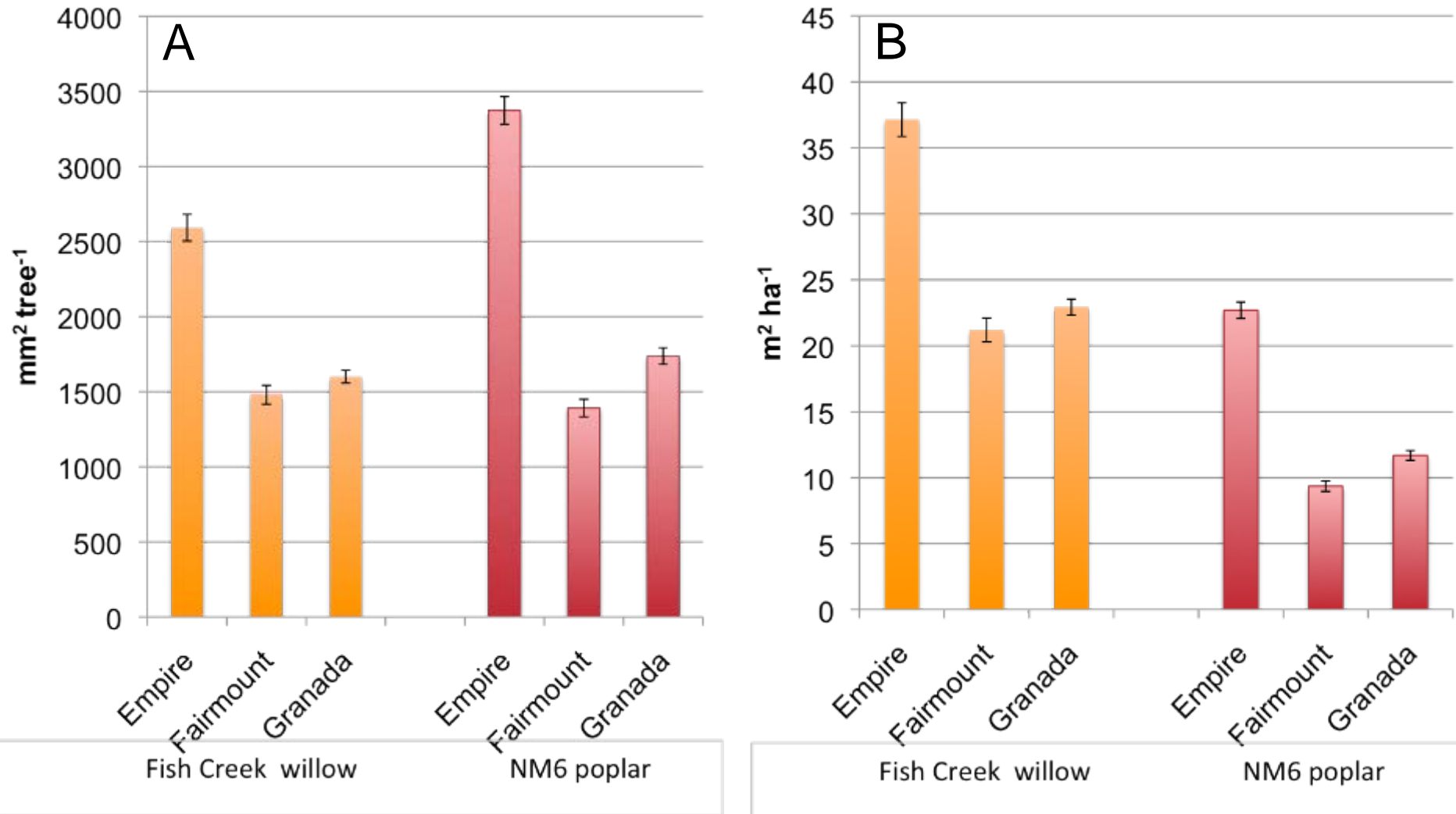


Figure 2: Average basal area **A)** per tree and **B)** per hectare for alley cropped short rotation woody crops following the third growing season in 2012. Means +/- standard errors are presented.

Results & discussion

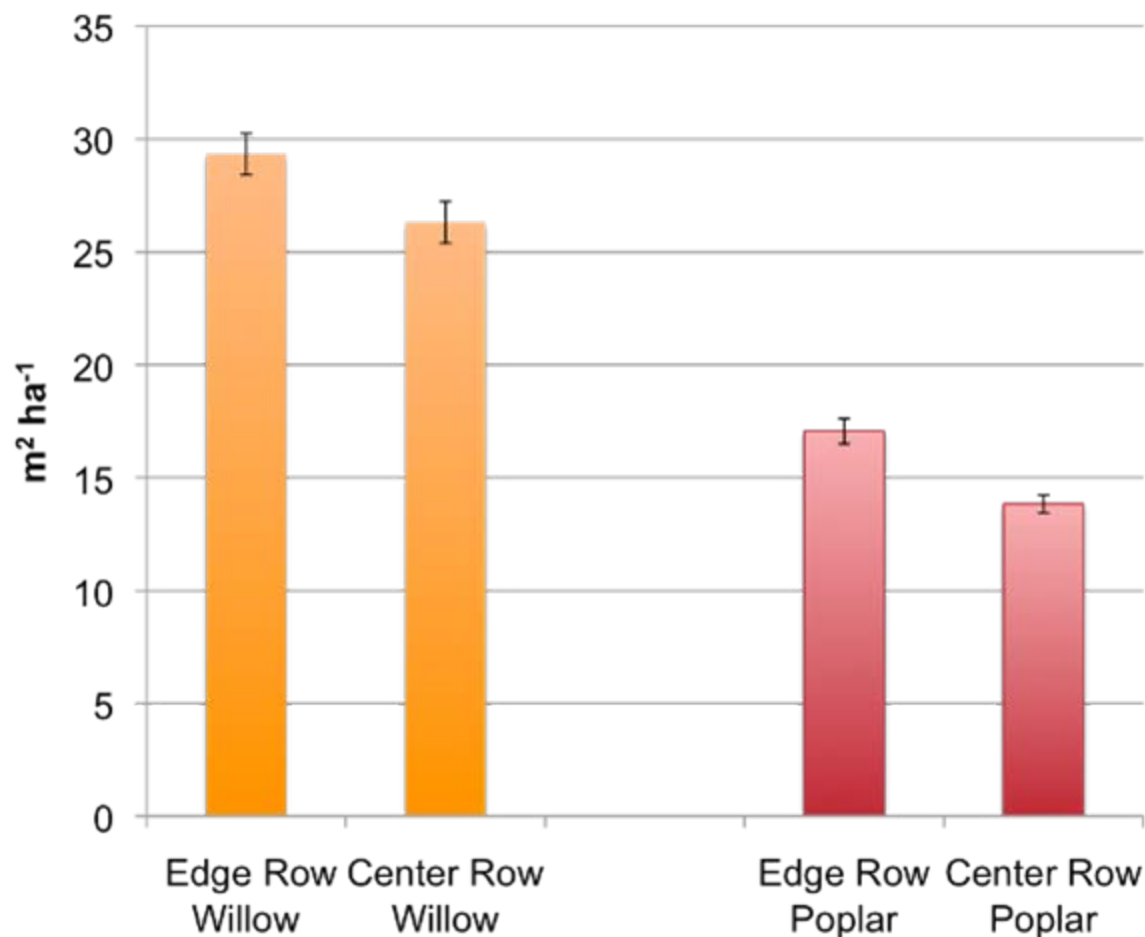


Figure 3: 2012 average basal area per hectare by clone and row position for alley cropped short rotation woody

Results & discussion

Table 2: Establishment index and weed density for four herbaceous alley crops at two Minnesota sites 45 days after seeding.

Treatment	Planting rate (PLSm ⁻²)	Establishment index [§]		Weed density (seedlings m ⁻²)	
		Empire	Granada	Empire	Granada
Switchgrass	1,481	0.21 br [†]	0.33 br	90.4 ar	38.8 as
Alfalfa – wheatgrass	439	0.82 ar	0.90 ar	69.9 ar	30.1 ar
Native polyculture	770	0.18 cr	0.21 br	73.2 ar	72.1 ar
Prairie cordgrass	10.8 [‡]	0.93 r	0.82 s	NA	NA

[†]Within each column and row, means with the same letter are not significantly different based on Tukey's HSD (0.05). Letters a – c are used to denote differences among treatments, while letters r – s are used to denote differences between sites.

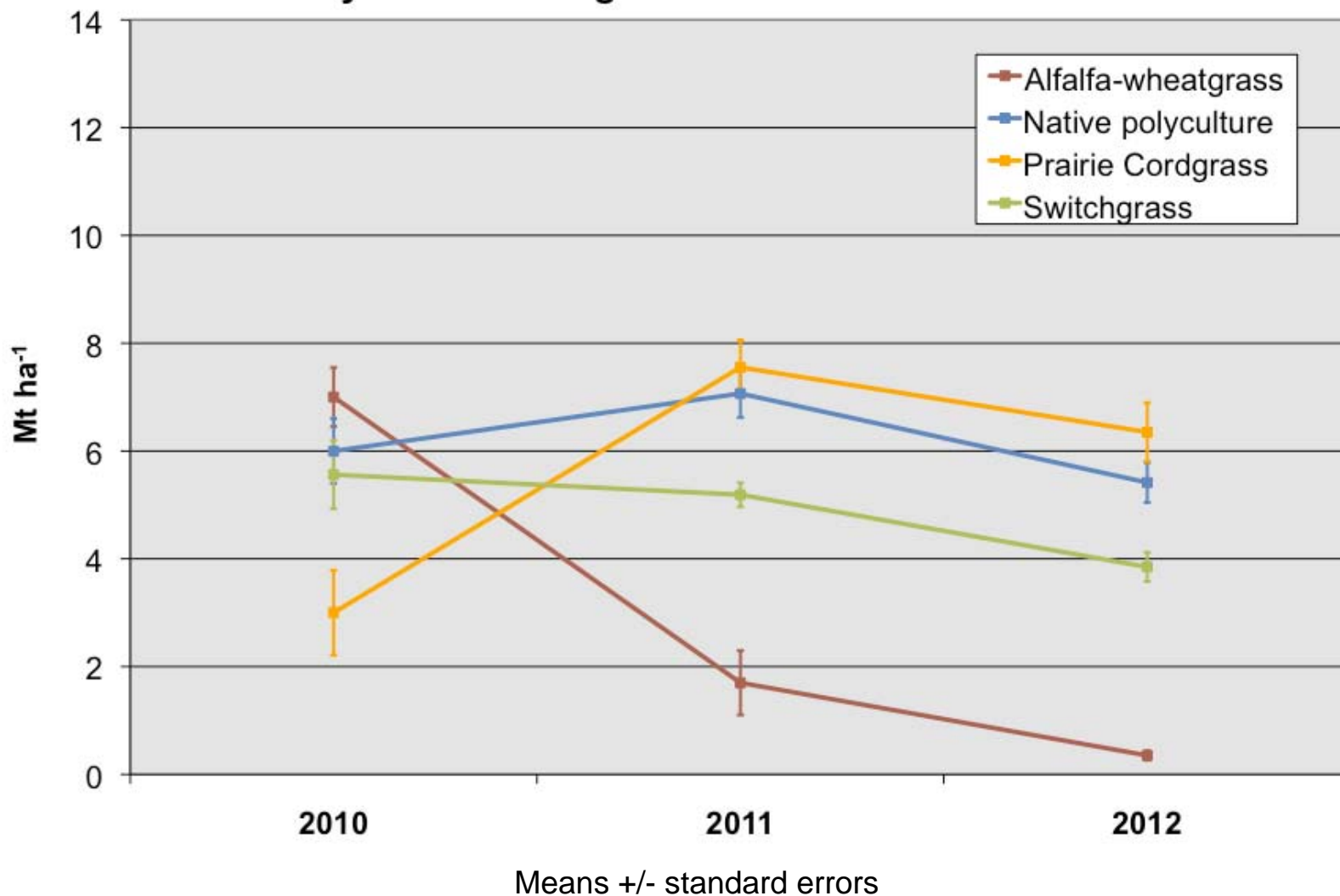
[‡]Live rhizomes were planted rather than seed, thus comparisons to seeded treatments were not made

[§]Emergence index is calculated as average seedling density / planting rate

NA: Not applicable; this data was not collected

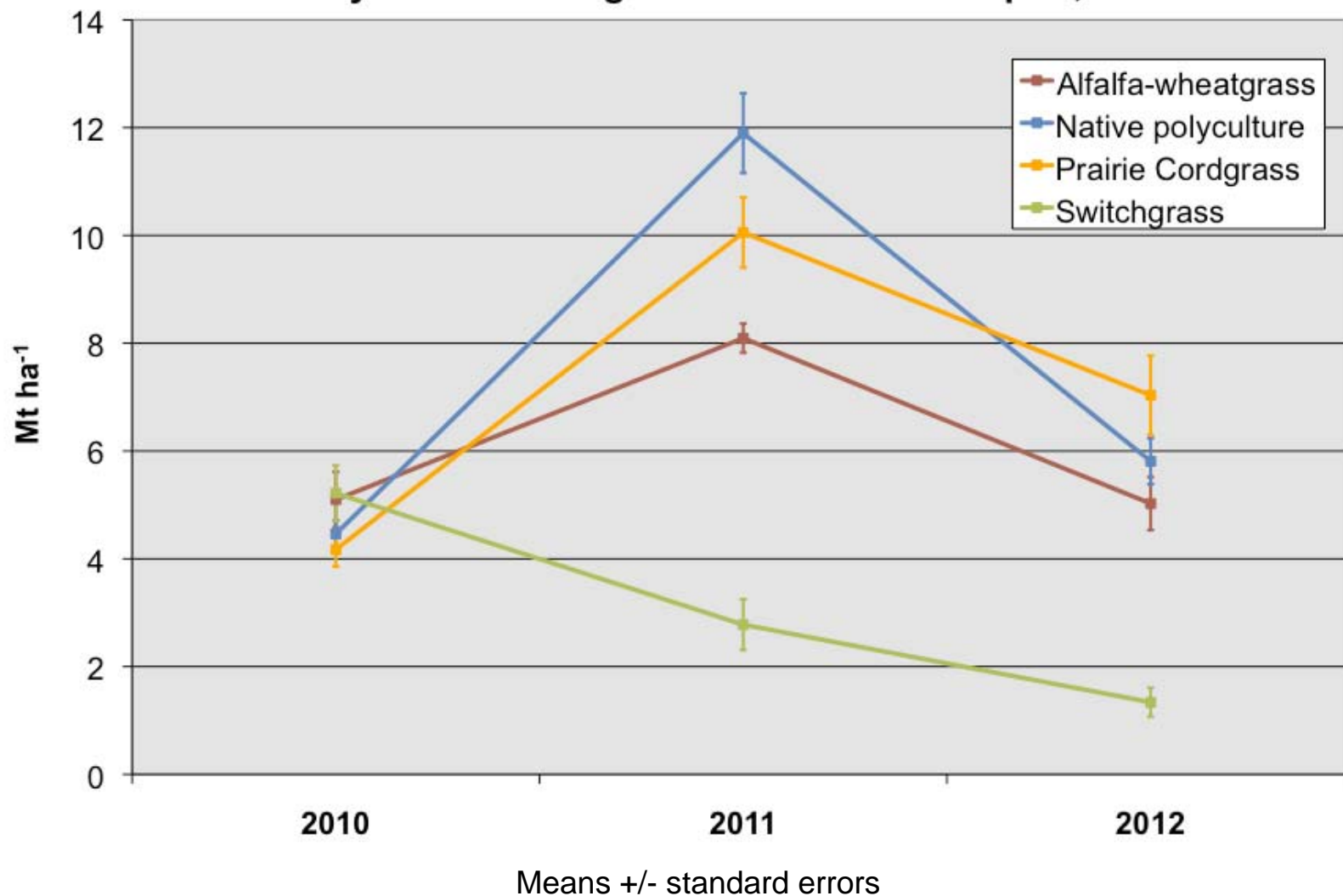
Results & discussion

Dry matter yield of alley cropped herbaceous biomass over three years following establishment at Granada MN



Results & discussion

Dry matter yield of alley cropped herbaceous biomass over three years following establishment at Empire, MN



Results & discussion

- Currently no differences in crop yield in edge vs. center of alley
- Declining yields at both sites from 2011 - 2012
 - Moderate drought at Granada
 - More shading at Empire due to N/S tree rows



Summary

- Herbaceous productivity
 - Good herbaceous crop establishment (high indices)
 - Native polyculture & prairie cordgrass were most productive herbaceous crops so far
 - No difference in edge vs. center alley, but yields are declining overall, possible effect of alley orientation
- Woody productivity
 - Excellent tree survival
 - Edge effects due to alley proximity
 - Differences between clones due to:
 - Tree spacing, individual tree size, coppice / no coppice management, site adaptability

Next steps

- Effects of interspecies interactions on resource availability and productivity in the alley cropping system
 - What is causing herbaceous yield decline? (light, water, N availability?)
 - Why no edge effects in herbaceous crops?
- Woody biomass harvest and allometrics
- Root biomass distribution and C accumulation since conversion from annual crops

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