Seeding Project at Cibola National Wildlife Refuge

Results from four years of seeding projects.

Matt Grabau

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Potential Benefits of Native Seed Application

- Preservation and enhancement of genetic diversity (Winfield and Hughes, 2002; Landis et al. 2003).
- Potential for very high planting densities:
  - Improved native species habitat?
  - Increased competitive advantage over saltcedar and other undesired species?
- **Economic efficiency.**

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Study Objectives

- Analyze the feasibility of direct seeding of riparian species for revegetation:
  1. Determine effects of seed treatment and storage methods on long-term viability and vigor of riparian tree seed.
  2. Determine the effects of: soil conditions; seeding rates; seed cleaning; and seeding methods on tree establishment and growth.
  3. Optimize irrigation methods for tree establishment.
  4. Determine establishment rates for different seed application methods and rates.

Study Phases

1. Laboratory and greenhouse study of seed storage.
2. Controlled environment (greenhouse) seeding study.
3. Small-scale field study plots at Cibola NWR—scope of this presentation.

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Phase 3 Small-scale (20' by 40' Plots) Field Study Chronology

- 2007 Plots: Direct seeding a mix of Fremont cottonwood (20%), Goodding's willow (40%), and coyote willow (40%).
- 2008 and 2009 Plots: Direct seeding Goodding's willow alone:
  - Different seeding and surface irrigation methods—2008.
  - Variable seeding rates—2009.

Field Study Location

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2007 Small-scale Field Study Matrix

Early-Time Sprinkler Irrigation	Seeding Method	Surface Irrigation Method
Three Weeks (Y)	Hydroseed Un -Cleaned Seed (UH)	Furrow (F)
None (N)	Hydroseed Cleaned Seed (CH)	Border (Small-Scale Basin) (B)
	Broadcast Cleaned Seed (CB)	

- Analyze seeding of ~125 PLS/ft^2 as 25 Fremont cottonwood, 50 Goodding's willow, 50 coyote willow.

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Note for 2007 results:

- Very poor establishment of Goodding's and coyote willow created various problems with sampling and statistical design.
- Focus on Fremont cottonwood for 2007 study plots.

Seeding Method Effects (ANOVA Modeling)

Results	Fremont Cottonwood	
	Establishment, Stems m^{-2}	**Above-ground Dry Biomass, g m^{-2}**
Seed Treatment	Least-squared Means and Significant Differences (Student's t-test)	
Un-cleaned Hydroseed	24.03 A	65.45 A
Cleaned Hydroseed	12.79 B	44.66 AB
Cleaned Broadcast	16.07 AB	25.47 B

- Hydroseeding (un-cleaned seed) resulted in highest cottonwood establishment.
- No significant effects of irrigation methods (sprinklers or furrows).

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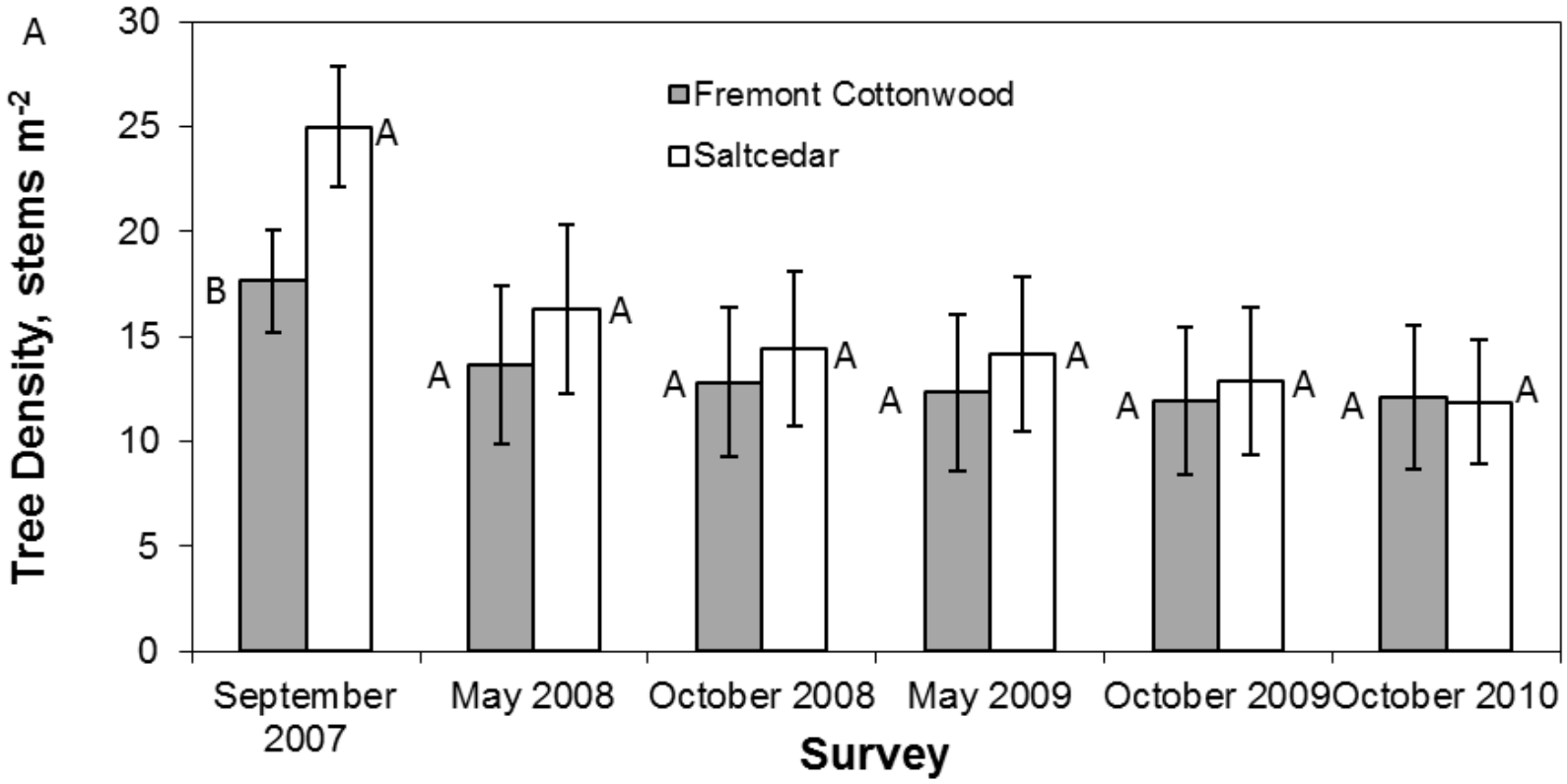
Long-term Vegetation Observations: Tree Density Over 4 Growing Seasons



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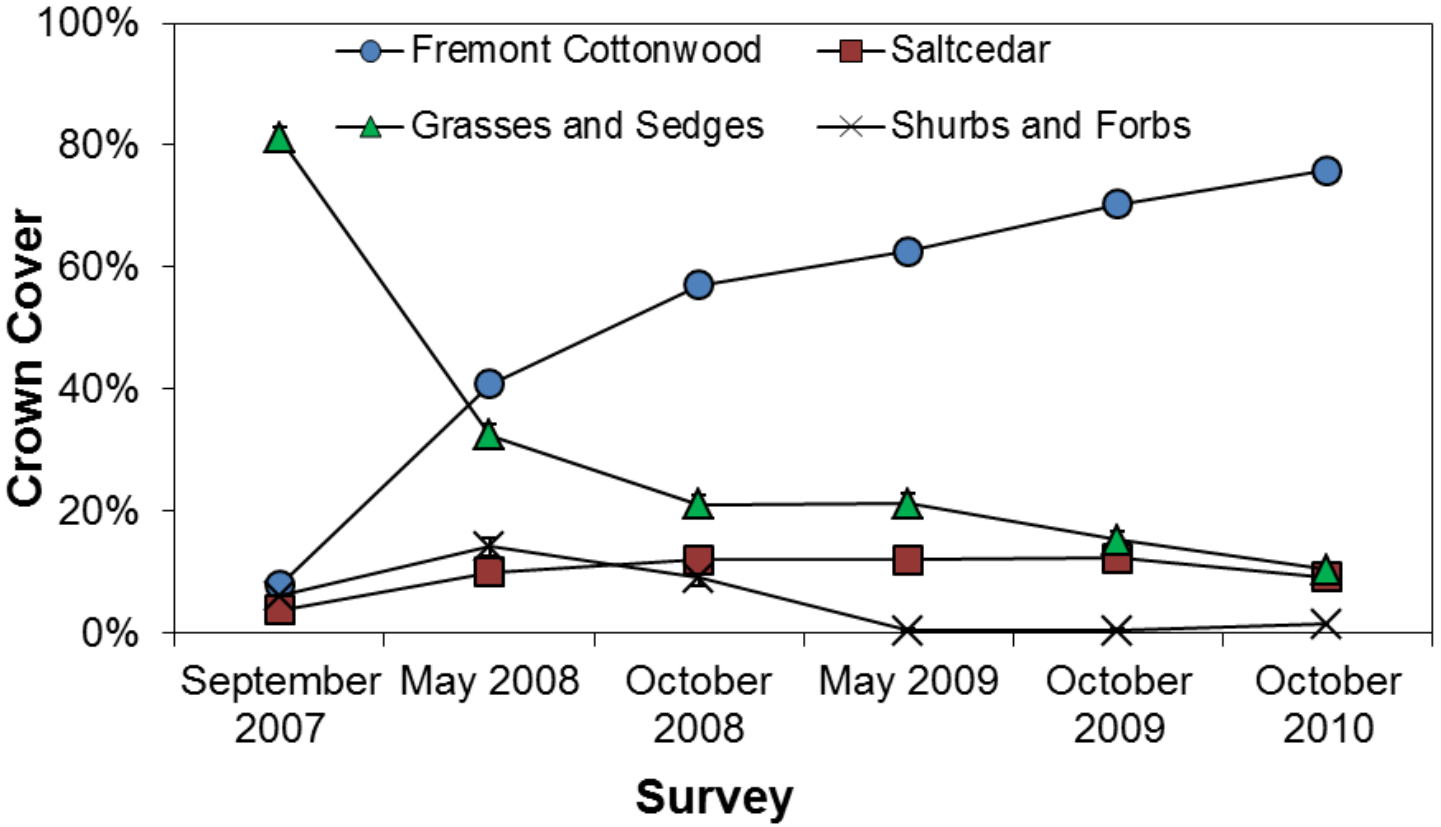
Long-term Vegetation Observations: Crown Cover Over 4 Growing Seasons



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One Growing Season

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Two Growing Seasons

4 Growing Seasons

2008 Small-scale Field Study Matrix

Seeding Method	Surface Irrigation Method
Hydroseed Un -Cleaned Seed (UH)	Furrow (F)
Broadcast Cleaned Seed (CB)	Border (Small-Scale Basin) (B)

Objective:

- Attempt to enhance willow establishment by:
  - Removing cottonwood from the seed mix.
  - Enhancing grass control.
- Goodding's willow seeded at approximately 150 PLS/ft^2.

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2008 Plots: Seeding Method Effects

Results	Goodding's Willow	
	Establishment, Stems m^{-2}	Canopy Cover, %
Seed Treatment	Least-squared Means and Significant Differences (Student's t-test)	
Un-cleaned Hydroseed	14.90 A	10.0 A
Cleaned Broadcast	3.76 B	3.4 B

- Hydroseeding (un-cleaned seed) resulted in ~3X higher Goodding's willow establishment.

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2008 Plots: Surface Irrigation Effects

Results	Tree Density, Stems m^{-2}		Canopy Cover, %	
	Goodding's Willow	Saltcedar	Goodding's Willow	Saltcedar
Surface Irrigation Method	Least-Squared Means and Significant Differences (Student's t-test)			
Border	9.1 A	56 A	6.3 A	48 A
Furrow	9.6 A	47 A	7.1 A	41 A

- Surface irrigation method did not affect establishment.
- Much higher density of saltcedar than Goodding's willow.

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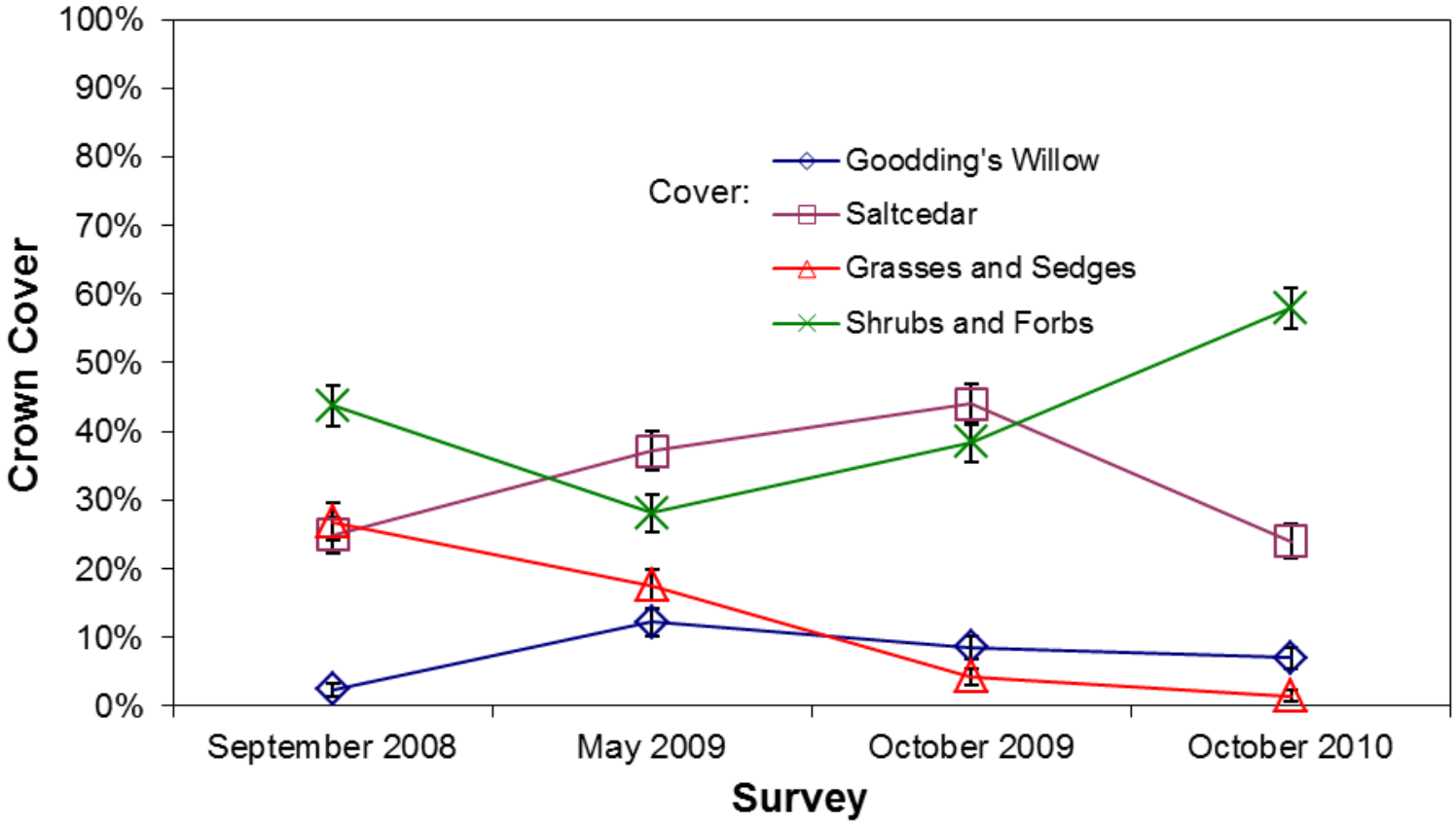
Long-term Vegetation Observations: Crown Cover Over 3 Growing Seasons



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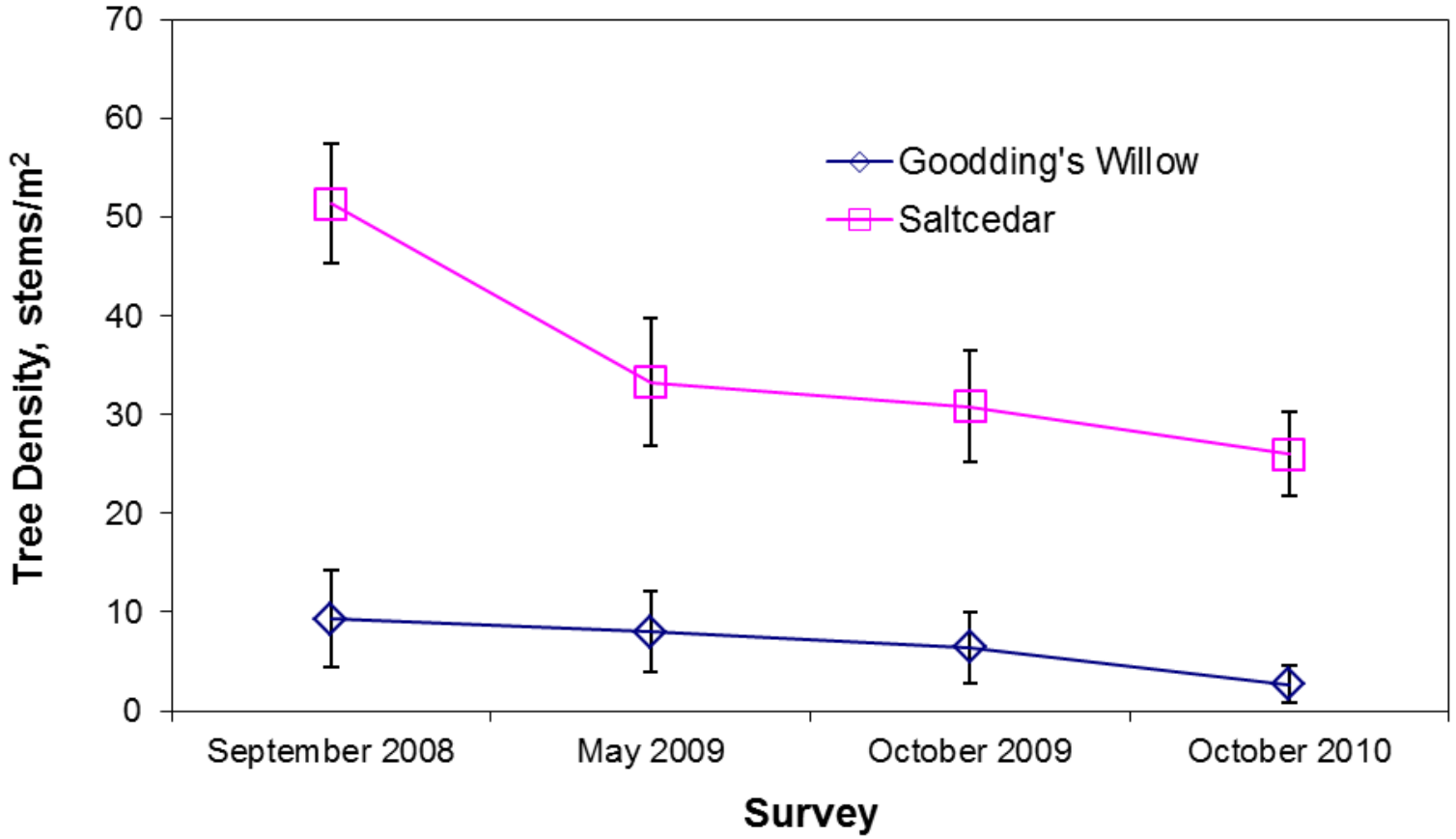
Long-term Vegetation Observations: Tree Density Over 3 Growing Seasons



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2009 Small-scale Field Study Matrix

Seeding Method	Surface Irrigation Method	Seeding Rate (PLS/ft^2 Goodding's Willow)
Hydroseed Un-Cleaned Seed	Furrow	50
		100
		150

- Objective:
  1. Refine establishment estimates and seeding rate effects for hydroseeding onto furrows.

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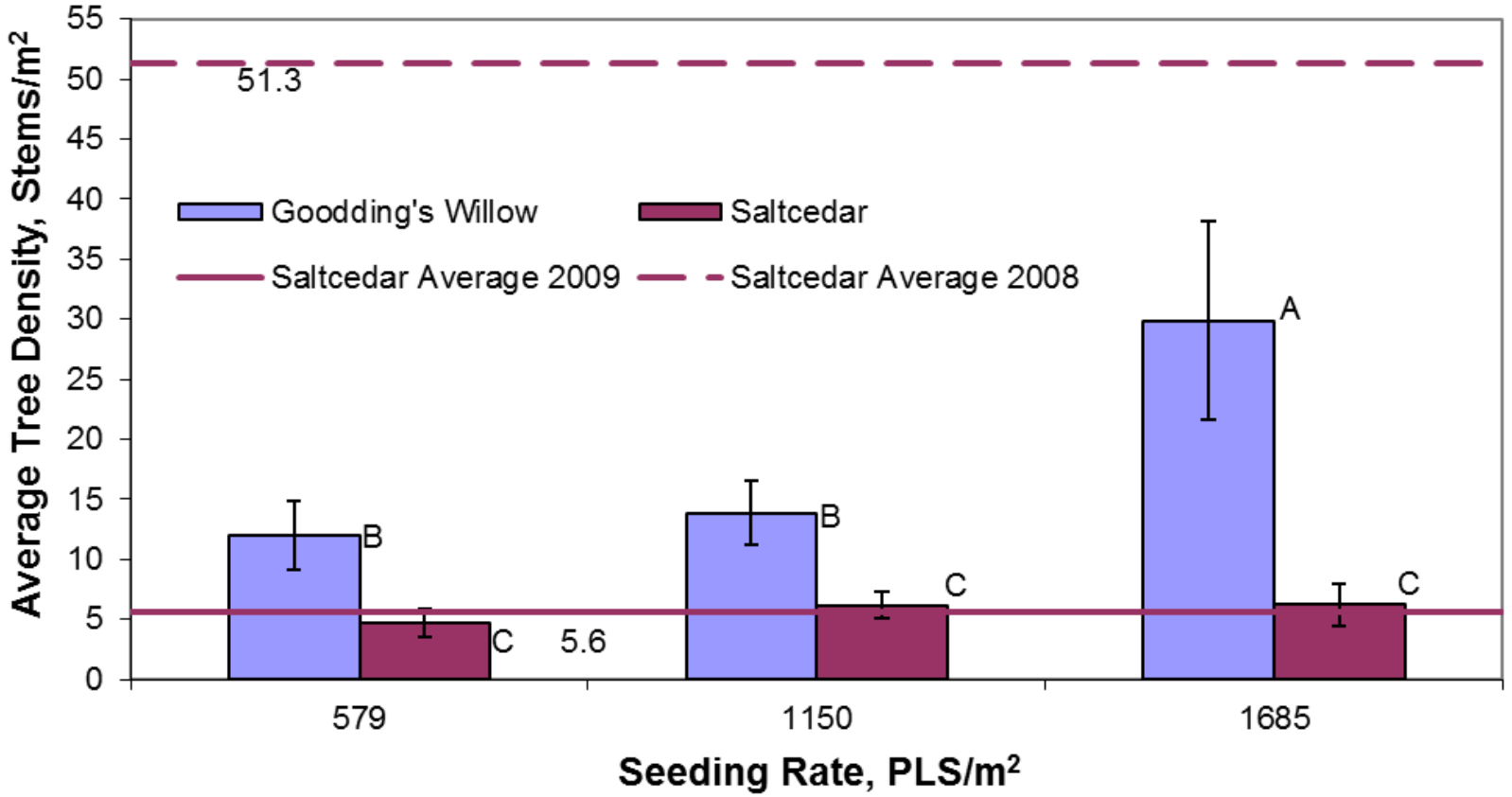
2009 Study Results: *Tree Density after One Growing Season*



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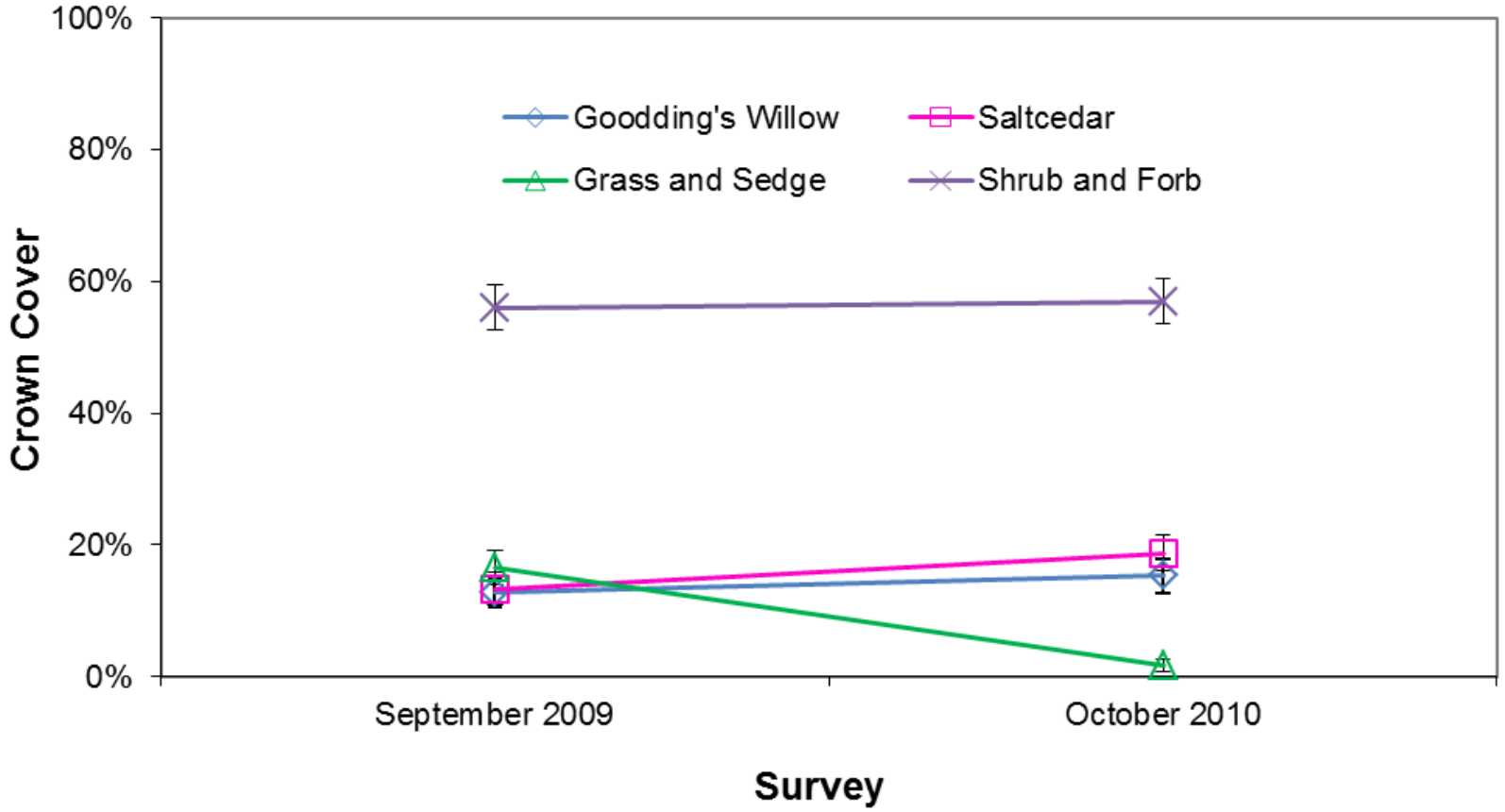
"Long-term" Vegetation Observations: Crown Cover Over 2 Growing Seasons



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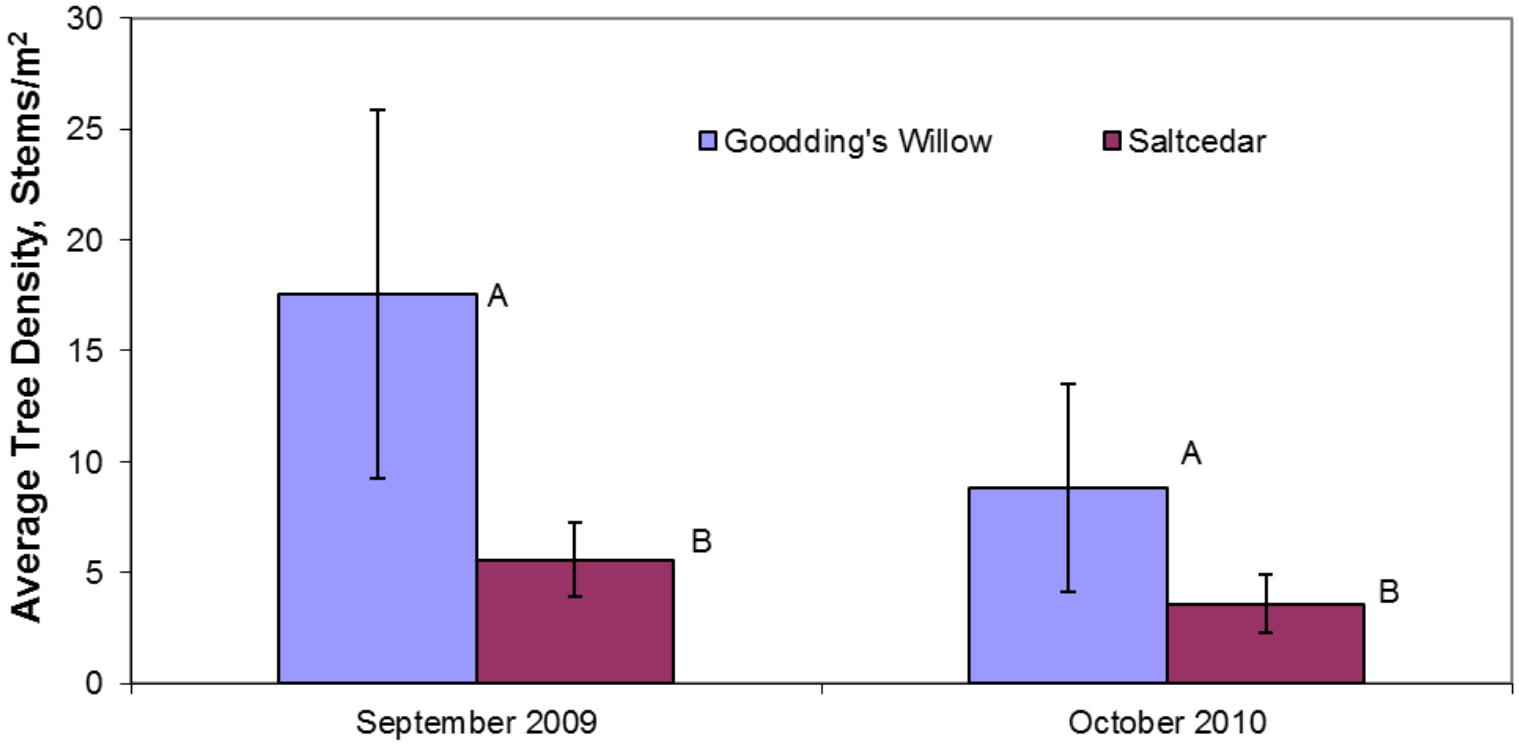
"Long-term" Vegetation Observations: Tree Density Over 2 Growing Seasons



~50% mortality for willow.
~37% for saltcedar.

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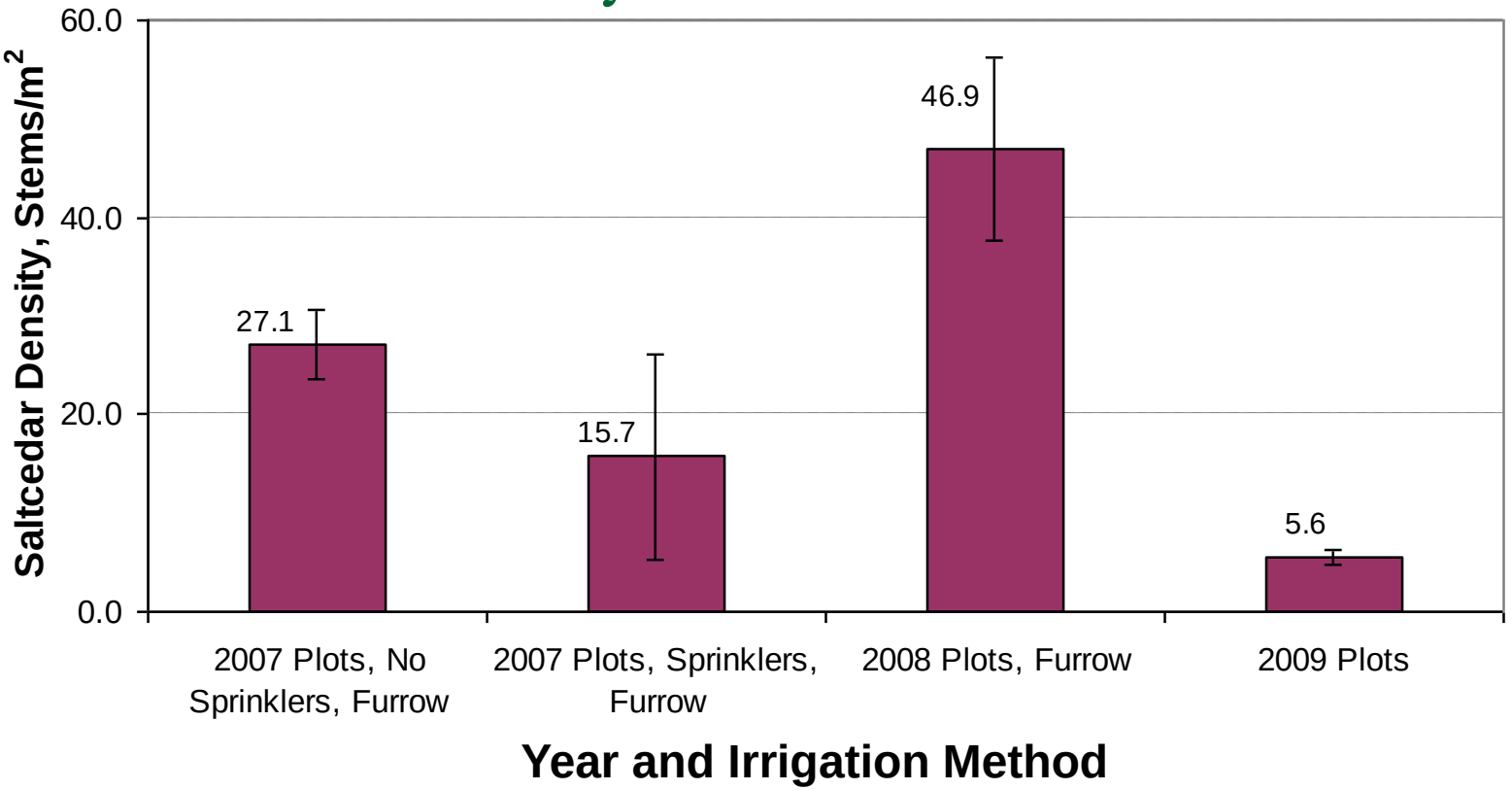
Saltcedar Density vs. Years for Furrows



- Year 1: Poor grass control, high cottonwood density. Filtration for sprinklers.
- Year 2: Excellent grass control, no cottonwood.
- Year 3: Excellent grass control, large-scale clearing of saltcedar in Cibola NWR Farm Unit.

Conclusions: *Phase 3 Small-scale Field Study*

1. Sprinklers are NOT necessary.
2. Cottonwood establishment of over 10% for un-cleaned hydroseed.
3. Goodding's willow establishment expected between 1 and 2%.
   - Note: very high seeding rates are likely economically feasible.
4. Very high grass and saltcedar establishment compared to seeded species (2007 and 2008 plots), reduced saltcedar establishment in 2009 plots.
5. Fremont cottonwood is out-competing saltcedar.
6. Saltcedar at high density is out-competing Goodding's willow.
7. Competition at similar densities is uncertain.

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Study Conclusions and Recommendations

- Seed storage duration is not limiting.
- Soil conditions (salinity, bulk density, texture and fertility) should be analyzed in field restoration sites prior to seeding (go/no-go decision).
- Fremont cottonwood will likely need to be seeded separately from willow species, or within seed mixes at very low rates.
- Volunteer vegetation controls might be needed, and can include:
  - Reduction of the existing seedbank.
  - Application of grass-specific herbicide during the first year.
  - Management of saltcedar seed dispersal near the site.
  - Removal of saltcedar during the first year.

Direct Seeding or Not?

- Benefits:
  - Increase in genetic, sexual, and structural diversity.
  - Decrease of 30% to 50% in costs compared to rooted cuttings—at 10X the tree density (<$0.05 per tree) (GSA 2010).
  - High density establishment possible for cottonwood and willow—just apply the density you require.
- Remaining questions:
  - Can willow seedlings survive long-term?
  - What would scaling effects be?
  - What are the site-specific effects?

Current Efforts

- In conjunction with The Sonoran Institute, a demonstration project is being implemented in Baja California, Mexico.
  - Fremont cottonwood and Goodding's willow seeding on a five-acre site.
- Interest in site-specific effects, particularly for Goodding's willow.
- Nursery production of seedlings?

Acknowledgments

- The Bureau of Reclamation
- Cibola NWR, Bill Williams NWR, Havasu National Wildlife Refuge
- The University of Arizona Office of Arid Land Studies

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Questions?

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