Growth and Survival Responses of Seedlings and Cuttings of Carolina Willow (*Salix caroliniana*) To Nutrients, Soil Types, and Water Availability

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OBJECTIVES

- Understand how environmental conditions control the spread of *Salix caroliniana* along the St. Johns River, FL
- Evaluate effects of water availability, soil texture, and nutrient concentration on growth and early seedling and cuttings survival of *Salix caroliniana*

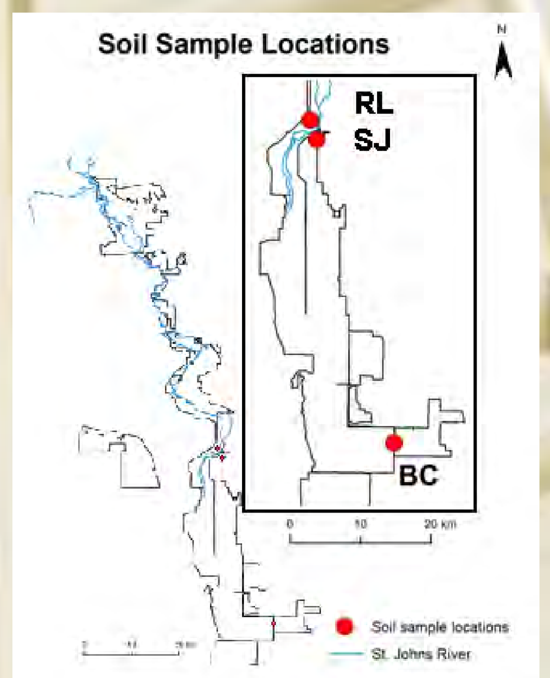
INTRODUCTION

Carolina willow (*Salix caroliniana* Michx.) is a plant native to the southeastern US that has increased along the Upper St. Johns River, Florida. Its expansion transforms herbaceous marshes, wet prairies, sloughs, and shrub swamps to willow swamps.

METHODS

We performed two greenhouse experiments to assess growth and early survival of S. *caroliniana* seedlings and cuttings under different soil types, nutrient levels, and moisture regimes.

Soil types



We collected soil from three sites:

- inorganic soil from St. Johns Marsh Conservation Area (SJ)
- organic soil with high N and P from River Lakes Conservation Area (RL)
- organic soil with lower P levels from Blue Cypress Marsh Conservation Area (BC)

We created six soil treatments using pure soils and 50:50 mixtures of three soil types. The total soils combination resulted in six soil treatments.

Nutrient concentration

We established six nutrient treatments using fertilizers to produce:

1. ambient nutrients (i.e., those in tap water)
2. enhanced NH_4 (ambient + 0.375 mg/l)
3) enhanced PO_4 (ambient + 0.25 mg/l)
4) enhanced NH_4 & PO_4
5) enhanced micronutrients: K = ambient + 8 mg/l , Cu = ambient + 5 µg/l , Mg = ambient + 14 mg/l , Fe = ambient + 600 µg/l, and
6) enhanced NH_4^+, PO_4^- & micronutrients.

Hydrology regime

One Block Experimental Design

Soil Treatment	Nutrient level: ambient	+N	+P	+N +P	+micro	+N + P + micro
Invasion susceptible (S)	Ambient water	Ambient water	Ambient water	Mild drought	Mild drought	Mild drought
Invasion resistant (R)	Ambient water	Ambient water	Ambient water	Mild drought	Mild drought	Mild drought
75% S: 25% R	Standing water	Standing water	Standing water	Episodic flooding	Episodic flooding	Episodic flooding
25% S: 75% R	Standing water	Standing water	Standing water	Episodic flooding	Episodic flooding	Episodic flooding

Replicated four times

Both experiments used a similar randomized complete block design with six different soil types crossed with four levels of moisture, maintained at one of six nutrient levels, and replicated 4-8 times.

The hydrologic regime followed one of four schedules (watered from above every other day with 178mL of tap water):
1) Ambient Rainfall: equivalent to mean central Florida wet season rainfall (76.9 cm).
2) Simulated Drought: one-half mean central Florida wet season rainfall.
3) Constant Inundation: water levels maintained above the soil surface by ~ 1 cm.
4) Fluctuating Water Level: simulated flashy (short-term) changes in hydrology. Weeks 1 & 4 were identical to Ambient Rainfall, and weeks 2 & 3 were the same as Constant Inundation.

Willow cuttings and seedlings in the greenhouse at the beginning of the project.

Willow cuttings and seedlings in the greenhouse three months later.

Effects on Seedlings

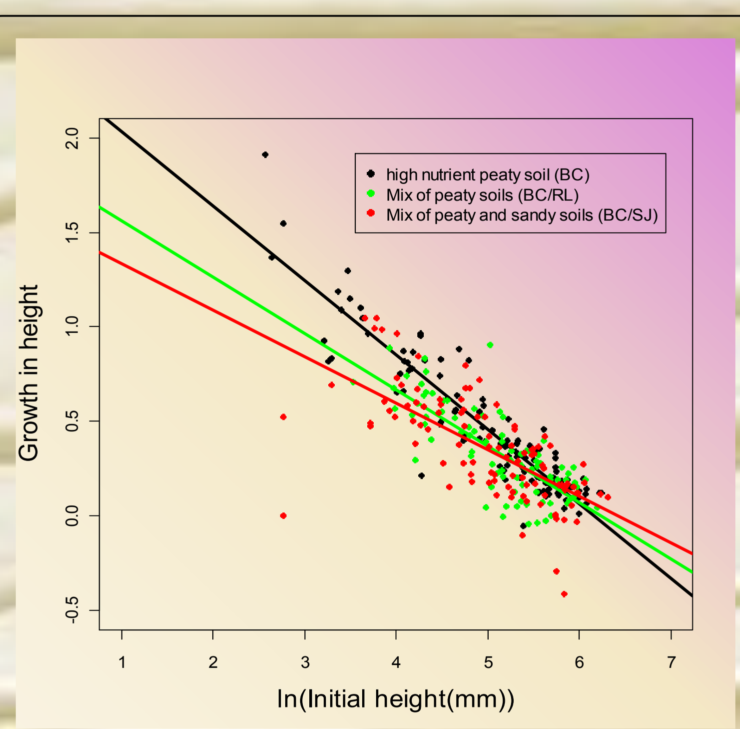


Figure 1. Growth in willow seedling height as a function of the natural logarithm of initial size and soil treatment.

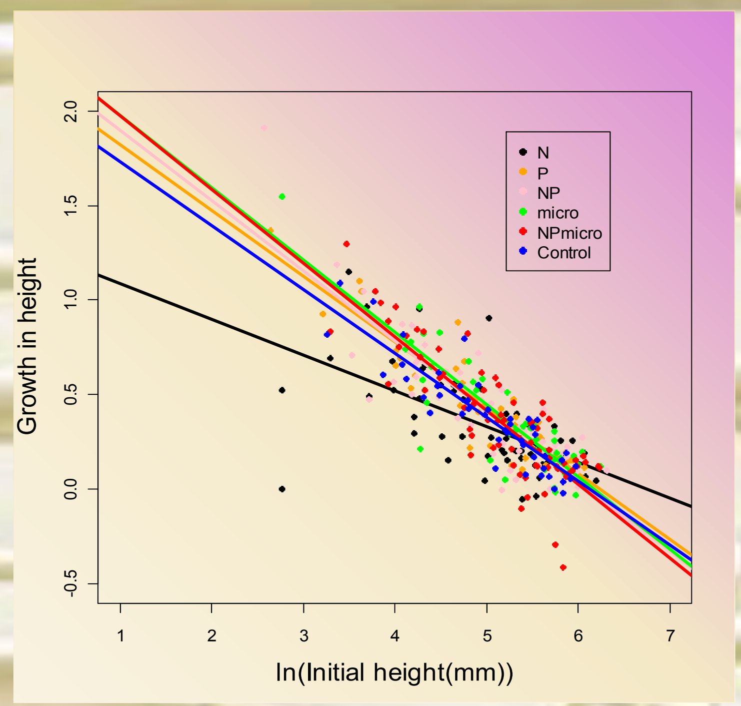


Figure 2. Growth in willow seedling height as a function of the natural logarithm of initial seedling size and nutrient treatments.

Small seedlings grew significantly faster on pure BC soil than on mixtures but the pattern reversed for large seedlings (Figure 1). Seedlings in the nitrogen-addition treatment had less growth than all others, except for the very largest seedlings, where the pattern reversed (Figure 2). No other treatments differed significantly.

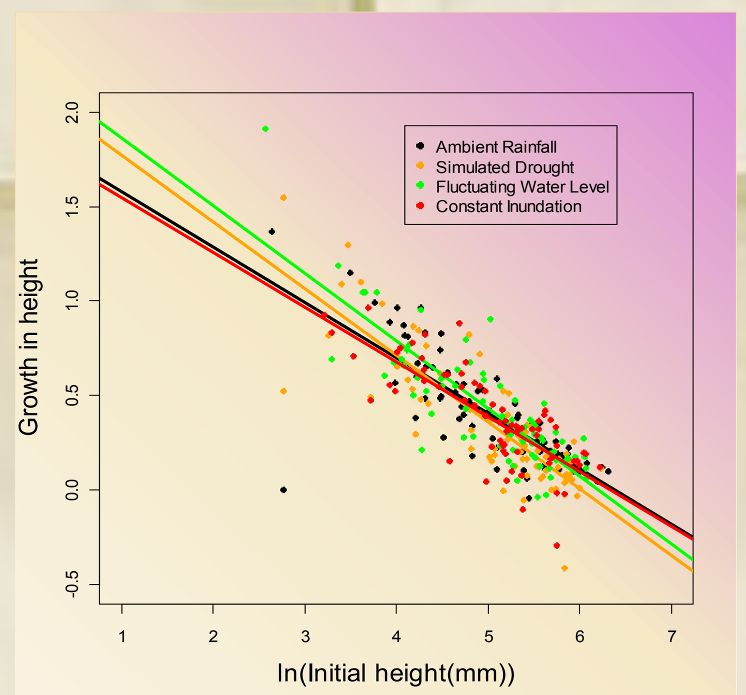


Figure 3. Growth in willow height as a function of initial seedling size and watering treatments

Coefficients	Estimate	Std.Error	t	Pr(>|t|)
(Intercept)	2.381	0.187	12.728	<0.0001
log(initial)	-0.386	0.037	-10.418	**<0.0001**
Soil BCRL	-0.539	0.180	-2.994	**0.003**
Soil BCSJ	-0.678	0.147	-4.605	**<0.0001**
Nutrients N	-0.573	0.225	-2.550	**0.011**
log(initial) x SoilBCRL	0.091	0.035	2.578	**0.010**
log(initial) x SoilBCSJ	0.117	0.029	4.028	**<0.0001**
log(initial) x NutrientsN	0.108	0.045	2.404	**0.017**

Compared to the control, only the simulated drought treatment influenced willow growth in height but this contrast was not statistically significant (Figure 3). Seedlings in the simulated drought treatment grew slowly, if they survived.

Effects on cuttings

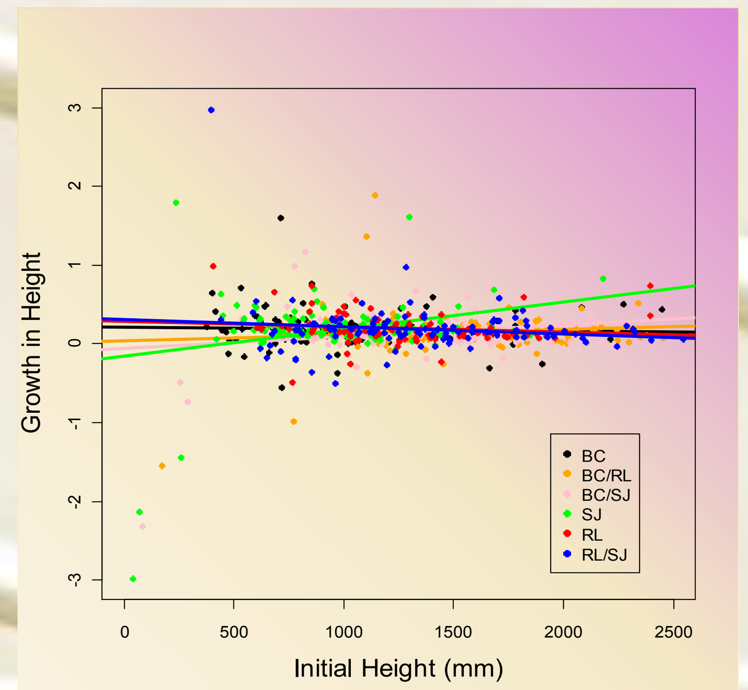


Figure 4. Growth in willow height (= stem length) as a function of initial cutting height and soil treatment.

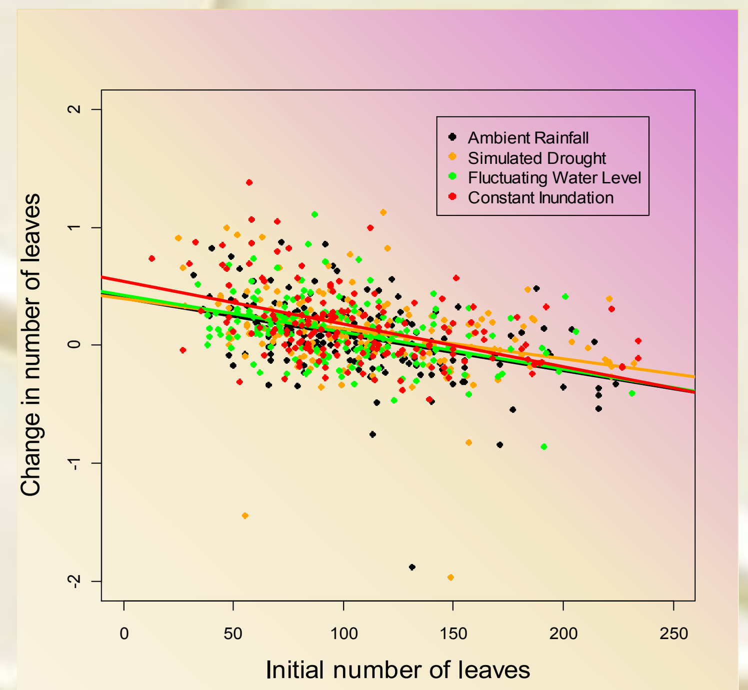


Figure 5. Growth in number of leaves as a function of initial leaf number and watering treatment.

Growth in height (= stem length) varied significantly with the initial diameter x soil interaction. Small cuttings grown in sandy, SJ soils barely increased in height while larger cuttings in the same soil treatment displayed the largest increases in diameter (Figure 4). Growth in leaf number of cuttings tended to be lower in the simulated drought treatment than in the control, but the difference was not statistically significant (Figure 5).

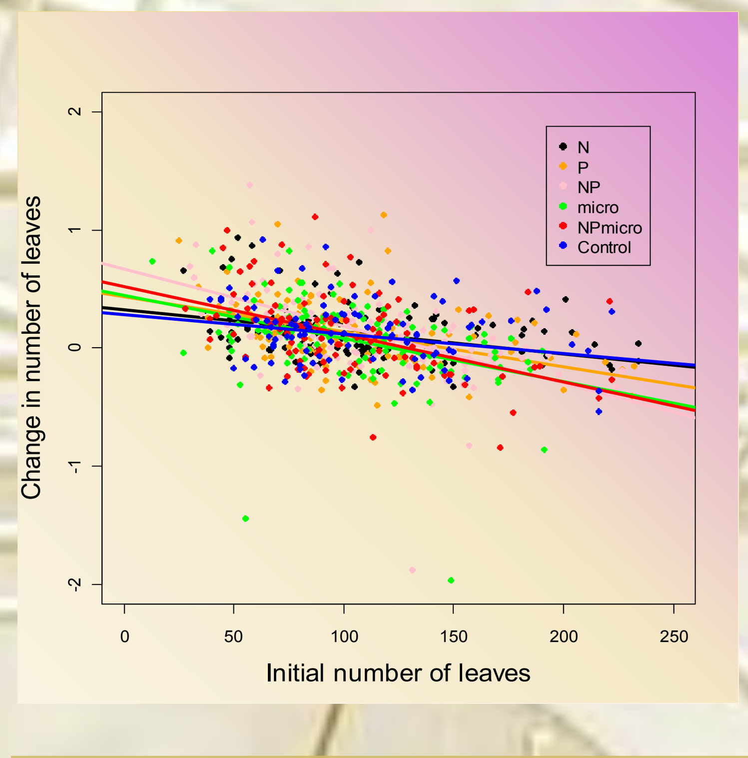


Figure 6. Growth in number of leaves as a function of initial leaf number and nutrient treatments.

Coefficients	Estimate	Std.Error	t	Pr(>|t|)
Intercept	0.2114	0.0832	2.543	**0.01124**
Soil Treatments				
SoilSJ	-0.3667	0.1190	-3.08	**0.00216**
SoilSJBC	-0.2662	0.1300	-2.048	**0.04092**
Interactions				
initial:SoilSJ	0.0004	0.0001	3.304	**0.00101**
initial:SoilSJBC	0.0002	0.0001	1.659	0.09754
initial:SoilSJRL	-0.0001	0.0001	-0.654	0.51344

At small initial sizes, willow cuttings grew the most leaves when fertilized with both nitrogen and phosphorus, NP plus micronutrients, or micronutrients alone; but at large initial sizes the ranking was reversed and cuttings grew the most leaves when supplied with just ambient nutrients(Figure 6).

CONCLUSIONS

- Soil moisture is critical for survival of Carolina willow seedlings and cuttings
- Organic soil with lower phosphorus concentration promoted survival and growth of *S. caroliniana* seedlings.
- Soil type determines growth of *S. caroliniana* cuttings, with greater growth on peaty soils.
- Seedling success of Carolina willow was not influenced by nutrient addition.
- This information is useful to manage Carolina willow and prevent it from spreading within the St. Johns River floodplain.

ACKNOWLEDGMENTS

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