ECOLOGICAL STUDIES OF WILLOW (*SALIX CAROLINIANA*): MONTHLY STATUS REPORT #10

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Ecological Studies of Willow (*Salix caroliniana*): Monthly Status Report #9
Covering the time period from November 1-31, 2009

This status report summarizes progress made on the Ecological Studies of Willow project through November 31, 2009, with reference to the tasks and timeline outlined in the Scope of Work and presented in Table 1 below.

Table 1. Timeline of tasks to be accomplished in Years 1 & 2. Tasks initiated and underway in this reporting month are highlighted in blue, completed tasks in red.

YEAR 1

Quarter	**Months**	**Tasks accomplished**
1st	Dec 2008	Initiate and complete Task 1 (*Finalize research plan*)
2nd	Jan – Mar, 2009	Initiate Task 2.1 (*Germination experiment*) Initiate Task 2.4 (*Life history*)
3rd	Apr – Jun, 2009	Continue Task 2.1 (*Germination experiment*) Initiate Task 2.2 (*Willow transplantation*) Continue Task 2.4 (*Life history*) Initiate Task 2.5 (*Spatial analysis of willow distribution*)
4th	Jul – Sep, 2009	Continue Task 2.4 (*Life history*) Complete Tasks 2.1 & 2.2 (*Germination experiment* & *Willow transplantation*) Complete Task 3.1 (*Data analysis and final report, Year 1*) Continue Task 2.5 (*Spatial analysis of willow distribution*)

YEAR 2

Quarter	**Months**	**Tasks accomplished**
1st	Oct – Dec, 2009	Initiate Task 2.3 (*Fire response*) Continue Task 2.4 (*Life history*) Continue Task 2.5 (*Spatial analysis of willow distribution*)
2nd	Jan – Mar, 2010	Continue Task 2.3 (*Fire response*) Continue Task 2.4 (*Life history*) Continue Task 2.5 (*Spatial analysis of willow distribution*)
3rd	Apr – Jun, 2010	Initiate Task 2.2 (2nd iteration, *Willow transplantation*) Continue Task 2.3 (*Fire response*) Continue Task 2.4 (*Life history*) Continue Task 2.5 (*Spatial analysis of willow distribution*)
4th	Jul – Sep, 2010	Complete Task 2.2 (2nd iteration, *Willow transplantation*) Continue Task 2.3 (*Fire response*) Continue Task 2.4 (*Life history*) Continue Task 2.5 (*Spatial analysis of willow distribution*) Complete Task 3.2 (*Data analysis and final report, Year 2*)

Progress on Task 2.1 – Germination and Early Survival and Growth Experiments

The UCF team presented its analysis of the greenhouse experiments on willow seedlings in the last report. Below, we present our initial analyses of the cutting data.

High survival of willow cuttings allowed us to analyze data on stem diameter and stem length variation using the original design (Table 2).

Table 2. Number of individuals per treatment combination that survived the whole experiment. Soil types are Blue Cypress (BC), River Lakes (RL), St. Johns (SJ) and their 50:50 mixtures. Each plant was subjected for a month to four watering regimes (ambient water, mild drought, standing water and episodic flooding) in random order.

Nutrients	Soil type					
	BC	BC/RL	BC/SJ	RL	SJ	RL/SJ
Control	4	3	5	4	4	4
micronutrients	5	5	4	4	4	5
N	5	5	4	5	4	5
N P	5	5	5	3	6	4
N P micronutrients	4	5	5	3	5	5
P	5	5	4	4	6	4

We analyzed variation in growth of both stem diameter and stem length:

$$growth = \log\left(\frac{final\_measurement}{initial\_measurement}\right)$$

We attempted to control for non-treatment variation using willow size at the beginning of each interval as a covariate. This allometric function accounted for significant variation in stem diameter but not in stem length (Fig 1, Tables 3-4). Willows with a smaller diameter grew more than those with larger initial diameters.

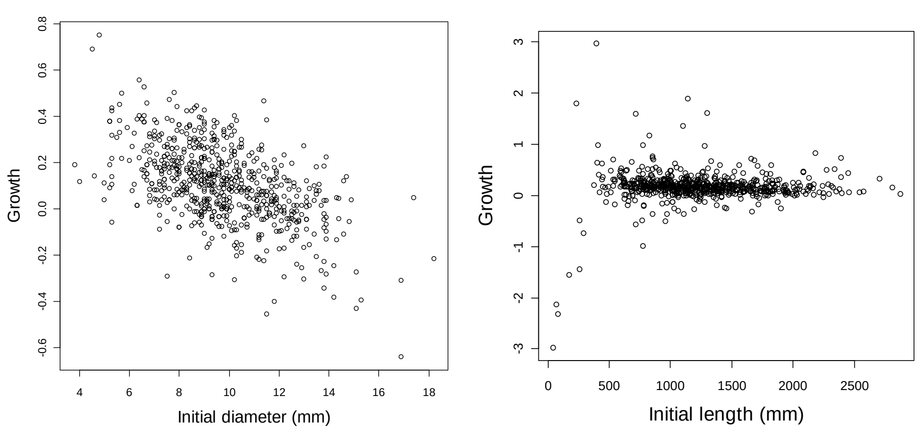

Fig. 1. Allometric relationship between initial size and growth in (LEFT) stem diameter and (RIGHT) stem length of willow cuttings. Notice the lack of relationship for stem length.

Table 3. Analysis of covariance of growth in cutting stem diameter as a function of soil, nutrients and watering regime. Initial diameter was used as a covariate (r^2=0.338). Table entries are sources of variation, degrees of freedom (df), sums of squares (SS), mean squares (MS), F-ratios (F) and their associated probabilities (P).

Response:	Stem diameter				
Source of variation	df	SS	MS	F	P
Initial	1	5.114	5.114	268.263	**<2e-16**
Soil	5	0.365	0.073	3.825	**0.00202**
Nutrients	5	0.119	0.024	1.245	0.28655
Watering regime	3	0.058	0.019	1.006	0.38980
Initial x Soil	5	0.464	0.093	4.870	**0.00022**
Residuals	628	11.972	0.019		

Table 4. Analysis of covariance of growth in stem length as a function of soil, nutrients and watering regime. Initial length was used as covariate (r^2=0.042, P=0.003). Table entries are sources of variation, degrees of freedom (df), sums of squares (SS), mean squares (MS), F-ratios (F) and their associated probabilities (P).

Response:	Stem length growth				
	df	SS	MS	F	P
Initial	1	0.164	0.164	1.5687	0.21086
Soil	5	0.434	0.087	0.8302	0.52842
Nutrients	5	1.016	0.203	1.9444	0.08513
Watering regime	3	0.329	0.110	1.0489	0.37036
Initial x Soil	5	2.19	0.438	4.1926	**0.00093**
Residuals	628	65.613	0.104		

The most informative models for growth in stem diameter and height included the main effect of soil type and its interaction with the covariable, initial diameter (Tables 5, 6). Residuals of both models were random, normal and independent (Fig. 2), indicating that the models were appropriate.

Willow cuttings grew significantly larger in diameter on RL soils compared to BC soil, regardless of watering or nutrient treatments (Table 7). Cuttings elongated significantly less on SJ compared to 100% BC soil, regardless of watering or nutrient treatments (Table 8). These results contrast sharply with those of willow seedlings, which did not survive well on non-BC soils and responded strongly to watering treatments and slightly (and negatively) to nitrogen addition.

We found no detectable effect of nutrient levels or watering regime on stem growth of cuttings. The high statistical power of this experiment makes it unlikely that this occurred due to a Type II error: failure to reject the null hypothesis when it is false. The low F-ratios for these treatments indicate that they explained little variation in willow responses. We observed similar effects in the willow island experiment; seedlings are more sensitive than cuttings to elevation above the marsh, and cuttings grow regardless of whether they are mostly submerged or high and dry. Cutting are simply much more resilient than seedlings.

Table 5. Akaike Information Criterion (AIC) and AIC weights for models of growth in stem diameter.

	All data	Crown (all data)		
	Model	df	AIC	Akaike weight
4	init + S + init:S	13	-711.093	0.86141
1	init + S + N + W + init:S + init:N	26	-706.493	0.08636
2	init + S + N + W + init:S	21	-705.444	0.05111
6	init + S	8	-697.682	0.00105
3	init + S + N + W	16	-690.796	0.00003
9	Init	3	-689.213	0.00002
5	init + N + init:N	13	-684.478	0.00000
8	init + W	6	-686.219	0.00000
7	init + N	8	-685.090	0.00000

Table 6. Akaike Information Criterion (AIC) and AIC weights for models of growth in stem height.

	Models for length growth	df	AIC	Akaike weight
3	Init + S + init:S	13	392.3077	0.87977
1	Init + S + N + W + init:S	21	396.9502	0.08635
6	Init	3	399.0027	0.03094
2	Init + S + N + W	16	408.2274	0.00031
4	Init + S	8	404.9511	0.00158
5	S	7	405.7751	0.00107

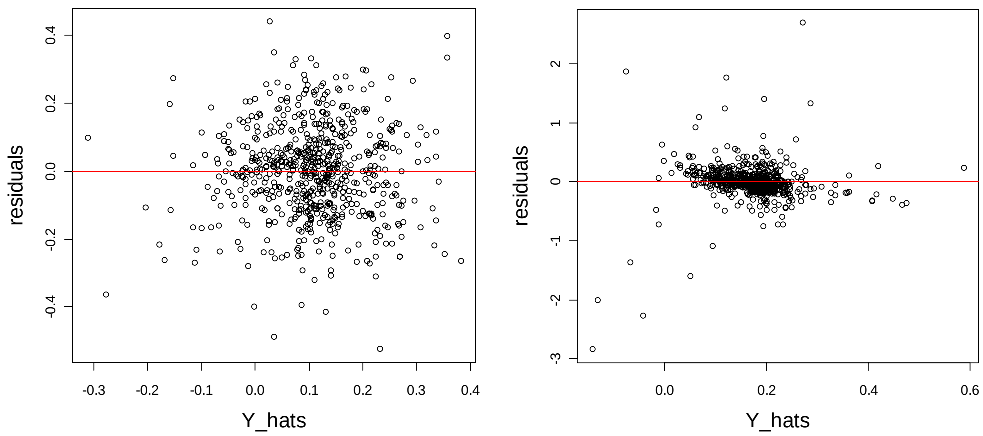

Fig. 2. Distribution of residuals for the best models. (LEFT) stem diameter growth model # 4; (RIGHT) stem length growth model # 3.

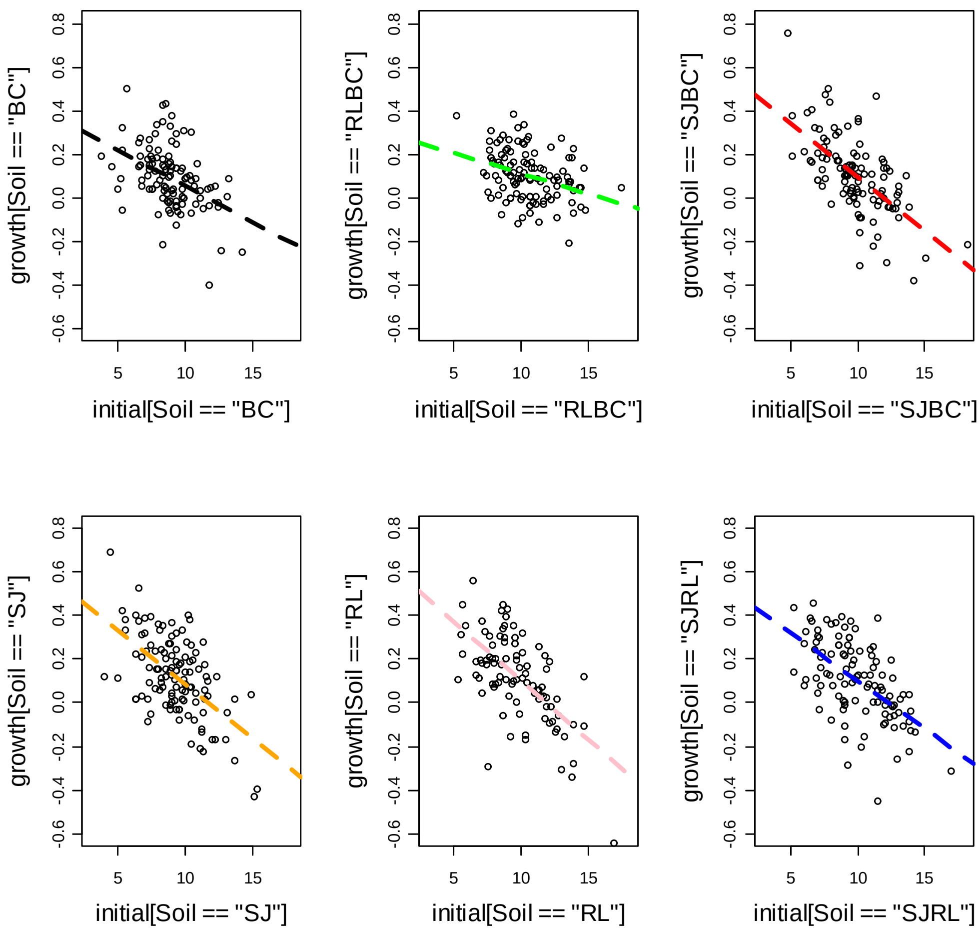

Fig. 3. Growth in stem diameter by soil. Notice lower growth of willows in BC compared to SJ soil.

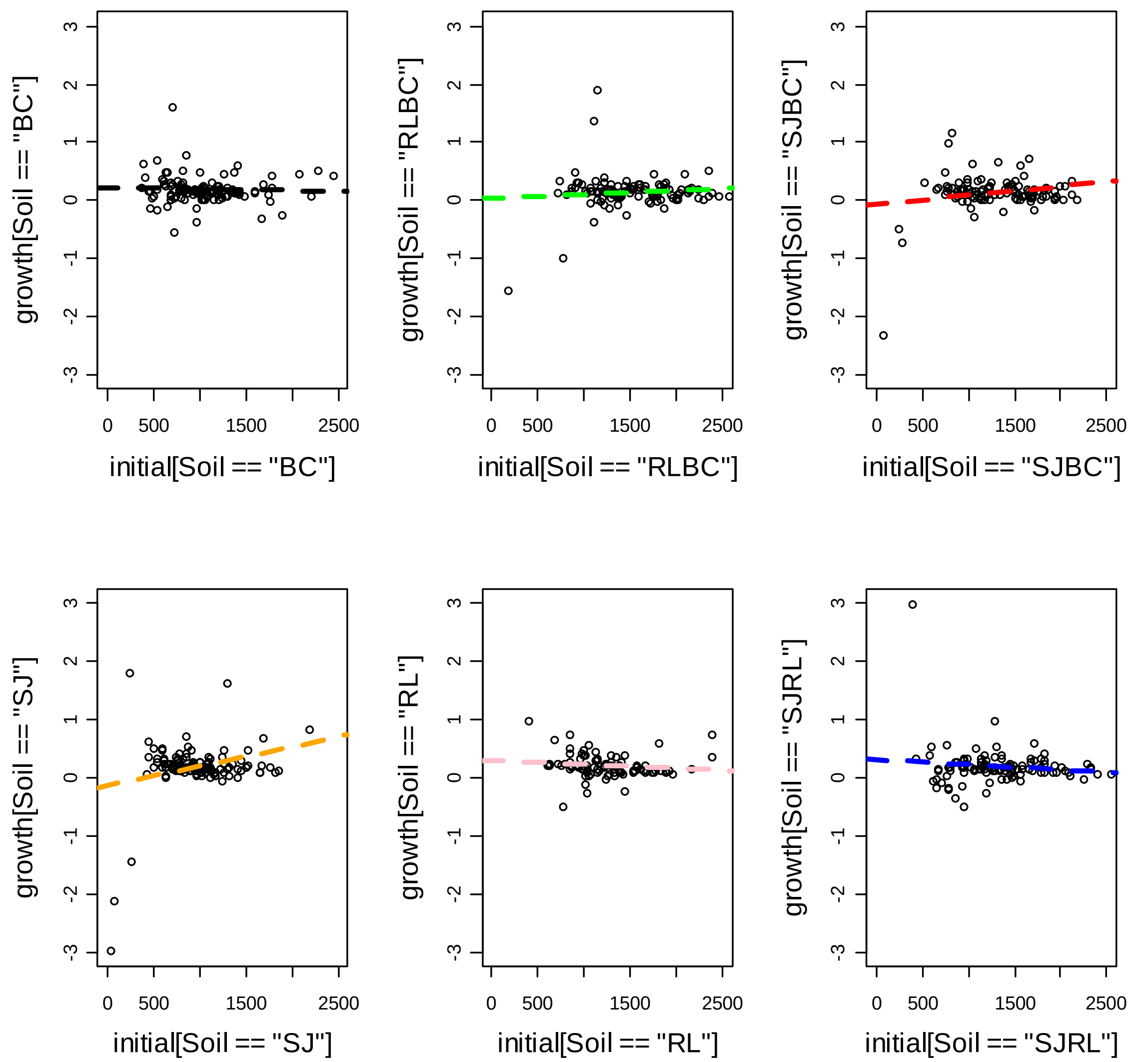

Fig. 4. Growth in stem length by soil treatment. Notice the leverage of small plants in the sandy soils (SJ), which explained the significant interaction.

Table 7. Simple contrasts among treatment levels for growth in diameter. The reference treatment (BC soil) does not appear in the list. Significant contrasts in bold. Because contrasts were not independent we used Bonferroni $(\alpha' = \alpha / k)$ to obtain an experimentwise error rate 0.01 for soil treatments.

Coefficients:				
	Estimate	Std.Error	t	Pr(>|t|)
(Intercept)	0.388381	0.06263	6.201	**1.01E-09**
initial	-0.03306	0.006907	-4.787	**2.11E-06**
SoilRL	0.251601	0.087987	2.86	**0.0044**
SoilRLBC	-0.08708	0.091406	-0.953	0.3411
SoilSJ	0.192937	0.085274	2.263	0.0240
SoilSJBC	0.207531	0.086585	2.397	0.0168
SoilSJRL	0.152724	0.085184	1.793	0.0735
initial:SoilRL	-0.02124	0.009272	-2.291	0.0223
initial:SoilRLBC	0.014414	0.009269	1.555	0.1204
initial:SoilSJ	-0.01661	0.009192	-1.806	0.0713
initial:SoilSJBC	-0.01681	0.009099	-1.848	0.0651
initial:SoilSJRL	-0.01098	0.008924	-1.231	0.2189

Table 8. Simple contrasts among treatment levels for growth in stem length. The reference treatment (BC soil) does not appear in the list. Significant contrasts in bold. Because contrasts were not independent we used Bonferroni $(\alpha' = \alpha / k)$ to obtain an experimentwise error rate 0.01 for soil treatments.

Coefficients:				
	Estimate	Std.Error	t	Pr(>|t|)
Intercept	0.2114	0.0832	2.543	0.01124
initial	0.0000	0.0001	-0.32	0.74932
SoilRL	0.0732	0.1315	0.556	0.57822
SoilRLBC	-0.1729	0.1364	-1.268	0.20523
SoilSJ	-0.3667	0.1190	-3.08	**0.00216**
SoilSJBC	-0.2662	0.1300	-2.048	0.04092
SoilSJRL	0.0947	0.1242	0.762	0.44621
initial:SoilRL	0.0000	0.0001	-0.419	0.67555
initial:SoilRLBC	0.0001	0.0001	0.951	0.34215
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

Progress on Task 2.2 – Willow Transplantation

A. Competition Experiment – We are scheduled to monitor this experiment every six weeks and this reporting interval did not fell within that period. The next scheduled monitoring of this experiment is on December 16, 2009.

B. Hydrology Experiment – We are scheduled to monitor this experiment every six weeks and this reporting interval did not fell within that period. The next scheduled monitoring of this experiment is on December 16, 2009.

Initiate Task 2.3 - Fire response

We are finalizing our sampling strategy for this task and will submit a proposed experimental design to the District by December 21, 2009.

Progress on Task 2.4 - Life History

We modified our approach to use a deterministic sampling scheme that incorporates information on soil types, vegetation assemblage, and human influences (e.g., proximity to roads and levees vs. open marsh). We will submit a proposed experimental design to the District by December 21, 2009.

Progress on Task 2.5 – Spatial Analysis of Willow Distribution.

We did not modify our existing spatial model during this period.

Summary of Activity

During this reporting period, the UCF team completed analyses of the greenhouse cutting experiment, considered alternative designs for fire experiment and demographic (life history) sampling, and discussed additional experiments for the upcoming growing season.