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Interaction of Soil Moisture and Seedling Shelters on Water Relations of Baldcypress Seedlings

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INTERACTION OF SOIL MOISTURE AND SEEDLING SHELTERS ON WATER RELATIONS OF BALDCYPRESS SEEDLINGS[1]

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ABSTRACT—Stomatal conductance, transpiration, and leaf water potential were measured during the 1996 growing season on baldcypress (*Taxodium distichum* (L.) Rich.) seedlings. Seedlings were hand-planted from 1-0 bareroot stock in mesic and permanently flooded soil conditions. One-half of all seedlings were fitted with 122-cm tall polyethylene tree shelters. Seedlings were planted 1 year before the initiation of plant water relation measurements. The study was located within the boundary of the Longhorn Army Ammunition Plant, Karnack, TX. The objective of the research was to study the feasibility of artificially regenerating baldcypress along the shores of Caddo Lake. Stomatal conductance and transpiration were consistently higher in seedlings planted in mesic soils versus seedlings planted in permanently flooded soils. Seedlings fitted with shelters regularly had higher stomatal conductance and transpiration then seedlings without shelters. Leaf water potential showed little consistency among treatments.

INTRODUCTION

Caddo Lake is an area of unique ecological importance. It is the largest natural fresh water lake in Texas with parts extending into Louisiana. Caddo Lake is divided into many smaller lakes of varying size, shape and depths separated by tree breaks and islands (Dahmer 1995). While Caddo Lake was originally formed through natural processes, a dam constructed in 1971, which replaced an original dam constructed in 1914 (Klimas 1987), now maintains the lake levels. An impressive aspect of the area is the dense stands of baldcypress (*Taxodium distichum* (L.) Rich) trees that inhabit Caddo Lake.

In the past 90 years, there has been very little recruitment of baldcypress seedlings at Caddo Lake. Baldcypress growth is below average on all but the highest annually exposed sites (Klimas 1987). Any number of factors may be responsible for the lack of baldcypress regeneration including high, stable water levels. Newly germinated seedlings can be killed by submergence in as little as 2 or 3 days (Williston and others 1980). Extended dry periods are required for seed germination and to allow the seedlings to grow tall enough to survive future flooding events (Conner and others 1986).

Herbivory may be another factor involved with the lack of baldcypress regeneration. Nutria (*Myocastor coypus*) has thwarted many efforts in artificial regeneration of baldcypress seedlings. This rodent species, introduced to Louisiana from South America in the 1930's, clips young seedlings near the root collar and eats the succulent bark (Conner and others 1986).

In natural habitats such as ponds, streams, and lakes, removal of these herbivores would be impractical. Seedling survival might be greatly increased, however, through the use of protective tree shelters. These protective shelters have also been shown to accelerate the initial height growth of seedlings (Windell and Haywood 1995).

Forested wetlands, such as Caddo Lake, perform important functions by acting as filters to help purify water and provide essential habitat for flora and fauna (Wilen and Frayer 1990). Baldcypress also acts as an important food and habitat species for many different types of wildlife. Seeds are eaten by wild turkey (*Meleagris gallopavo*), squirrels (*Sciurus* sp.), and wood ducks (*Aix sponsa*). Baldcypress foliage provides nesting habitat for bald eagles (*Haliaeetus leucocephalus*), osprey (*Pandion haliaetus*), and other top nesting birds. Catfish (*Ictalurus* sp.) use the buttress hollows for spawning (Wilhite and Toliver 1991).

OBJECTIVES

Research objectives of this proposal are: (1) to study the transpiration, stomatal conductance, and leaf water potential of baldcypress seedlings planted along different flood gradients; and (2) to study effects of protective tree shelters on transpiration, stomatal conductance, and leaf water potential of baldcypress seedlings.

METHODS

Planting

The study was located at a pond within the boundary of Longhorn Army Ammunition Plant (LHAAP) near Karnack, TX. On March 15, 1995, 231 1-0 bareroot seedlings were hand planted by the National Biological Service in mesic soils at 1 m by 1 m spacing. These seedlings were arranged such that every other seedling was fitted with a 122-cm tall, white polyethylene protective tree shelter. On the same date, 208 1-0 bareroot seedlings were hand planted at 1 m by 1 m spacing in flooding levels ranging from 0.14 m to 0.40 m in depth. These seedlings were also arranged such that every other seedling was fitted with the polyethylene tree shelter.

Water Relations

Stomatal conductance and transpiration measurements were obtained using a LI-COR 1600 Steady State Porometer (LI-COR, Inc., 4421 Superior Street, PO Box 4425, Lincoln,

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NE., 68504, USA). Measurements were performed by randomly selecting three or four seedlings from each treatment combination. The number of seedlings measured was dictated by weather for the in-situ conditions. Measurements were physically performed by rotating through each treatment combination four times within the hour using different randomly selected seedlings. Different seedlings were utilized to prevent defoliation of young seedlings and artificially changing water relations within the seedling. The upper most mature leaf in full sunlight was selected.

Following stomatal conductance and transpiration measurements, the leaf was removed from the seedling, cataloged, and kept in cool storage. Exact leaf area measured in the chamber of the porometer was determined by processing each leaf through a LI-COR 3000A leaf area meter. This area was utilized to obtain corrected stomatal conductance and transpiration data.

Leaf water potential was determined by standard pressure chamber techniques (Scholander and others 1965) using a PMS pressure chamber (PMS Instruments, Corvallis, OR 97333). From each seedling, another mature sun leaf was removed using a razor blade to make a clean sharp cut.

Measurements of stomatal conductance and transpiration were conducted for a 2-day period in June 1996, a 2-day period in July 1996, a 3-day period in August 1996 and 1-day in September of 1996. Leaf water potential readings were taken for the same 2-day period in June 1996, August 1996, and the 1-day reading in September 1996. Stomatal conductance and transpiration measurements were taken at midmorning, mid-day, and mid-afternoon time periods. Leaf water potential readings were taken at these same time periods but also included a predawn reading.

Analysis

Analysis of variance for a randomized complete block (RCB) design (SAS 1996) was used to test for any statistical differences in seedling water relations caused by the four treatment combinations. Significant differences between treatments are discussed at the 5 percent probability level. For each measurement period, the analysis used days as replications (blocks) with flooding and shelters as main effect. The dependent variables were transpiration, stomatal conductance, and leaf water potential.

RESULTS AND DISCUSSION

Plant Water Relations

In June 1996, stomatal conductance and transpiration were not significantly different within the flooding or shelter treatments at any of the three daily time periods. Also there was no significance among treatment interaction (table 1). Leaf water potential displayed no significant differences for this same period (table 2).

In July, transpiration was significant (P> 0.0491) (table 3) during the AM readings for the seedlings planted on mesic soils. Seedlings on mesic soils were 3.30 mmols per m^2 per s compared to the flooded seedlings at 1.71 mmols per m^2 per s. There was no significance among treatment interaction for the month of July. For all treatments, observable patterns do seem to exist. In the flood treatment, seedlings planted in mesic soils recorded higher readings for all time periods of the month over the seedlings planted in permanently flooded conditions. Sheltered seedlings recorded higher readings over the nonsheltered seedlings except for the AM stomatal conductance in which both readings were similar. Mesic sheltered seedlings consistently recorded higher readings than all other treatment combinations. Only the AM stomatal conductance failed to follow the trend but was only 0.3 mmols per m^2 per s from having the highest reading.

Table 1—Mean stomatal conductance (g, mmol per m^2 per s) and mean transpiration (*E*, mmol per m^2 per s) of 1-year-old bare-root baldcypress (*Taxodium distichum* L.) seedlings planted March 15, 1995, near Caddo Lake on Longhorn Army Ammunition Plant at Karnack, TX. Measurements were taken June 4-5, 1996, using a Li-Cor 1600 Steady State Porometer

Treatment	AM *g*	Midday *g*	PM *g*	AM *E*	Midday *E*	PM *E*
Flooding						
Mesic	41.72	63.09	51.07	0.72	2.18	1.77
Flood	51.53	55.95	40.26	1.02	2.03	1.43
P>F	.5864	.5600	.5244	.3524	.7322	.5424
Shelters						
No shelters	55.51	53.95	44.71	1.04	1.90	1.57
Sheltered	37.75	65.09	46.61	.70	2.30	1.63
P>F	.3518	.3826	.9076	.2956	.3774	.9035
Flood X shelter						
Flood-no shelter	74.75	56.52	42.38	1.44	1.97	1.48
Flood-sheltered	28.34	55.34	38.14	.60	2.08	1.51
Mesic-no shelter	36.28	51.33	47.05	.65	1.83	1.52
Mesic-sheltered	47.16	78.84	55.08	.80	2.52	1.42
P>F	.1744	.3398	.7107	.1672	.5126	.7710

Table 2—Mean leaf water potential (M Pa, Mega Pascals) of 1-year-old bare-root baldcypress (*Taxodium distichum* L.) seedlings planted March 15, 1995, near Caddo Lake on Longhorn Army Ammunition Plant at Karnack, TX. Measurements were taken June 4-5, 1996 using a PMS Pressure Bomb

Treatment	Predawn	A.M.	Midday	P.M.
	Mega Pascals			
Flooding				
Mesic	-0.20	-1.14	-1.45	-1.47
Flood	- .22	- .95	-1.41	-1.44
P>F	.3390	.3505	.8064	.6652
Shelters				
No shelters	- .19	-1.12	-1.51	-1.44
Sheltered	- .23	- .97	-1.35	-1.46
P>F	.0880	.2580	.3302	.7552
Flood X shelter				
Flood-no shelter	- .21	-1.16	-1.46	-1.37
Flood-sheltered	- .23	- .74	-1.37	-1.51
Mesic-no shelter	- .16	-1.09	-1.57	-1.52
Mesic-sheltered	- .24	-1.19	-1.33	-1.42
P>F	.1873	.1088	.6481	.1419

Table 3—Mean stomatal conductance (g, mmol per m^2 per s) and mean transpiration (*E*, mmol per m^2 per s) of one-year-old bareroot baldcypress (*Taxodium distichum* L.) seedlings planted March 15, 1995, near Caddo Lake on Longhorn Army Ammunition Plant at Karnack, TX. Measurements were taken July 11-12, 1996 using a Li-Cor 1600 Steady State Porometer

Treatment	AM *g*	Midday *g*	PM *g*	AM *E*	Midday *E*	PM *E*
Flooding						
Mesic	514.14	545.47	234.80	3.30	3.75	4.17
Flood	202.66	375.21	40.60	1.71	3.03	1.48
P>F	.0505	.1410	.9720	.0491	.3054	.9302
Shelters						
No shelters	368.19	350.02	88.30	2.48	2.53	2.09
Sheltered	348.60	570.65	251.90	2.54	4.24	4.45
P>F	.8547	.0821	.5225	.9132	.0606	.4569
Flood X shelter						
Flood-no shelter	222.10	342.12	24.57	1.83	2.26	.93
Flood-sheltered	183.21	408.29	56.59	1.90	3.80	2.03
Mesic-no shelter	514.28	357.92	120.13	3.12	2.81	2.67
Mesic-sheltered	513.99	733.02	349.53	3.48	4.69	5.67
P>F	.8568	.1691	.6898	.6012	.7870	.7404

No significant differences were found in the month of August for stomatal conductance or transpiration for either of the two treatments or for treatment interaction (table 4). Definite trends continue to exist with the mesic seedlings and sheltered seedlings exhibiting the highest water relation readings throughout all three time periods for this month. Trends for interaction carry over this month with mesic, sheltered seedlings indicating the highest readings through all time periods. A significant difference for leaf water potential for the afternoon flooding treatment did exist (P> 0.02), with the mesic seedlings having an average leaf water potential of -1.48 M Pa and flooded seedlings one of -1.29 M Pa (table 5).

Table 4—Mean stomatal conductance (g, mmol per m^2 per s) and mean transpiration (*E*, mmol per m^2 per s) of 1-year-old bare-root baldcypress (*Taxodium distichum* L.) seedlings planted March 15, 1995, near Caddo Lake on Longhorn Army Ammunition Plant at Karnack, TX. Measurements were taken August 13-15, 1996, using a Li-Cor 1600 Steady State Porometer

Treatment	AM *g*	Midday *g*	PM *g*	AM *e*	Midday *E*	PM *E*
Flooding						
Mesic	343.04	243.88	229.54	3.40	5.47	4.22
Flood	261.38	186.59	161.82	2.74	4.72	3.71
P>F	.3289	.2106	.1213	.2418	.4268	.4896
Shelters						
No shelters	272.13	188.50	177.42	2.77	4.66	3.80
Sheltered	332.30	241.97	213.94	3.37	5.58	4.12
P>F	.4635	.2388	.3682	.2922	.3633	.6615
Flood X shelter						
Flood-no shelter	225.25	165.37	186.79	2.37	4.19	4.23
Flood-sheltered	297.52	207.80	136.85	3.11	5.25	3.18
Mesic-no shelter	319.01	211.63	168.05	3.18	5.13	3.37
Mesic-sheltered	367.08	276.13	291.02	3.63	5.81	5.06
P>F	.8800	.7962	.0608	.7867	.8352	.0961

Table 5—Mean leaf water potential (M Pa, Mega Pascals of 1-year-old bare-root baldcypress (*Taxodium distichum* L.) seedlings planted March 15, 1995, near Caddo Lake on Longhorn Army Ammunition Plant at Karnack, TX. Measurements were taken August 14-15, 1996, using a PMS Pressure Bomb

Treatment	Predawn	Midday	P.M.
	---------	*Mega Pascals* -------	
Flooding			
Mesic	-0.16	-1.62	-1.48
Flood	- .17	-1.50	-1.29
P>F	.7803	.2960	.0214
Shelters			
No shelters	- .14	-1.54	-1.4200
Sheltered	- .18	-1.59	-1.36
P>F	.2243	.5939	.4105
Flood X shelter			
Flood-no shelter	- .14	-1.45	-1.33
Flood-sheltered	- .19	-1.55	-1.25
Mesic-no shelter	- .14	-1.62	-1.50
Mesic-sheltered	- .18	-1.62	-1.47
P>F	.7500	.5939	.7195

In September of 1996, weather curtailed all measurements to just 1 day. No significant differences were found within treatments for stomatal conductance or transpiration (table 6). There was no significance for treatment interaction. Leaf water potential did show significance for pre-dawn readings (P> 0.01) between sheltered seedlings (-0.27 M Pa) and nonsheltered seedlings (-0.16 M Pa) (table 7).

CONCLUSIONS

Some plant water relation trends are evident. In the flood treatment, seedlings planted in the mesic soils tended to have higher rates of transpiration and stomatal conductance then those planted in permanently flooded conditions. For the shelter treatments, seedlings fitted with protective tree shelters transpired at higher rates then those seedlings with out shelters. Treatment interactions suggest that, in general, the dry-sheltered seedlings exhibit the highest rates of transpiration and stomatal conductance. While there were some significant differences in leaf water potential, there were no apparent tendencies. The one constant among the water potential data was that sheltered seedlings tended not to recover as well from the previous day's stress.

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Table 6—Mean stomatal conductance (g, mmol per m² per s) and mean transpiration (*E*, mmol per m² per s) of 1-year-old bareroot baldcypress (*Taxodium distichum* L.) seedlings planted March 15, 1995, near Caddo Lake on Longhorn Army Ammunition Plant at Karnack, TX. Measurements were taken September 13, 1996, using a Li-Cor 1600 Steady State Porometer

Treatment	AM *g*	Midday *g*	PM *g*	AM *e*	Midday *E*	PM *E*
Flooding						
Mesic	242.70	248.86	381.64	3.01	3.51	4.99
Flood	214.13	240.67	248.84	2.16	3.36	3.69
P>F	.5706	.8546	.1271	.0588	.7754	.1872
Shelters						
No shelters	242.38	209.18	276.21	2.56	2.97	3.76
Sheltered	210.36	280.35	354.27	2.49	3.89	4.93
P>F	.5217	.1295	.3542	.8604	.1000	.2328
Flood X shelter						
Flood-no shelter	271.73	167.43	259.44	2.52	2.41	3.50
Flood-sheltered	156.52	313.91	238.26	1.79	4.30	3.88
Mesic-no shelter	203.25	250.92	292.98	2.60	3.53	4.02
Mesic-sheltered	282.15	246.80	470.29	3.42	3.48	5.98
P>F	.0744	.1107	.2440	.0816	.0848	.4142

Table 7—Mean leaf water potential (M Pa, Mega Pascals) of 1-year-old bare-root baldcypress (*Taxodium distichum* L.) seedlings planted March 15,1995, near Caddo Lake on Longhorn Army Ammunition Plant at Karnack, TX. Measurements were taken September 13, 1996, using a PMS Pressure Bomb

Treatment	Predawn	A.M.	Midday
	- - - - - - - - *Mega Pascals* - - - - - - -		
Flooding			
Mesic	-0.25	-1.48	-1.47
Flood	- .18	-1.42	-1.42
P>F	.0546	.5951	.5770
Shelters			
No shelters	- .16	-1.42	-1.42
Sheltered	- .27	-1.47	-1.47
P>F	.0117	.7030	.6889
Flood X shelter			
Flood-no shelter	- .13	-1.37	-1.37
Flood-sheltered	- .22	-1.47	-1.47
Mesic-no shelter	- .18	-1.48	-1.48
Mesic-sheltered	- .32	-1.47	-1.47
P>F	.4747	.5951	.5770

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