THE EFFECT OF WATER POTENTIAL UPON THE GEOGRAPHIC DISTRIBUTION OF CARYA TEXANA

By

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Submitted to the Faculty of the Graduate College
of the Oklahoma State University
in partial fulfillment of the requirements
for the Degree of
MASTER OF SCIENCE
May, 1978

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ACKNOWLEDGMENTS

The author wishes to express his appreciation to his major adviser, Dr. James K. McPherson, for his guidance, assistance, and patience during the course of this investigation and for helpful criticism in the preparation of this manuscript.

Appreciation is also due Dr. James Ownby, Dr. Paul Richardson, and Dr. Barb Reed for their help and encouragement throughout this study.

Dr. Ronald Tyrl was helpful in offering advice and moral support at various times during this investigation and his kindness is deeply appreciated.

Shelly Hall and Roger Umber were helpful in gathering data, offering constructive criticism, and moral support.

A special thanks to my parents, Mr. and Mrs. J. W. Hirst, for a lifetime of love, understanding, and encouragement.

Finally, a most sincere thank you to my wife, Janet, for her understanding, patience, assistance, and support throughout this study. Without her, this study would never have succeeded.

TABLE OF CONTENTS

Chapter Page

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Carya texana, common called Texas or black hickory is a true hickory reaching heights at maturity of 10-15 meters and a diameter-at-breast height rarely exceeding .6 meters (Sargent, 1926). Most natural reproduction is by root sprouting, with nuts being only a minor means. Black hickory occurs in northern and eastern Texas, eastern Oklahoma, and parts of Missouri, Arkansas, and Louisiana. Within its range, this species is most commonly found on rock outcrops and/or thin soils which usually support upland forests (Bruner, 1931), but can be found occasionally on the floodplain of creeks or rivers.

Carya texana occurs throughout the eastern half of Oklahoma. In the eastern parts of its range within the state, it is a major constituent of the upland forest canopy along with Quercus marilandica, blackjack oak; Quercus stellata, post oak; Celtis sp., hackberry; and Quercus velutina, black oak. Near the western limits of its range, it becomes less prominent, giving way to less diverse upland forest stands of posk oak, blackjack and Bumelia lanuginosa, chitamwood.

Quercus marilandica, blackjack oak, is a black oak and a principal constituent of the Cross-Timbers region in central Oklahoma. It is found in intimate association with post oak and black hickory. Blackjack extends approximately 320 kilometers further west than black hickory (Figure 1), and is considered by many workers to be among the most

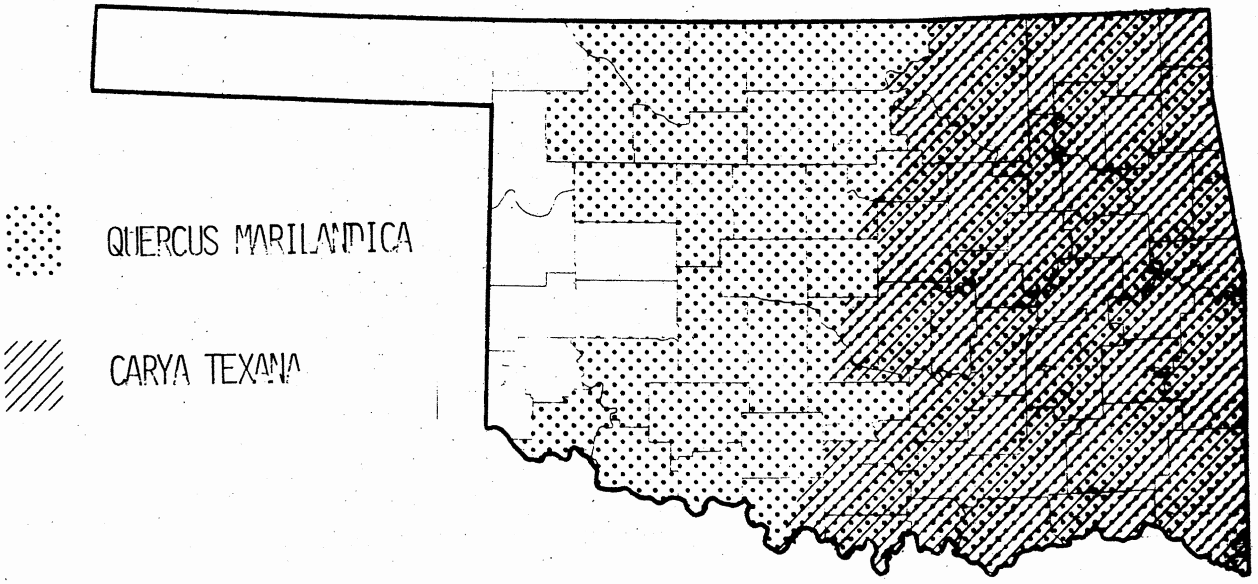

Figure 1. Geographic Distribution of *Carya texana* and *Quercus marilandica* in Oklahoma

drought-hardy deciduous trees in the state (Bruner, 1931). It ranges in size from a tree, 12-18 meters in height, in the eastern parts of the state, to a shrubby tree in the west, no more than 6-8 meters tall. It is a prolific stump sprouter and may form dense stands on dry, rocky outcrops in the western half of Oklahoma, where it often occurs as the only tree species.

There are many species that extend only as far westward as central Oklahoma, including *Carya texana*, *Quercus velutina*, *Carya cordiformis*, *Platanus occidentalis*, *Diospyros virginiana*, and *Quercus shumardii* (Little, 1971). Closer investigation reveals that many of these species' western limits generally parallel the isohyets on a state precipitation map. It seems probable that this distribution pattern is due to limited moisture availability.

Kramer (1974) states that most basic concepts in the study of water relations were established fifty years ago. The importance of measuring plant water stress was recognized by ecologists and physiologists, then and now. For example, numerous measurements of plant sap osmotic potential are recorded in the older literature (Harris, 1934; Korstian, 1924). Interest later shifted to water potential, a value used to include other parameters affecting water relations. Water potential, ψ w, includes three basic components; the osmotic potential (solute concentration), ψx, pressure potential (turgor pressure), ψp, and matric potential, ψ m (Meyer et al., 1973). But difficulty in achieving reliable measurements of water potential discouraged many ecological investigators. As a result, many workers tried to evaluate water stress in terms of water content, saturation deficit, relative water content, and stomatal aperature (Kramer, 1969).

Schollander et al. (1964) reintroduced an idea first described by Dixon (1914). The resulting "pressure bomb" has revolutionized field measurements of water potential, which is regarded as the single most useful value for characterization of plant moisture stress (Kramer, 1972). The Schollander pressure chamber method can estimate moisture stress in trees regardless of rooting depth (Waring and Cleary, 1967; Schollander et al., 1965).

Recent studies in water relations have reinforced some early concepts and advanced many new and interesting ideas. Klepper (1968) described diurnal fluctuations of water potential in fruit trees. Hass and Dodd (1972), working with honey mesquite, investigated the seasonal fluctuations of water potential. Hickman's (1971) study combined diurnal and seasonal water stress patterns in several herbaceous plant species. He concluded that the most common pattern of seasonal change consisted of a characteristic diurnal fluctuation which steadily increased in magnitude throughout the growing season. Griffin (1973) studied water potentials of three California oak species in an effort to relate water relations to the different habitats occupied by these species. He concluded that the moisture gradient inferred by the pressure chamber helped to interpret oak distributions. Syverstein (1973) stated that plant distributions depend on the availability of water as much as any single environmental factor.

The major goals of this study were to determine the role of water in limiting the western geographical distribution of C. texana; to examine the water potential of this species across a moisture gradient; and to compare its water potential to that of Q. marilandica, a more drought-hardy species.

CHAPTER II

SITE DESCRIPTION

All field research was conducted on four sites located in north-central Oklahoma (Figure 2). The study area was dominated by upland forest interspersed with tall grass prairie, a mixture typical of this region (Bruner, 1931).

Site 1, the eastern-most site, was located 15 km west of Sand Springs, Oklahoma, on land adjacent to the Arkansas River just below Keystone Dam (Tulsa Co: R10E-T19N-Sec. 9).

This site was located in the Eastern Sandstone Cuesta Plains geomorphic province (Curtis and Ham, 1972). The topography was one of generally rolling to hilly uplands. Soils were in the Darnell-Stephenson series typified by light sandy soils with reddish subsoils on various sandy material developed under Oak-Hickory forests with various openings. They were characterized by excessive runoff, low moisture storage, and droughty nature with some surface stone and ledge rock outcrops (Gray and Galloway, 1959).

Site 2, located 31 km west of site 1, was located approximately 10 kilometers southwest of Oilton, Oklahoma, on private land. The land was leased for grazing but no cattle were on the area (Creek Co.: R7E-T18N-Sec. 14).

This site was located in the Northern Limestone Cuesta Plains geomorphic province. The topography and soils were generally similar to

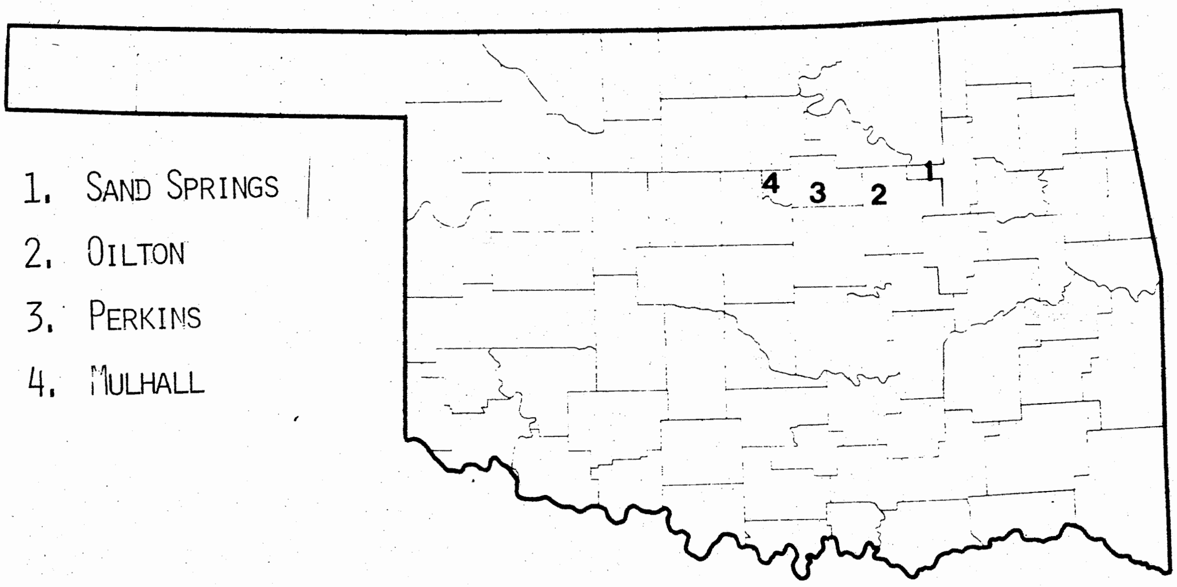

Figure 2. Locations of the Four Study Sites in North-central Oklahoma

those described for site 1.

Site 3, located 43 km west of site 2, was located approximately 5.5 km east of Perkins, Oklahoma, on private land. The land was under no grazing or agricultural pressure (Payne Co.: R3E-T17N-Sec. 3).

Site 3 is located in the Central Redbed Plains geomorphic province. Topography was undulating, dissected old stream terraces. Soils were in the Dougherty-Teller-Yahola series being general similar to those already described in the Darnell-Stephenson series. They were reddish-yellow, often stratified sandy loam alluvium. They were characterized as erosive from wind and water, and generally low in fertility (Gray and Galloway, 1959).

Site 4, the western-most site, was located 31 km west of site 3. It was approximately 6.5 km north and east of Mulhall, Oklahoma, on private land currently being grazed (Payne Co.: R1W-T19N-Sec. 28).

This site was also located in the Central Redbed Plains geomorphic province. The topography consisted of a gently rolling upland. Soils were in the Renfrow-Zaneis-Vernon series with typically dark soils and clayey subsoils developed under tallgrass prairie, mostly in clayey redbeds. The soils were characteristically erosive and droughty.

Climate

Oklahoma has a temperature climate with rather pronounced seasonal fluctuations of both temperature and precipitation (Myers, 1976). Statewide, precipitation ranges from 150 cm per year in the southeast to less than 50 cm per year in the northwest, an exceptional gradient for an area of near-level topography.

Site 1, located near Sand Spring, was less than 1 kilometer from the Keystone Dam Climatological Station. This station was used for daily precipitation reports, but did not report annual precipitation information. The closest reporting station recording this information was Tulsa International Airport which reports a yearly average of 96.5 cm per year. Data available for the first 10 months of the study year shows precipitation totals 77.6 cm (Table I).

Site 2, located near Oilton, was within 5 kilometers of a National Weather Service Reporting Station. Since only daily reports were available from this station, annual precipitation information was taken from Cushing, Oklahoma, 17 kilometers southwest. The annual average for the Cushing station was 89.1 cm per year. Data were available for the entire study year. Precipitation for the study year was 87.7 cm.

Site 3, located near Perkins, was 6.5 kilometers from an Oklahoma State University Agronomy Experiment Station. Average annual precipitation for site 3 was obtained from this source while the daily reports came from Dr. James McPherson's farm, also the location of site 3. Average yearly precipitation on this site totals 89.8 cm per year. The total for the study year was 67.8 cm.

Site 4, located near Mulhall, was 11 kilometers from the Lake Carl Blackwell Hydrological Station. Annual average for this site as reported by Myers (1976) was 81.7 cm per year. Totals for this year were 68.0 cm.

TABLE I

MONTHLY, YEARLY, AND AVERAGE ANNUAL PRECIPITATION FOR THE 4 STUDY SITES

		Precipitation in cm		
Month	Site 1	Site 2	Site 3	Site 4
January	---*	1.0	0.9	0.9
February	3.9	3.6	1.4	3.1
March	9.2	10.2	---	5.7
April	5.8	7.4	3.6	5.8
May	19.7	19.0	18.5	23.4
June	7.0	3.1	4.7	2.7
July	4.7	10.1	8.5	8.2
August	9.5	15.3	11.0	5.9
September	16.8	7.4	5.4	5.3
October	16.8	2.5	4.0	3.0
November	---	4.4	---	3.3
December	---	3.8	0.0	0.7
Yearly Total	77.6	87.8	67.8	68.0
Annual Average	96.5	89.1	89.8	81.7

*Insufficient data available

CHAPTER III

METHODOLOGY

Trees at four sites were measured during the growing season to determine if any differences existed in water potentials of a single species and between species on the same site. Trees selected were healthy, actively growing, and in close proximity. All sites were approximately the same density since stand density significantly affects the water potentials that develop (Wambolt, 1973). Trees varied somewhat in age ranging from 5-25 cm D.B.H. Trees with crown damage or obvious disease were avoided.

Ten trees were selected from each of the three eastern sites, five trees each of *C. texana* and *Q. marilandica*. On site 4, where only *Q. marilandica* was present, six trees were selected for study.

My twig sampling methods resembled those used by Waring and Cleary (1967) and Griffin (1973). A measurement consisted of a leafy twig 5-10 cm long cut from the lower crown near the 2 meter height. These samples were taken one tree at a time and sealed in the pressure chamber within one minute. Approximately 1 cm of stem was left protruding from the lid of the chamber. Chamber pressure was increased at a rate of 0.5 bars per second until sap bubbled from the cut end. The pressure chamber was a P.M.S. Model 1000 which was pressurized with dry nitrogen gas. Samples taken during daylight hours came from branches in full sun and all samples were taken from the south side of the tree.

The accuracy of the pressure bomb has been questioned by some investigators (Kaufmann, 1968). He states that water status as measured with the pressure chamber may be erroneous due to differences between xylem sap tension and actual water potential in the leaves. To avoid this possible source of error, measurements with a Westeor thermocouple psychrometer were compared to those made with a pressure chamber. Differences were shown to be consistently less than ± 1 bar. Several species were measured including the two used in this study.

In order to establish precise times when daily water potentials were at their highs and lows, preliminary measurements were made during May, 1977. Water potential readings were taken hourly from 0400 to 1600 hrs. The highest daily water potentials were observed about 0600 hrs. and the lowest at about 1300 hrs. These two times, predawn for the highs and early afternoon for the lows, are also generally accepted by workers in the field as being baselines for showing minimums and maximums of water potentials (Klepper, 1968; Haas and Dodd, 1972; Griffin, 1973; Ehrlinger and Miller, 1975).

During June, July, and August, predawn and afternoon water potential measurements were made at each site each week. At each site, the predawn and afternoon measurements were made on the same day. Efforts were made to take the readings of all 4 sites on consecutive days. During the months of May, September, and October, readings were taken only on alternate weeks.

CHAPTER IV

RESULTS

During the growing season, both C. texana and Q. marilandica experienced similar average water potentials (Table II). Predawn averages for hickory were slightly lower than those of blackjack while afternoon averages showed hickory a little higher. Statistical analysis shows no significant ($p < .05$) differences between the two species.

TABLE II

AVERAGE ANNUAL WATER POTENTIAL FOR CARYA TEXANA AND QUERCUS MARILANDICA FOR ALL SITES

Species	Entire Season	First Half	Second Half
C. texana (A.M.)	-9.1*	-1.5	-16.1
Q. marilandica(A.M.)	-8.2	-3.0	-12.1
C. texana(P.M.)	-24.4	-18.0	-29.8
Q. marilandica(P.M.)	-24.7	-20.1	-28.4

*All measurements are in bars

Differences in precipitation amounts between May, June, and the first part of July compared to the second half of July, August, and

September seemed to naturally divide the growing season into two parts. During the first half of the growing season, hickory maintained a higher water potential in both predawn and afternoon readings than the blackjacks (Tables III, IV, and V). All had significant differences in the predawn and two sites, site 1 and site 3, showed a difference in the afternoon.

During the second half of the growing season, there were significant differences between both the predawn and afternoon readings. At this time blackjack maintained a higher water potential than hickory. Blackjack had water potential readings significantly higher than those of hickory on sites 1, 2, and 3 (Tables VII, VIII, and IX). Predawn and afternoon measurements showed hickory to be more stressed than blackjack.

The lowest water potentials recorded during the study were recorded on site 2 on August 11. Here the hickories had a predawn average of -48.4 bars and an afternoon average minimum of -51.0 bars. The hickories also exhibited the highest water potentials recorded during the study. At site 1, on two dates, June 3 and June 8, and on site 3 on June 7, some positive water potential was recorded. Since no quantitative measure was possible, these were recorded as 0.0. On these days, predawn measurements were taken and it was discovered that sap flowed out of the cut end of the leafy twig as soon as it was observed after being cut from the tree and without any pressure being applied.

Representative highest and lowest water potentials are shown in Table XI. Comparisons between the species show that hickory had the highest and lowest water potentials recorded during the study. All

TABLE III

DIURNAL EXTREMES IN WATER POTENTIAL OF *CARYA TEXANA*(C) AND *QUERCUS MARILANDICA*(Q) DURING THE FIRST HALF OF THE GROWING SEASON

	Site 1			
	Predawn maxima (-Bars)**		Afternoon minima (-Bars)**	
Date	C	Q	C	Q
5-24	1.1(1.0-1.5)	2.3(2.0-3.0)	16.0(13.0-18.5)	21.5(19.0-23.0)
6-3	.5(0.0-1.0)	2.8(2.0-3.0)	18.2(16.0-20.5)	24.1(21.0-27.5)
6-8	.2(0.0-0.5)	1.7(1.5-2.0)	18.2(16.5-23.0)	20.3(16.0-25.5)
6-16	1.4(1.0-2.0)	2.9(2.5-3.0)	15.8(13.5-17.5)	19.4(17.0-22.5)
6-24	1.8(1.5-2.0)	3.6(3.0-4.0)	15.1(14.0-17.5)	15.9(14.5-18.0)
7-2	1.0(0.0-1.5)	2.7(2.0-3.5)	20.5(18.0-23.0)	23.9(22.0-25.5)
Average	1.0*	2.7*	17.3*	20.8*

*Significant at $p < .05$

**Tree averages based on 5 twigs per species and date, ranges of twig potentials shown in parenthesis

TABLE IV

DIURNAL EXTREMES IN WATER POTENTIAL OF *CARYA TEXANA*(C) AND *QUERCUS MARILANDICA*(Q) DURING THE FIRST HALF OF THE GROWING SEASON

	Site 2			
	Predawn maxima (-Bars)**		Afternoon minima (-Bars)**	
Date	C	Q	C	Q
6-6	1.4(1.0-2.0)	2.3(1.0-3.0)	19.1(16.5-23.0)	18.6(17.0-20.0)
6-15	1.5(1.0-2.5)	3.0(2.0-3.5)	21.2(18.0-25.0)	19.8(18.5-21.5)
6-21	1.5(1.0-2.0)	3.3(3.0-4.0)	23.6(23.0-25.0)	24.9(24.0-26.0)
7-5	2.4(1.5-3.5)	4.0(3.5-4.5)	24.6(23.0-26.0)	26.0(24.5-29.0)
Average	1.7*	3.2*	22.1	22.3

*Significant at $p < .05$

**Tree averages hased on 5 twigs per species and date, ranges of twig potentials in parentheses

TABLE V

DIURNAL EXTREMES IN WATER POTENTIAL OF *CARYA TEXANA*(C) AND *QUERCUS MARILANDICA*(Q) DURING THE FIRST HALF OF THE GROWING SEASON

	Site 3			
	Predawn maxima (-Bars)**		Afternoon minima (-Bars)**	
Date	C	Q	C	Q
5-26	.7(0.5-1.5)	1.8(1.5-2.5)	9.1(7.5-12.0)	15.2(13.5-16.0)
6-2	1.4(1.0-2.0)	1.9(1.0-3.0)	18.0(17.0-19.5)	22.9(20.0-26.0)
6-7	.1(0.0-0.5)	1.9(1.5-2.0)	14.9(13.0-18.0)	22.3(19.5-24.5)
6-14	2.0(1.5-3.0)	2.7(1.5-3.5)	14.7(14.0-16.0)	17.7(17.0-18.5)
6-22	2.1(1.5-2.5)	3.6(3.0-4.0)	14.2(13.5-15.0)	14.9(14.0-16.0)
6-30	4.1(3.0-5.0)	5.1(4.5-6.0)	16.3(15.5-17.5)	18.6(18.0-19.0)
Average	1.7*	2.8*	14.5*	18.6*

*Significant at $p < .05$
**Tree averages based on 5 twigs per species and date, ranges of twig potentials shown in parenthesis

TABLE VI

DIURNAL EXTREMES IN WATER POTENTIAL OF *QUERCUS MARILANDICA*(Q) DURING THE SECOND HALF OF THE GROWING SEASON

	Site 4	
	Predawn maxima (-Bars)*	Afternoon minima (-Bars)*
Date	Q	Q
5-8	3.4(2.5-4.0)	15.5(11.0-19.0)
5-19	4.8(4.0-7.0)	10.4(9.0-12.0)
6-5	2.3(1.5-4.0)	20.1(16.5-23.0)
6-20	2.0(1.0-3.0)	23.9(19.0-27.0)
7-3	1.9(1.0-4.0)	19.5(14.0-23.5)
7-8	3.9(2.5-5.0)	16.2(15.0-18.0)
7-16	5.3(4.0-7.0)	25.3(25.0-27.0)
Average	3.4	18.7

*Tree averages based on 6 twigs per species and date, ranges of twig potentials shown in parentheses

TABLE VII

DIURNAL EXTREMES IN WATER POTENTIAL OF *CARYA TEXANA*(C) AND *QUERCUS MARILANDICA*(Q) DURING THE SECOND HALF OF THE GROWING SEASON

Site 1

	Predawn maxima (-Bars)**		Afternoon minima (-Bars)**	
Date	C	Q	C	Q
7-20	10.7(7.0-14.0)	8.3(7.0-10.5)	27.3(26.5-30.5)	26.7(25.0-29.5)
7-28	5.1(4.0-5.5)	7.0(6.5-7.5)	23.4(22.0-26.0)	19.3(18.0-22.5)
8-4	21.2(15.0-25.5)	12.3(10.0-14.5)	33.1(32.0-34.5)	31.5(28.5-34.0)
8-13	25.4(19.0-30.0)	16.7(15.0-21.5)	15.7(12.0-18.0)	13.9(12.0-17.5)
8-18	4.6(3.5-5.5)	4.8(4.0-5.5)	25.8(24.5-28.0)	27.8(22.0-33.0)
8-25	-----	-----	26.2(24.5-28.0)	25.1(22.5-29.0)
9-22	2.5(1.5-3.0)	5.4(3.5-7.0)	22.9(21.5-25.0)	21.2(18.5-24.0)

*Significant at $p < .05$

**Tree averages based on 5 twigs per species and date, ranges of twig potentials in parentheses

TABLE VIII

DIURNAL EXTREMES IN WATER POTENTIAL OF *CARYA TEXANA*(C) AND *QUERCUS MARILANDICA*(Q) DURING THE SECOND HALF OF THE GROWING SEASON

	Site 2			
	Predawn maxima (-Bars)**		Afternoon minima (-Bars)**	
Date	C	Q	C	Q
7-8	14.3(11.0-16.0)	11.6(11.0-12.5)	34.2(32.0-35.5)	28.5(27.5-30.5)
7-27	1.4(1.0-2.0)	3.6(3.0-4.5)	25.1(24.0-30.0)	29.9(29.0-30.0)
8-3	32.1(30.5-35.0)	27.9(27.0-29.5)	42.4(40.5-44.5)	38.1(35.0-43.0)
8-11	48.4(45.0-50.5)	36.9(34.0-38.0)	51.0(49.0-53.5)	41.2(40.0-42.0)
8-17	-----	-----	14.3(8.0-19.0)	17.7(11.0-22.5)
8-24	23.5(22.0-25.0)	21.0(19.0-23.0)	43.0(40.5-45.0)	38.5(37.5-39.0)
Average	23.9*	20.2*	35.0*	32.3*

*Significant at $p < .05$

**Tree averages based on 5 twigs per species and date, ranges of twig potentials in parentheses

TABLE IX

DIURNAL EXTREMES IN WATER POTENTIAL OF *CARYA TEXANA*(C) AND *QUERCUS MARILANDICA*(Q) DURING THE SECOND HALF OF THE GROWING SEASON

	Site 3			
	Predawn maxima (-Bars)**		Afternoon minima (-Bars)**	
Date	C	Q	C	Q
7-19	13.9(6.0-22.0)	5.2(4.5-6.0)	28.5(20.5-32.5)	28.8(25.5-30.0)
7-25	2.1(1.5-2.5)	3.6(3.0-4.5)	24.6(19.5-30.5)	27.6(23.0-31.0)
8-2	-----	-----	28.6(22.0-33.5)	26.9(23.5-29.5)
8-10	22.6(16.5-27.0)	8.3(7.0-9.5)	33.1(29.0-39.0)	25.0(23.5-29.0)
8-16	9.2(6.5-11.0)	7.6(7.0-8.5)	25.8(25.5-27.0)	19.8(19.0-21.5)
8-23	16.8(16.0-18.0)	11.0(9.0-12.5)	33.6(31.0-37.0)	31.2(30.0-32.0)
Average	12.9*	7.1*	29.0*	26.6*

*Significant at $p < .05$

**Tree averages based on 5 twigs per species and date, ranges of twig potentials in parentheses

TABLE X

DIURNAL EXTREMES IN WATER POTENTIAL OF QUERCUS MARILANDICA(Q) DURING THE SECOND HALF OF THE GROWING SEASON

	Site 4	
	Predawn maxima (-Bars)*	Afternoon minima (-Bars)*
Date	Q	Q
7-21	8.9(7.0-11.0)	25.2(23.0-28.0)
7-29	10.8(7.5-14.0)	28.5(27.0-29.5)
8-5	11.6(9.0-13.5)	33.3(30.5-36.0)
8-15	9.3(8.0-11.0)	30.4(25.0-34.0)
8-21	7.3(6.0-8.0)	29.0(28.0-30.0)
8-27	20.7(14.0-26.0)	32.7(31.0-35.0)
9-9	19.8(13.0-24.0)	33.4(25.0-37.0)
9-29	19.9(12.0-24.0)	33.8(27.5-38.0)
10-13	21.1(18.5-23.0)	32.8(30.5-35.0)
Average	13.4	31.0

*Tree averages based on 6 twigs per species and date, ranges of twig potentials in parentheses

TABLE XI

WATER POTENTIALS (-BARS) OF HICKORY AND BLACKJACK UNDER CONDITIONS OF HIGH AND LOW WATER STRESS. TWO REPRESENTATIVE VALUES FOR THE SEASON AT SITES 1-3 ARE PRESENTED

	SITE 1				SITE 2				SITE 3			
	Highs		Lows		Highs		Lows		Highs		Lows	
	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM
_C_. _texana_	0.5	18.2	10.7	27.3	1.4	19.1	32.1	42.4	0.7	9.1*	22.6	33.1
	0.2	18.2	21.2	33.1	1.5	21.2	48.4**	51.0**	0.1*	14.7	16.8	33.6
_Q_. _marilandica_	2.3	21.5	12.3	31.5	2.3	18.6	27.9	38.1	1.8	15.2	5.2	28.8
	1.7	20.3	8.3	26.7	3.0	19.8	36.9	41.2	1.9	22.3	11.0	31.2

*Highest recorded during study
**Lowest recorded during study

examples of high water potential occurred during the first half of the growing season while the lowest occurred during the second half. Hickory showed more fluctuation in diurnal patterns during the first half of the growing season and on the moister site 1; it had a smaller fluctuation on the drier sites due to the poor predawn recovery.

One very consistent pattern emerged. On all sites where both species were present, hickory had higher early-season water potentials than blackjack. On site 1 (Figure 3), hickory maintained a higher predawn and afternoon water potential until the 7th week. Then the hickory developed the lower water potential for most of the rest of the growing season. On site 2 (Figure 4), hickory similarly initially maintained a higher water potential until the 6th week, when blackjack reversed the trend. This same pattern developed on site 3 (Figure 5) during the 6th week. Site 4 (Figure 6) contained only blackjack and was generally comparable to readings for the other sites.

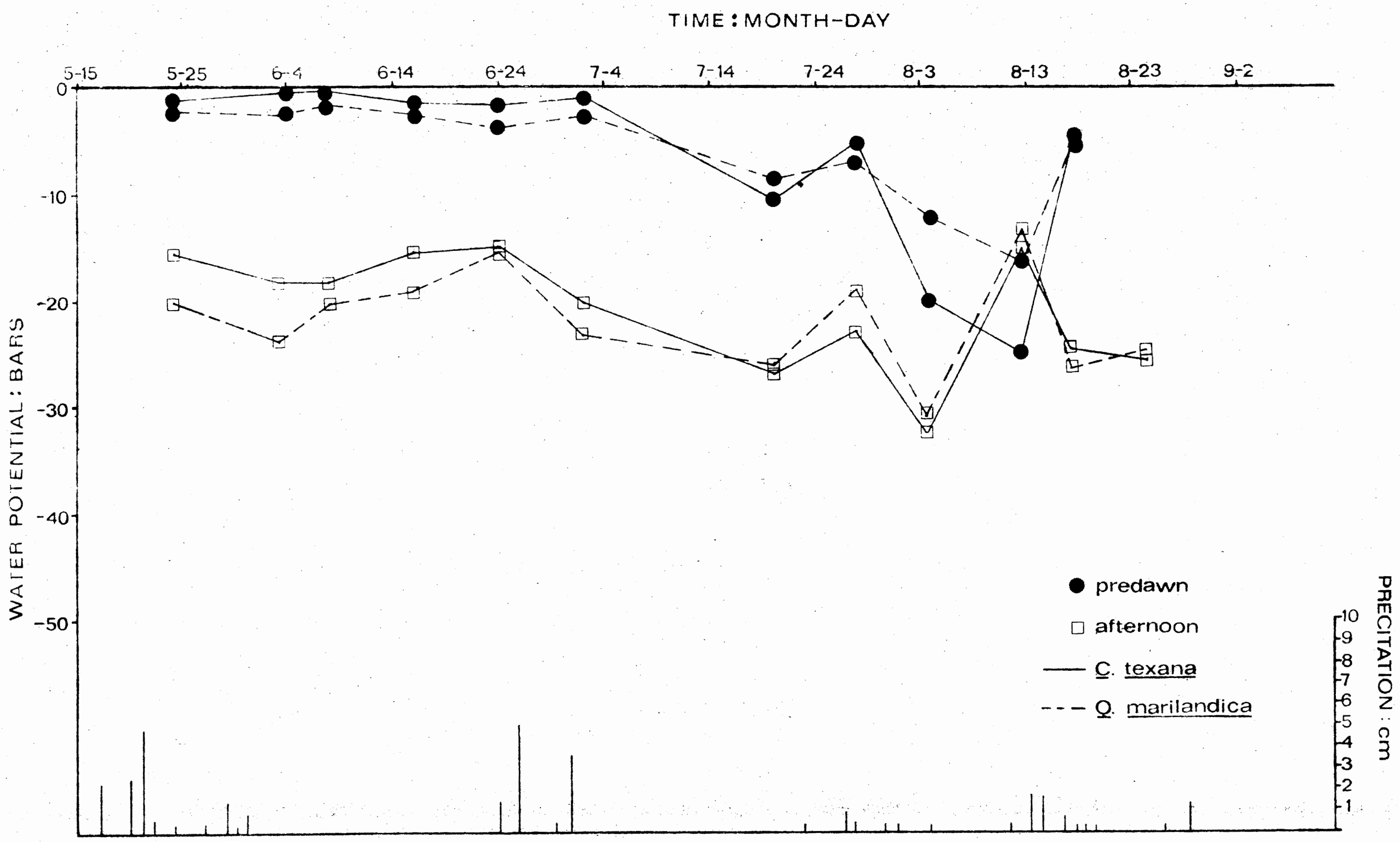

Figure 3. Weekly Water Potentials Throughout the Growing Season, Site 1

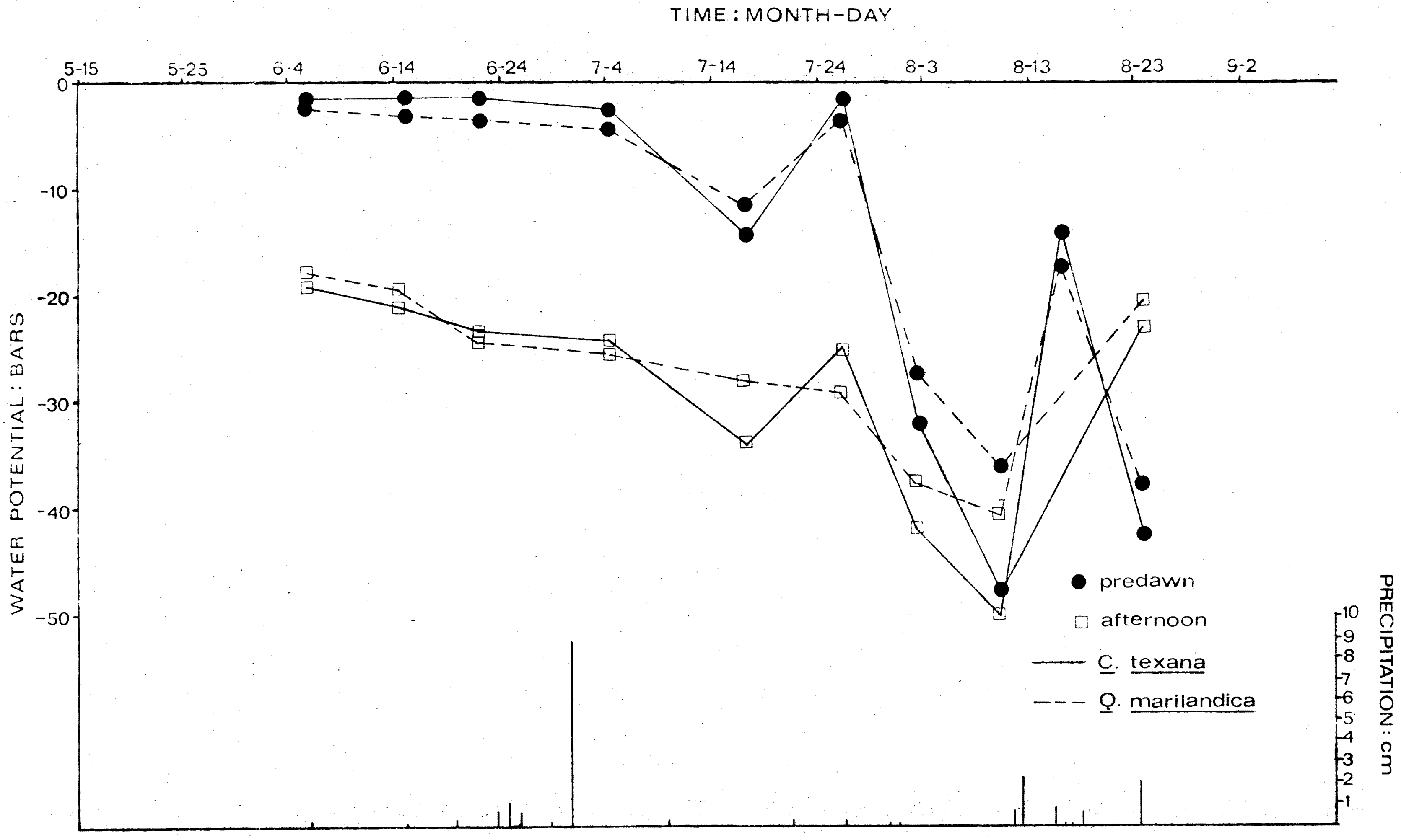

Figure 4. Weekly Water Potentials Throughout the Growing Season, Site 2

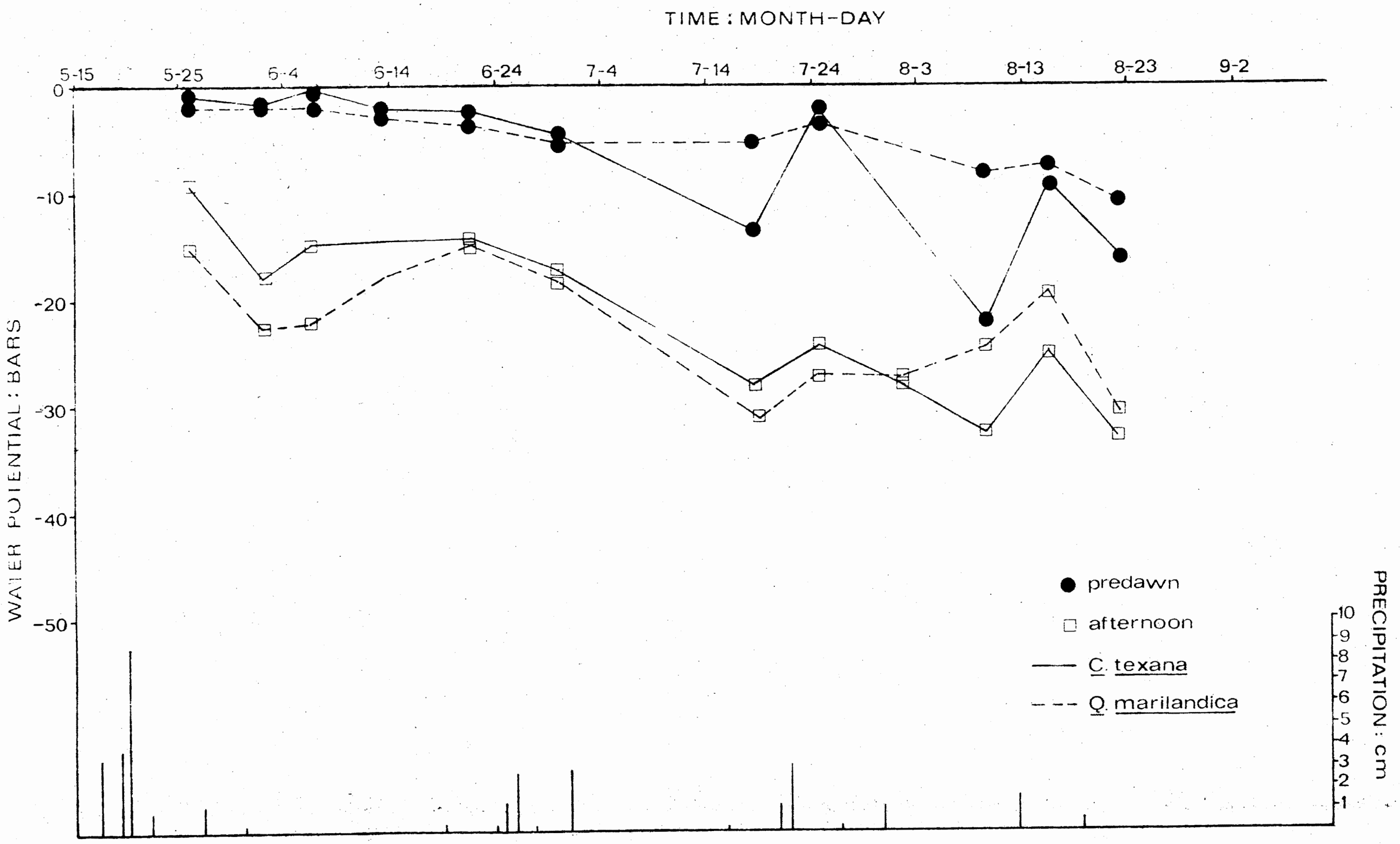

Figure 5. Weekly Water Potentials Throughout the Growing Season, Site 3

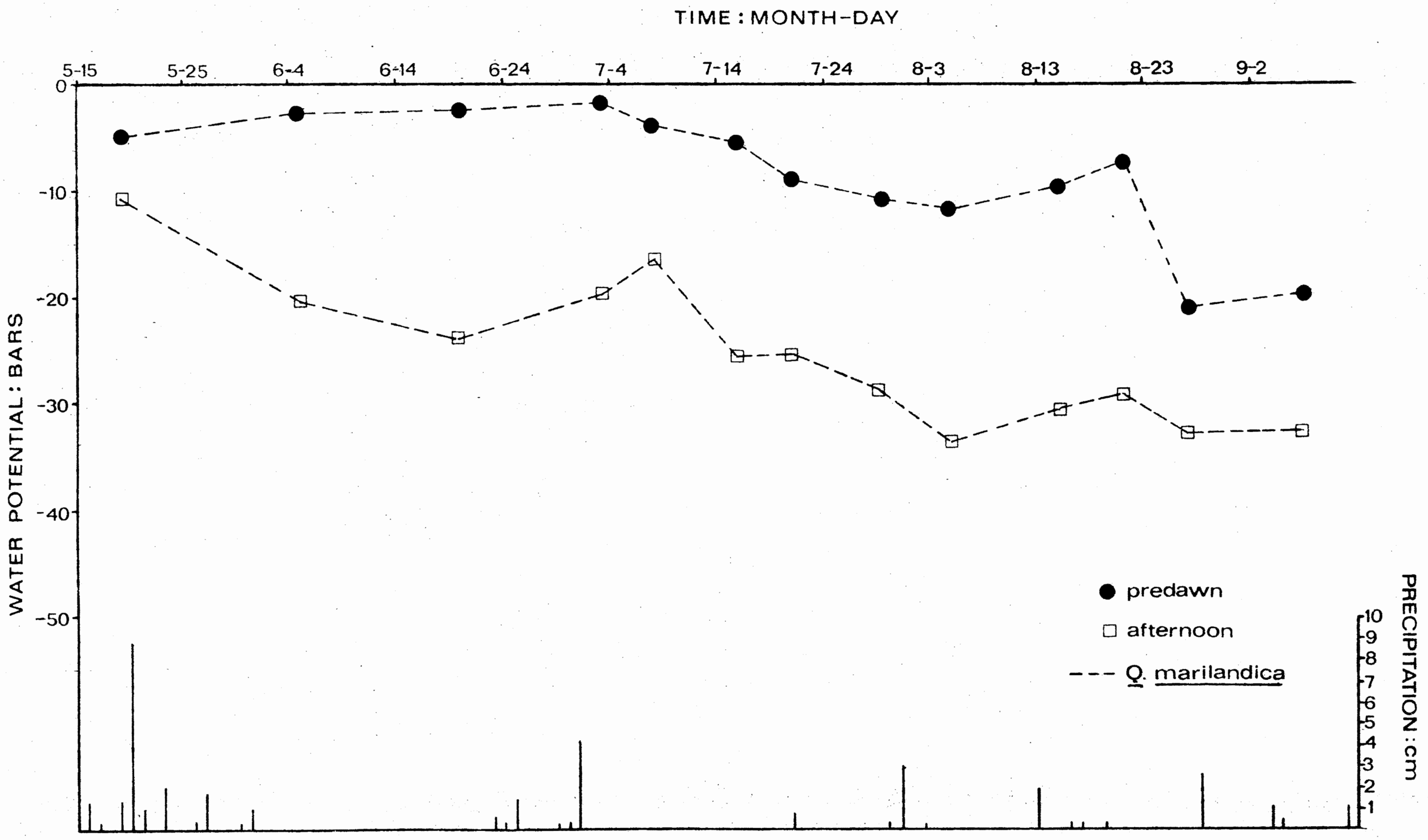

Figure 6. Weekly Water Potentials Throughout the Growing Season, Site 4

CHAPTER V

DISCUSSION AND CONCLUSIONS

During periods of abundant moisture, hickory exhibited a higher water potential than blackjack. Inversely, during periods of high moisture stress, hickory developed a lower water potential than blackjack. In general, hickory fluctuated more, suggesting it did not have as complete control of its water status as blackjack. At the worst extremes of dryness, hickory was able to make almost no predawn recovery while blackjack made considerable. Water potentials for both species decreased steadily throughout the growing season. Blackjack seemed better able to control the magnitude of its water potential. It had a smaller decrease in water potential and its minimum water potential was higher. Hickory exhibited a drought resistance mechanism; premature leaf drop.

The study species seemed to exhibit a different pattern in the first half of the growing season from that in the second. During the first half of the growing season, from May to July 15, hickory maintained a significantly higher water potential in the predawn and afternoon than blackjack. Hickory seemed to exhibit some positive water potential on two sites in the predawn measurements. It seems likely that hickory was better able than blackjack to secure water from the soil when soil moisture was abundant. Control of transpiration during this part of the growing season was apparently not critical.

As the middle of the growing season approached both species began to exhibit a more exaggerated diurnal fluctuation, but hickory still made higher predawn recoveries.

During the second half of the growing season, from July 15 to leaf drop, when soil moisture conditions were much poorer, a different pattern was noted. Blackjack exhibited a significantly higher water potential than hickory in both predawn and afternoon measurements. Both species exhibited an extreme diurnal fluctuation in water potential. However, blackjack was consistently able to make a higher predawn recovery than hickory and its afternoon minima did not reach as low. During the first week of August, hickory was exhibiting the lowest water potentials of the growing season, some 10 bars lower than blackjack on the same site. Predawn readings for the second half of the growing season showed that blackjack was able to make considerable predawn recovery despite poor moisture conditions. During this period, hickory predawn potentials fell progressively lower, while blackjack, on all but the driest site, remained fairly constant. This logically leads to the conclusion that blackjack is able to secure or conserve water better than hickory when water is limited.

Comparisons of the seasonal course of water potentials shows how the two species coped with the water stress encountered. On all the sites, except site 3 which had the best seasonal distribution of precipitation, blackjack showed a slight to rapid decrease in diurnal fluctuation. This was apparently due to blackjack's ability to successfully control the amount of water lost by transpiration. Even during the driest part of the growing season, blackjack was generally able to limit afternoon water losses and make considerable predawn recovery, causing the magnitude of the diurnal fluctuation to actually become smaller as the growing season progressed. On site 3, where this trend did not develop, it was probably due to the relatively low water stress in the plant throughout the season, allowing the plant to continue active transpiration during the hottest periods without critical water shortages developing.

Conversely, on all but the driest site 2, hickory showed a rapid increase in diurnal fluctuations. It is logical to assume this was due to the inability of hickory to control the amount of water lost to transpiration. During the driest part of the growing season, hickory made less predawn recovery than blackjack and developed lower afternoon minima. On site 2 this pattern did not occur, probably due to the extreme moisture stress allowing so little predawn recovery that the two readings, maxima and minima, remained rather close together. This was most pronounced on August 11, when the predawn maximum was -48.4 bars and the afternoon minimum was -51.0 bars, a change of only 2.6 bars. At this time, differences of 10 to 11 bars were found at the other sites. It also seems likely that this was approaching the lower limits of tolerance for this species as leaf drop was beginning to occur and was complete in the next 7-10 days. It was also noted here that _Quercus_ _stellata_, post oak, a common associate of hickory and blackjack in Oklahoma, also experienced leaf reduction by dropping many but not all of its leaves.

In spite of hickory's inability to control loss of water due to transpiration, it did show the ability to improve water status faster than blackjack when water became available. On all three sites where both species were present hickory had a higher water potential, both predawn and afternoon, shortly after rainfall was recorded. This was partly responsible for the extreme fluctuations of water potential recorded for hickory.

Hickory's tendency toward premature autumnal leaf drop caused by water stress could put them at a competitive disadvantage. If this happens yearly, another species such as blackjack, growing in close proximity, could competitively exclude hickory from growing and successfully reproducing.

In conclusion, _Carya_ _texana_ appears less able to cope with stress problems imposed by the drier environment of central and western Oklahoma, possibly limiting its western distribution. Results obtained in this study seem consistent with this hypothesis.

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