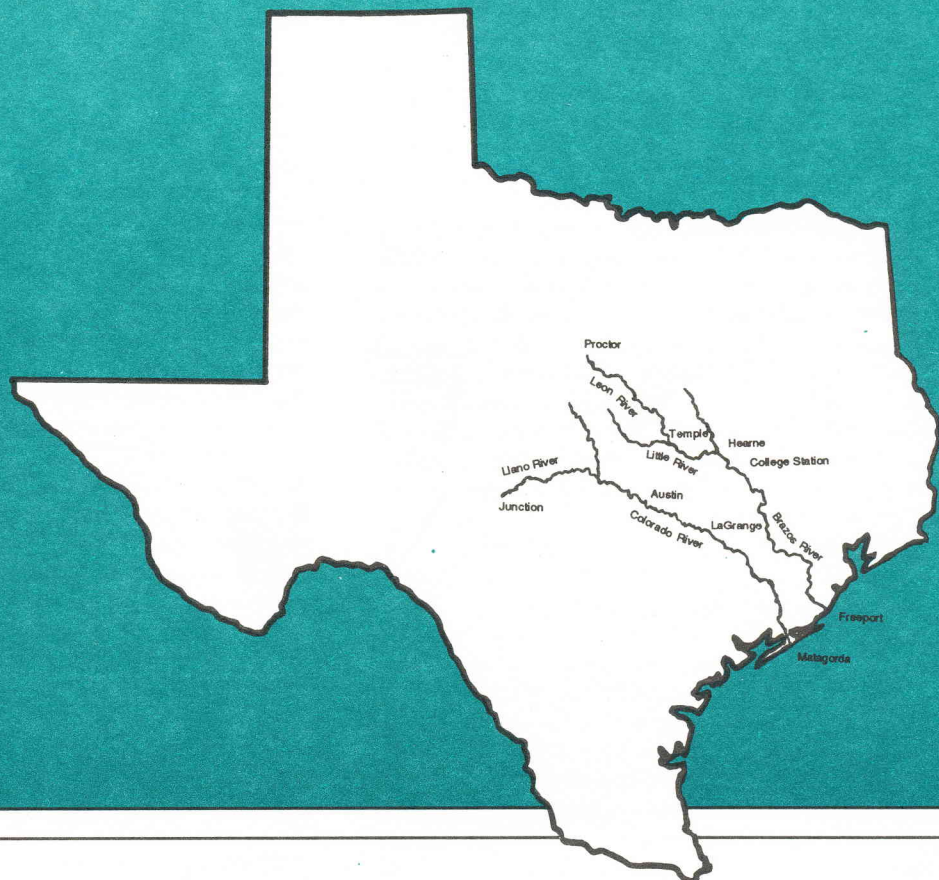


A Summary of the Location, Abundance, Distribution, and Condition of *Carya* on the Brazos and Colorado River Systems in Texas



A SUMMARY OF THE LOCATION, ABUNDANCE, DISTRIBUTION, AND CONDITION OF *CARYA* ON THE BRAZOS AND COLORADO RIVER SYSTEMS IN TEXAS

Robert C. Maggio, Marvin K. Harris, Sam J. Ingle, and M. Rene Davis*

INTRODUCTION

The location, distribution, abundance, and condition of a population of organisms are key features in developing an understanding of the present situation, reconstructing the past, and anticipating or even directing the future. This survey was undertaken to provide a record of *Carya*, principally pecan, that could be used in such endeavors. We initially adapted this remote sensing technology to provide a complete permanent record of the widespread defoliation caused by walnut caterpillar, *Datana integerrima* Grote and Robinson (Lepidoptera: Notodontidae), on pecan in Texas in 1973 (Harris 1983; et al. 1976; 1982; 1983; Maggio et al. 1983; Rogers and Harris 1983). Experience gained in that effort resulted in this work which created a data base for general use with this important natural resource.

The pecan, *Carya illinoensis* (Wang). Koch, is the most important horticultural plant native to the United States (Brison 1974); the indigenous range extends from western Texas to the Mississippi Valley on the east and from southern Illinois to Mexico (Little 1971). Pecan is the dominant hickory in Texas, reigning virtually alone in the west-central region. They share their preferred habitats in alluvial soils near rivers and streams with other *Carya* like *acuticarpa* (Michx. f.) Nutt., *tomentosa* Nutt., *ovata* (Mill.) Koch, and *cordiformis* (Wang.) Koch in the eastern portion of Texas (Little 1971). The Spanish Conquistadores documented the American Indians using pecan nuts extensively in the 16th century (see Brison 1974) and modern archaeologists date *Carya* shells from middens many centuries earlier showing early human recognition of and reliance on this resource.

Pecan is the principal hickory used today for food by humans with annual U.S. production averaging about 100 million kg. Production in Texas averages about 17 million kg but has ranged from 3.4 to 50 million kg within the past decade, 1980 being the low and 1981 the high. This wide variation in Texas is largely due to the extensive reliance on so-called native trees for production.

Native pecan trees are trees that nature planted. Humans, subsequently, cleared away competing trees and brush allowing grass to grow beneath and between the irregularly spaced canopies created by the procedure. Estimates prior to the survey reported here indicated native pecan accounted for about 90% of the hectareage and 80% of the commercial nut production in Texas with the remainder coming from vegetatively propagated orchards. The documentation provided by this survey will allow a more detailed examination of this natural resource from a number of perspectives. Future plans are to create user-friendly software that will allow users to obtain and use the data base in their own laboratories.

DATA BASE DEVELOPMENT

Aerial photography was used to quantify the resource (Maggio et al. 1983). Color infrared, aerial positive transparencies with a 9" x 18" format and a 50% overlap were used to photograph the Brazos River System from Proctor to Freeport (Figure 1), and Junction to Wharton on the Colorado River System (Figure 7). The Brazos River System includes portions of the Leon, Little, and Brazos rivers, while the Colorado River System includes the Llano River. Over 1,760 photographs were taken of an area approximately 1 km either side of the river for the Brazos River and 1,500 photographs were taken of the Colorado River. The photographs were imaged at a scale of 1:10,000 and were taken April 4-7, 1977. Using the river as a flight line, a single pass was made over the area of interest.

Geo-referencing of the aerial photography was accomplished by transferring the Universal Transverse Mercator (UTM) grid system (each grid cell is 1 km²) from a 7.5-minute USDA Geological Survey quadrangle map (1:24,000 scale), that covered the same area as the photograph, onto an acetate overlay that was registered to each photograph. The southwest corner of each km² block transferred from the 7.5-minute quadrangle map was assigned an X coordinate (Easting, the number of meters east of a meridian), and a Y coordinate (Northing, the number of meters north of the Equator) from the

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quadrangle map. Each km² was subdivided using a breakdown grid, the resulting finer grid obtained 100 uniquely identifiable grid cells, each covering one hectare on the 1:10,000 scale aerial photography (Maggio et al. 1983).

Photointerpretation for the three categories of hickory was performed using crown size and shape, tonal characteristics, and height and tree spacing for identification. The aerial photographs were imaged during early April when hickory was just leafing out but after most other species of hardwoods had mature foliage. Upon field inspection, hickory (*Carya*, spp.), hackberry (*Celtis occidentalis*, L.), and mesquite (*Prosopis juliflora*, Schwartz) were found to leaf out at approximately the same time, but crown size and shape were used to distinguish the hickory from these two species. Pecan, *Carya illinoensis* (Wang.) Koch, was the predominant hickory particularly in the upper reaches of these river systems. The survey primarily identified this species in three categories: wild, where trees were found intermixed with other trees in a closed canopy; native, where trees were in irregularly spaced pure standards; and orchards, where trees were in regularly spaced pure stands.

DATA CAPTURE

Data capture was accomplished by placing a semi-frosted acetate overlay with the 1-ha UTM grid on it over the photograph. In order for a grid cell to be photointerpreted and entered into the data base, it must contain either: 1) *Carya* trees, 2) the river, 3) the corners of the aerial photograph, or 4) a combination of 1, 2, and 3. The area encompassed by a 1-ha grid cell was evaluated and the following data were recorded:

1. The UTM zone in which the 1-ha grid cell fell.
2. A four digit UTM X coordinate and a five digit UTM Y coordinate for each 1-ha grid cell.
3. If *Carya* was present in the cell, the classification was recorded - native, orchard, or wild.
4. The percentage of the 1-ha grid cell covered by trees, regardless of species.
5. The percentage of the cell covered by *Carya*.
6. The roll and frame number of the photograph on which the UTM grid cell was imaged.

A computer program was developed for an IBM PC which displayed a 1 km² block that was subdivided into 100, 1-ha grid cells. The photointerpreter entered the three digit X and four digit Y coordinates for the Southwest corner of the 1 km² that was to be photointerpreted, thus initializing the computer program such that the operator responded to screen prompts to key in the data to be captured. Each 1-ha grid cell was then identified by adding one digit to the X and one digit to the Y coordinate which represented the number of cells over (X coordinate) and up (Y coordinate) with reference to the coordinates of the kilometer block being photointerpreted. The resulting unique nine digit number that identified the 1-ha grid cell was displayed on the video screen and also stored in the data base.

Next, the photointerpreter was prompted to enter the class of *Carya* identified in the 1-ha grid cell. Once this

class (native, orchard, or wild) was entered, the identified 1-ha grid cell on the video screen was filled with a square, circle, or triangle to represent the appropriate class of *Carya*. This visual display aided the photointerpreter in tracking those areas for which data had been previously entered. Subsequent prompts asked for the percentage of trees, percentage of *Carya*, and the roll and frame number of the photograph being photointerpreted. This process was repeated for each 1-ha grid cell in each km² block on the photograph. Once an entire photograph was completed, all of the km² blocks covered on the photograph were displayed with the 100-ha cells in each km² block shaded according to the class of *Carya* occupying the cell. This procedure allowed the photointerpreter to review the data for the entire photograph to determine whether all data were captured properly prior to moving to the next photograph.

THE DATA BASE

The final data base consists of over 75,000, 1-ha grid cells. With each cell referenced to UTM coordinates, it can be portrayed spatially in map form or manipulated statistically to produce tabular output. The data can be sorted either by the UTM Northing (Y coordinate) or Easting (X coordinate) to provide geographic subsets of the data base for either spatial or tabular display. Figures 2 through 6 represent the Brazos River System data base spatially and graphically. Each figure is made up of two parts. The map depicts the portion of the river system being displayed with reference to surrounding cities. A UTM grid has been superimposed on the map in order to reference the data base. The associated graphical presentation of the data depicts the quantity of the three types of *Carya* (native, orchard, or wild). The Northings drawn on this portion of the figure correspond with those in the map portion of the figure. The two portions of the figure are registered to one another (by using the Northing coordinates) so that the abundance and distribution of *Carya* can easily be seen. Also, in graphical presentation, the number of kilometers of river running through each 10,000-meter tier (Northing) of the data base is given so that a relative density per kilometer of river may be computed. This type of presentation is also provided for the Colorado River System (Figures 8-13).

DATA BASE STATISTICS

For each of Figures 2 through 6 and 8 through 13, a corresponding table has been prepared. These tables provide some statistics regarding: 1) the geographic area, depicted in 10,000-meter tiers of the data base, covered on each figure, 2) the number of hectares covered on the aerial photographs used to image the area covered, 3) the number of grid cells containing *Carya* in each of the three categories of *Carya* (native, orchard, or wild), 4) the hectareage of ground covered by *Carya* canopy, and 5) the hectareage of ground covered by tree species other than *Carya*.

Each table can be referenced to its corresponding figure by reading the UTM coordinates (Y coordinate) for each tier and locating the same tier on the map. The data shown in each tier in a table characterizes the *Carya* resource for that corresponding tier on the map.

The hectareage covered on the film represents the total hectareages covered by the aerial photographs that were used to image that particular tier. The next six columns in the table show the hectareages of ground covered by *Carya* canopy and the hectareages imaged on the aerial photographs that contained *Carya*. This presentation is done for the three categories of *Carya*. The last column lists the hectareage covered by canopies of species of trees other than pecan.

ACKNOWLEDGEMENT

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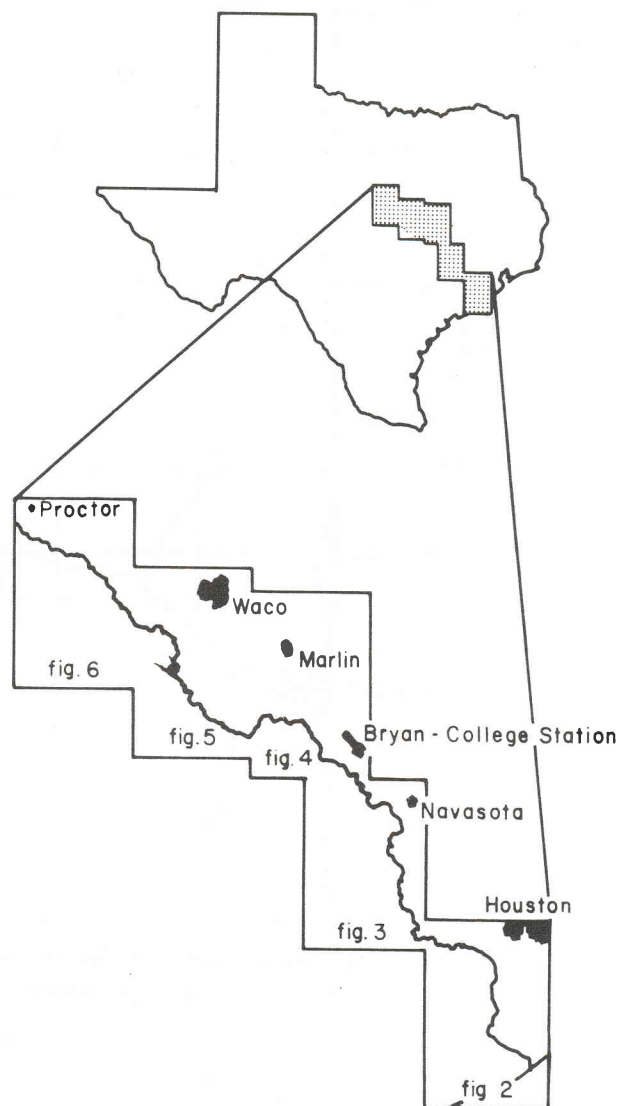


Figure 1: Index of Location and Abundance Maps,
Brazos River System

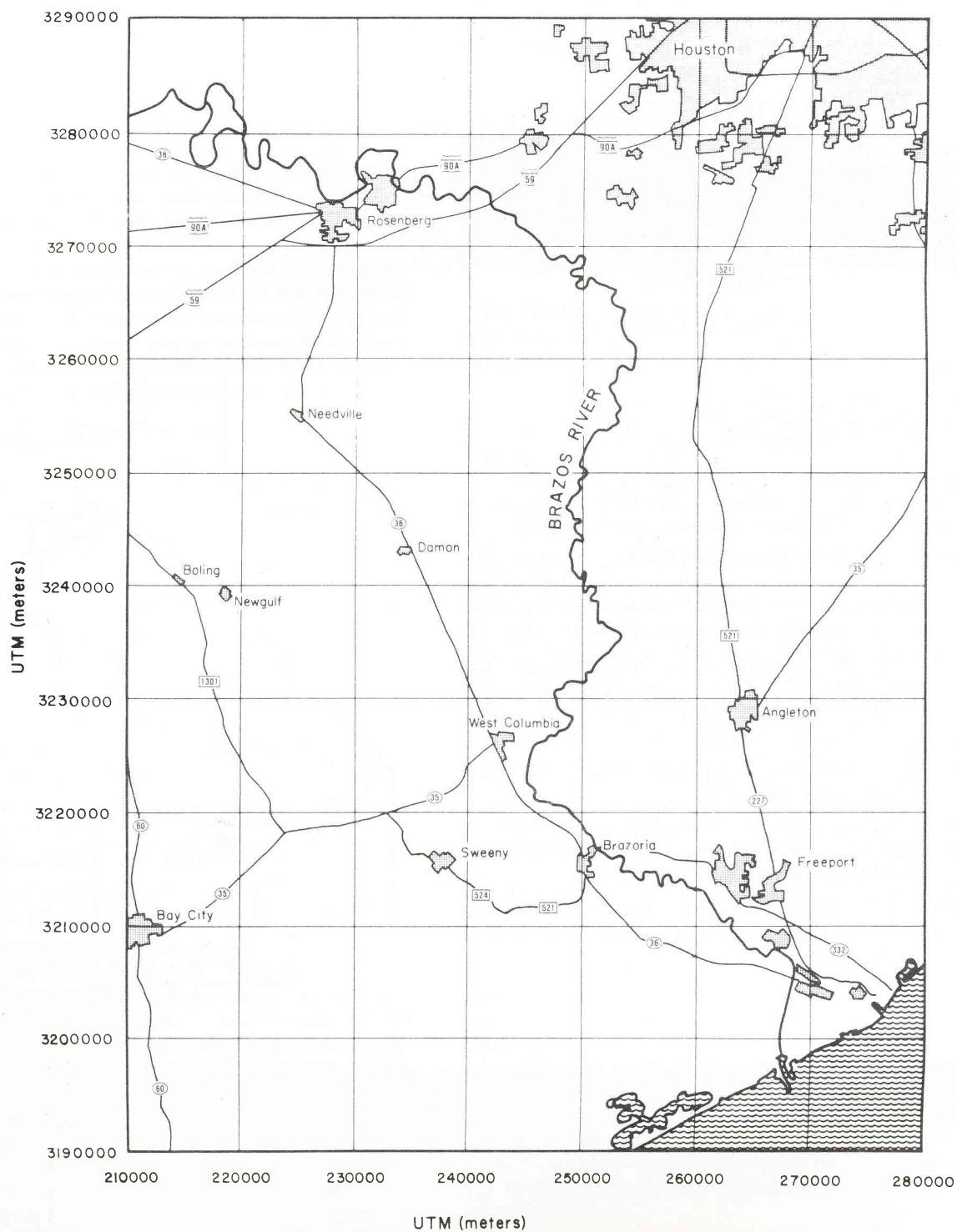


Figure 2: Location and Abundance of *Carya*, Brazos River System

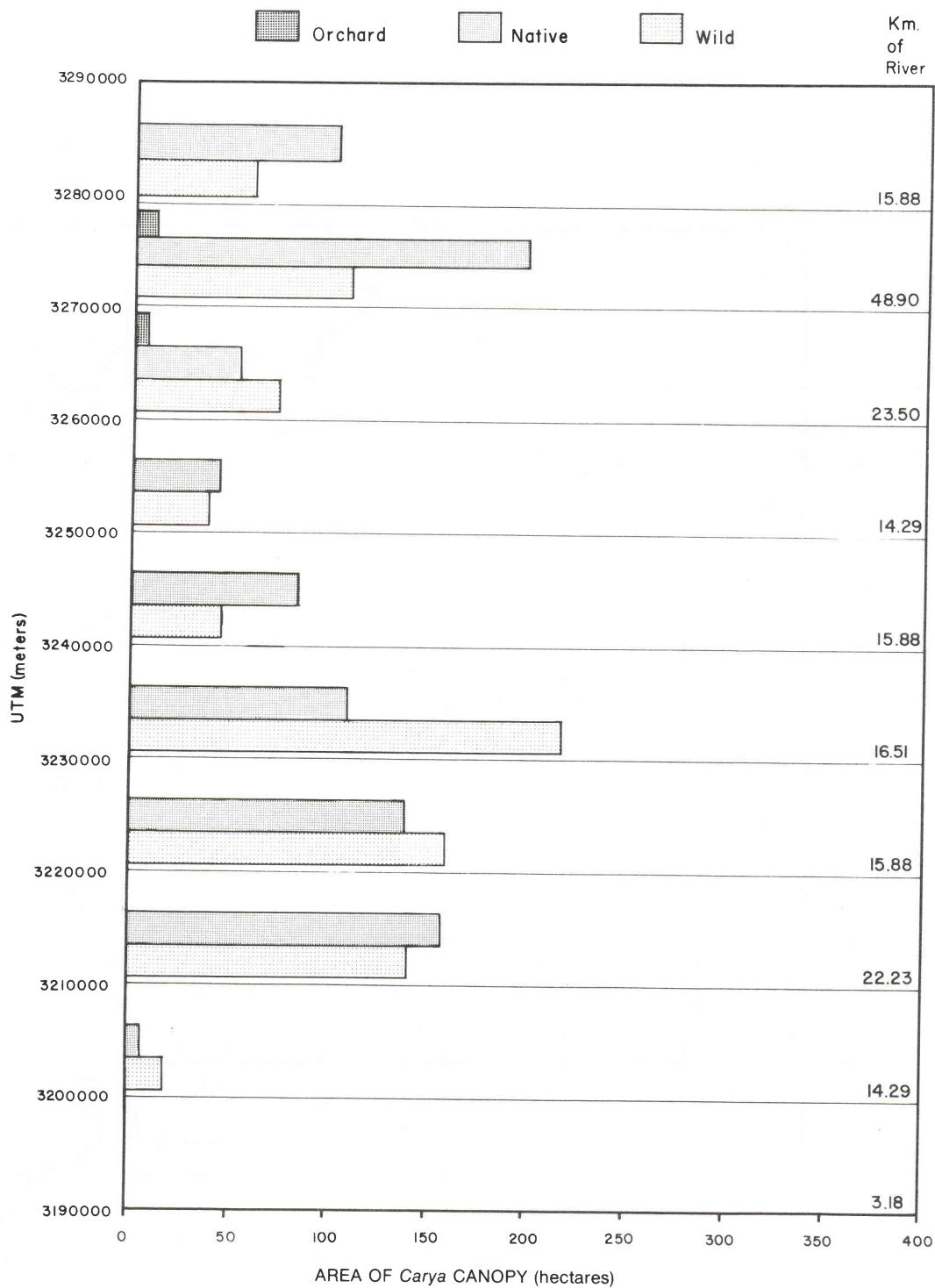


Table 1. Tabular listing of data base statistics for the portion of the Brazos River System covered by Figure 2

UTM	Native			Orchard		Wild		
	No. Ha Covered on Film	Canopy Ha of Pecan	No. of Ha Containing Pecan	Canopy Ha of Pecan	No. of Ha Containing Pecan	Canopy Ha of Pecan	No. of Ha Containing Pecan	No. of Ha of Other Trees
32000	3513	6.63	61	0.00	0	18.86	182	110.29
32100	5692	158.11	910	0.00	0	140.07	1137	727.30
32200	4082	139.05	800	0.00	0	159.23	1069	666.95
32300	4296	111.56	670	0.00	0	220.80	1363	858.90
32400	3617	84.83	664	0.00	0	45.80	340	197.83
32500	3629	44.17	489	0.00	0	38.79	535	338.95
32600	4774	53.47	589	6.13	22	73.80	844	472.76
32700	14572	198.01	1860	9.65	36	111.26	1036	440.33
32800	4578	100.97	939	0.32	2	59.56	505	232.58

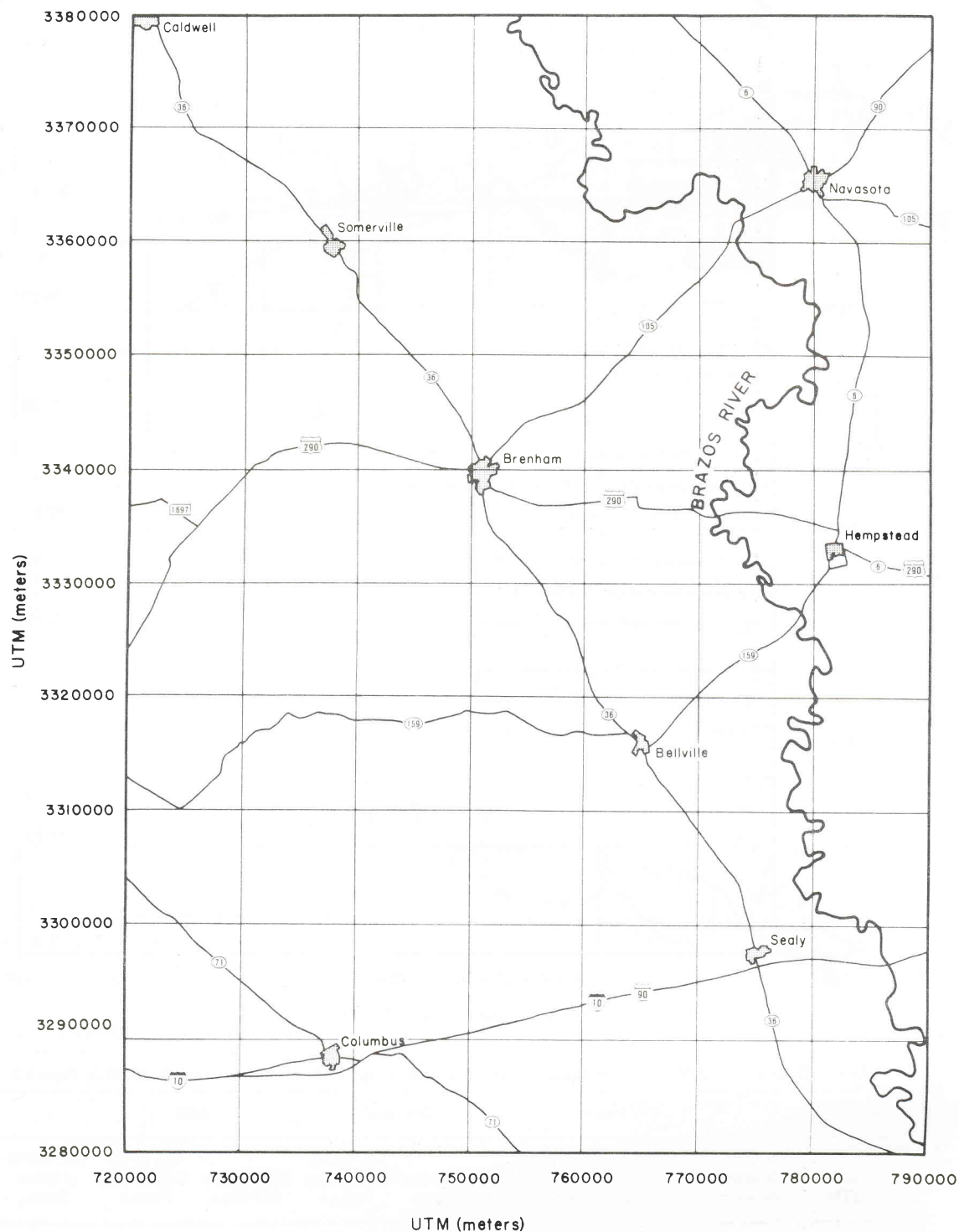


Figure 3: Location and Abundance of *Carya*, Brazos River System

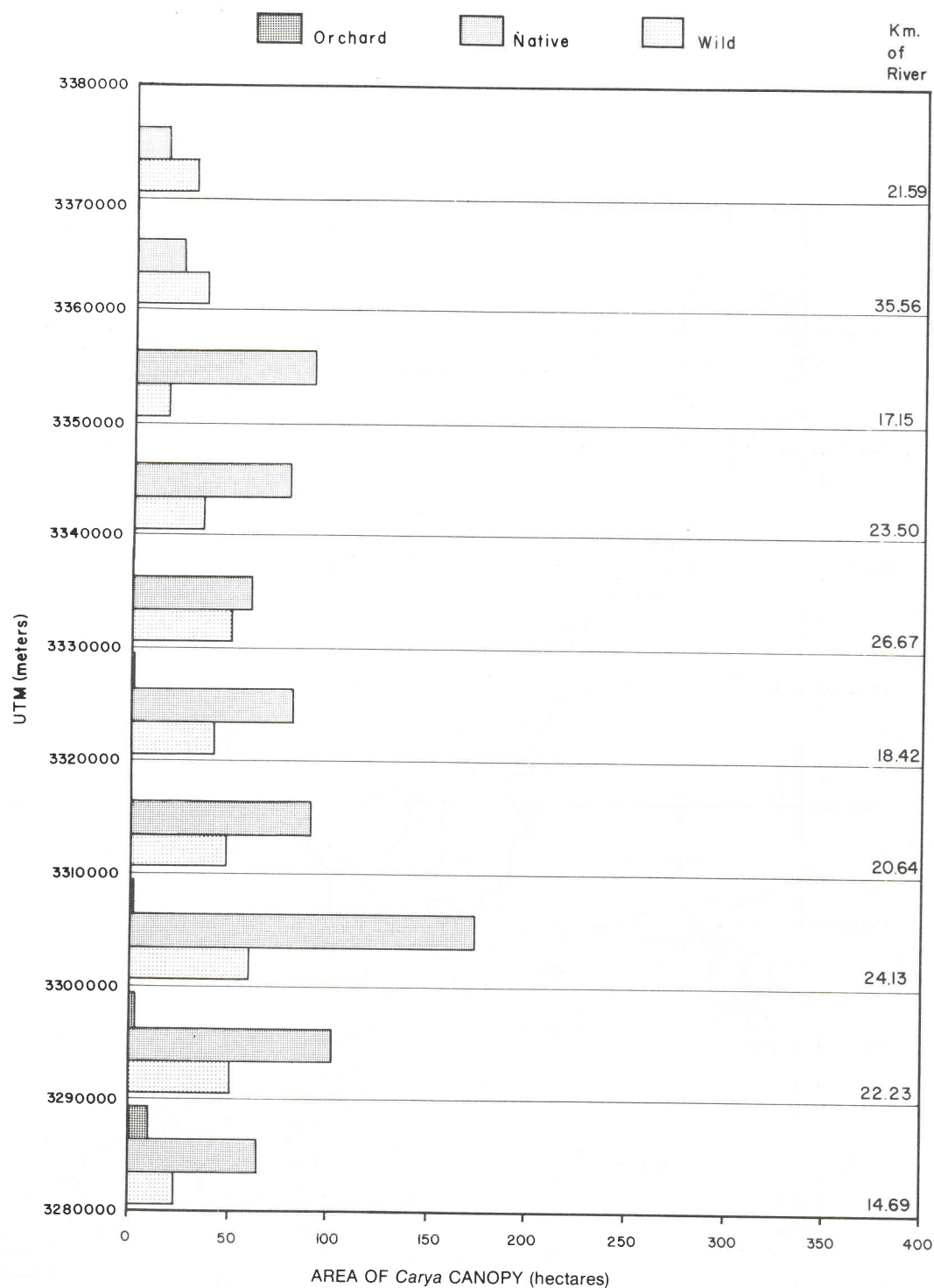


Table 2. Tabular listing of data base statistics for the portion of the Brazos River System covered by Figure 3

UTM	Native		Orchard		Wild		No. of Ha of Other Trees
	No. Ha Covered on Film	Canopy Ha of Pecan	No. of Ha Containing Pecan	Canopy Ha of Pecan	No. of Ha Containing Pecan	Canopy Ha of Pecan	
32800	3622	64.63	625	9.89	22	22.95	72.47
32900	1626	102.44	791	2.07	28	50.93	90.74
33000	4247	173.82	998	1.07	7	59.66	219.38
33100	4517	90.86	690	0.00	0	47.81	152.28
33200	4413	81.47	646	1.02	4	41.22	202.10
33300	3739	60.72	583	0.00	0	49.71	210.37
33400	3580	77.82	638	0.00	0	35.57	137.33
33500	4357	89.94	726	0.83	5	20.27	93.82
33600	9872	23.15	236	0.41	5	36.16	88.40
33700	4370	18.99	339	0.00	0	29.73	150.31

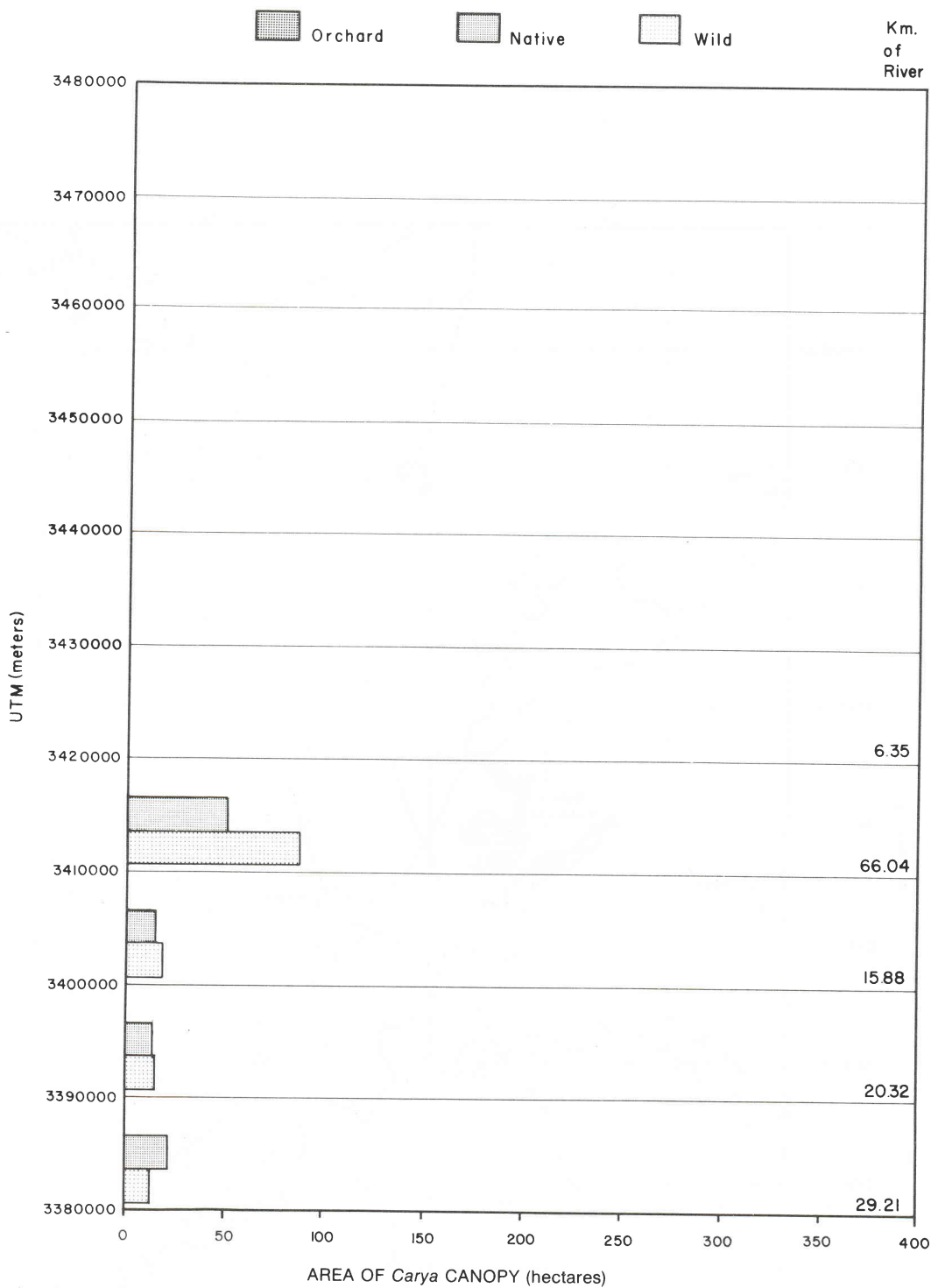


Table 3. Tabular listing of data base statistics for the portion of the Brazos River System covered by Figure 4

UTM	Native			Orchard			Wild	
	No. Ha Covered on Film	Canopy Ha of Pecan	No. of Ha Containing Pecan	Canopy Ha of Pecan	No. of Ha Containing Pecan	Canopy Ha of Pecan	No. of Ha Containing Pecan	No. of Ha of Other Trees
33800	3998	21.28	435	0.63	2	11.83	328	119.83
33900	4774	13.30	274	0.00	0	14.48	325	134.21
34000	5263	13.56	228	0.00	0	18.16	305	164.07
34100	13256	50.03	563	0.00	0	86.96	1175	529.04

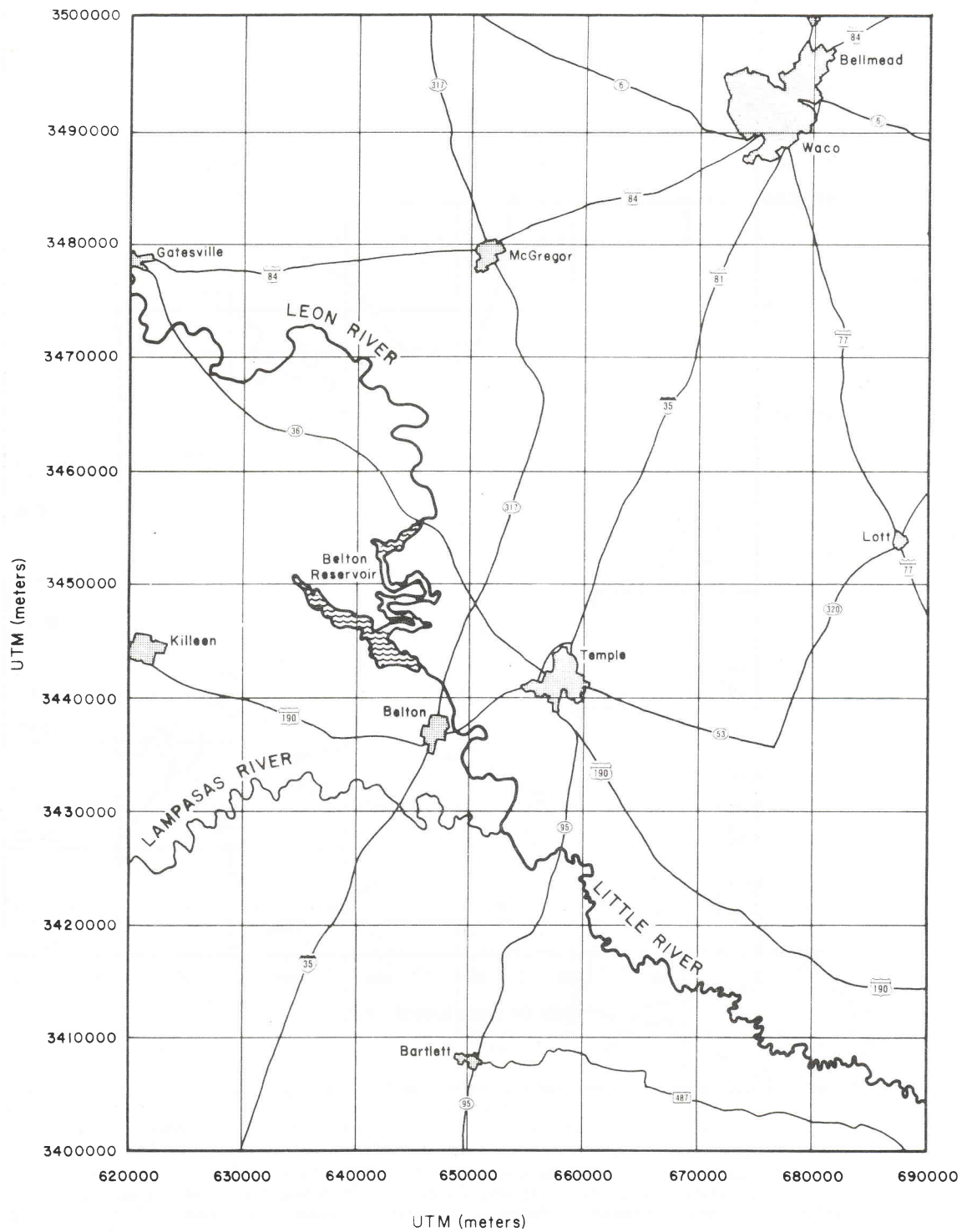


Figure 5: Location and Abundance of *Carya*, Brazos River System

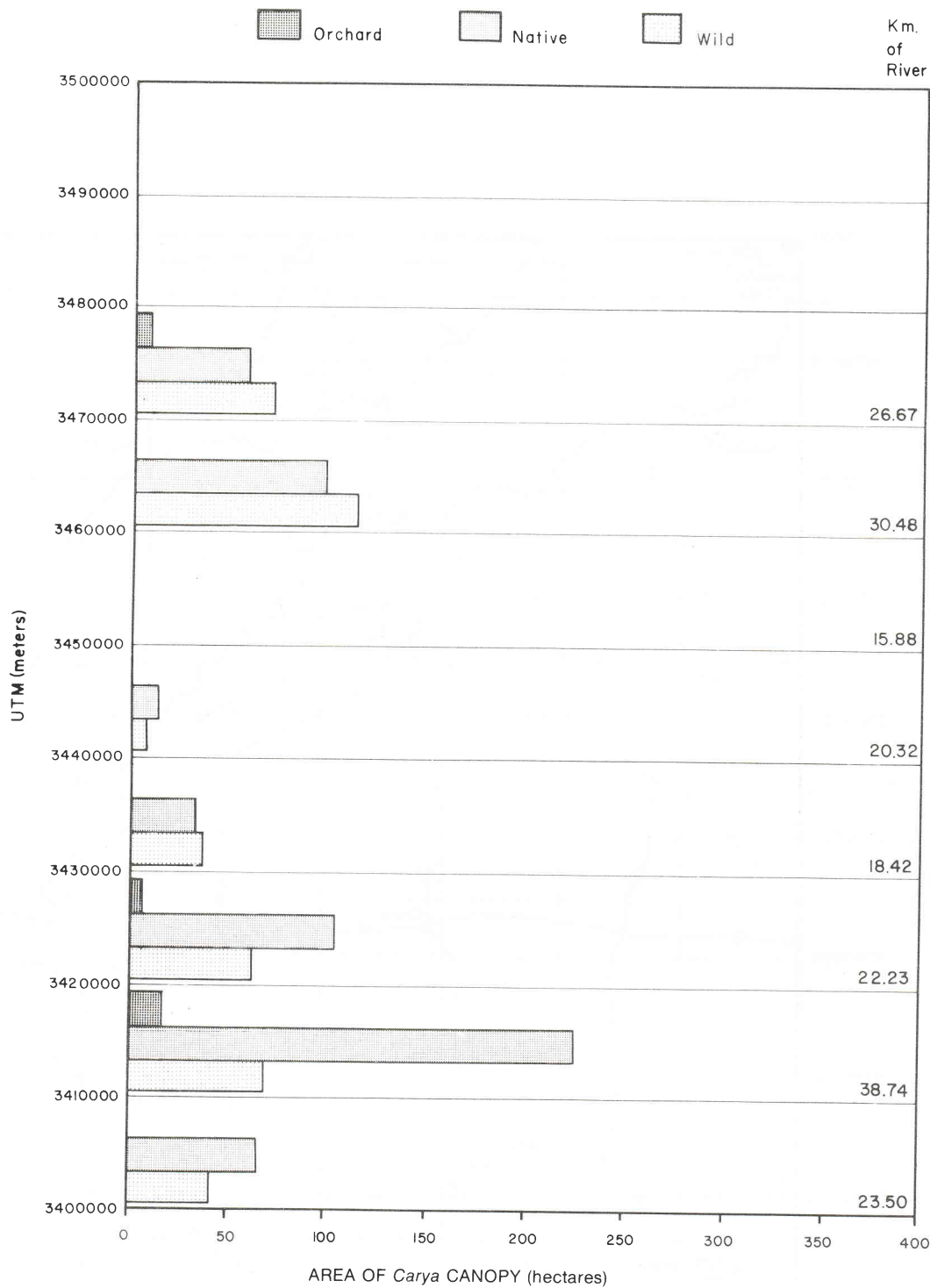


Table 4. Tabular listing of data base statistics for the portion of the Brazos River System covered by Figure 5

UTM	Native			Orchard		Wild		
	No. Ha Covered on Film	Canopy Ha of Pecan	No. of Ha Containing Pecan	Canopy Ha of Pecan	No. of Ha. Containing Pecan	Canopy Ha of Pecan	No. of Ha Containing Pecan	No. of Ha of Other Trees
34000	3856	64.68	378	0.00	0	40.80	370	146.62
34100	6683	224.30	1055	16.79	63	68.72	691	168.28
34200	5055	103.03	643	6.13	18	61.75	623	211.91
34300	7081	32.67	258	0.00	0	35.38	480	223.92
34400	1095	13.40	76	0.06	1	7.90	102	37.71
34500	0	0.00	0	0.00	0	0.00	0	0.00
34600	7320	96.47	722	1.32	8	110.83	866	278.94
34700	6328	56.81	464	7.32	31	70.63	591	249.98

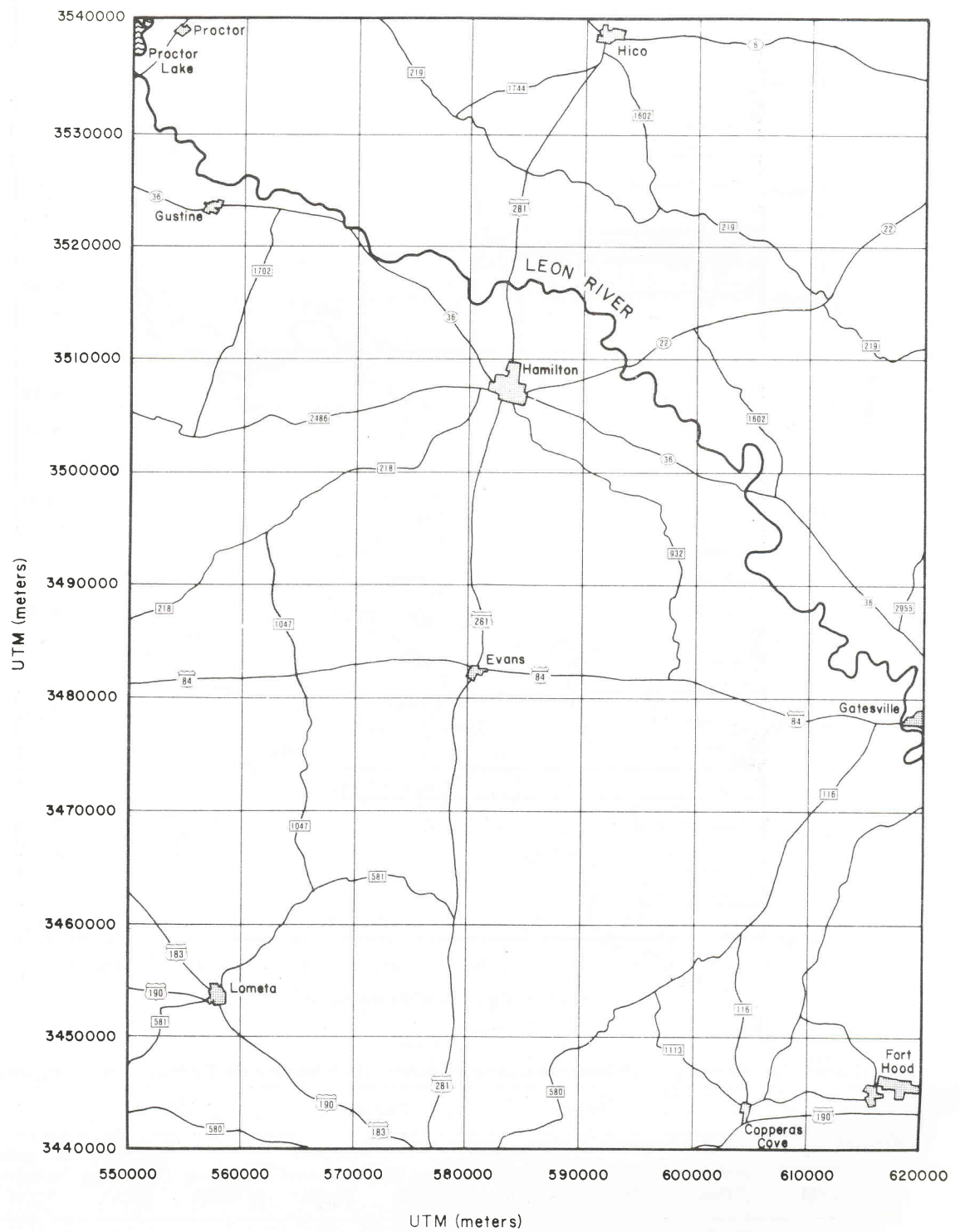


Figure 6: Location and Abundance of *Carya*, Brazos River System

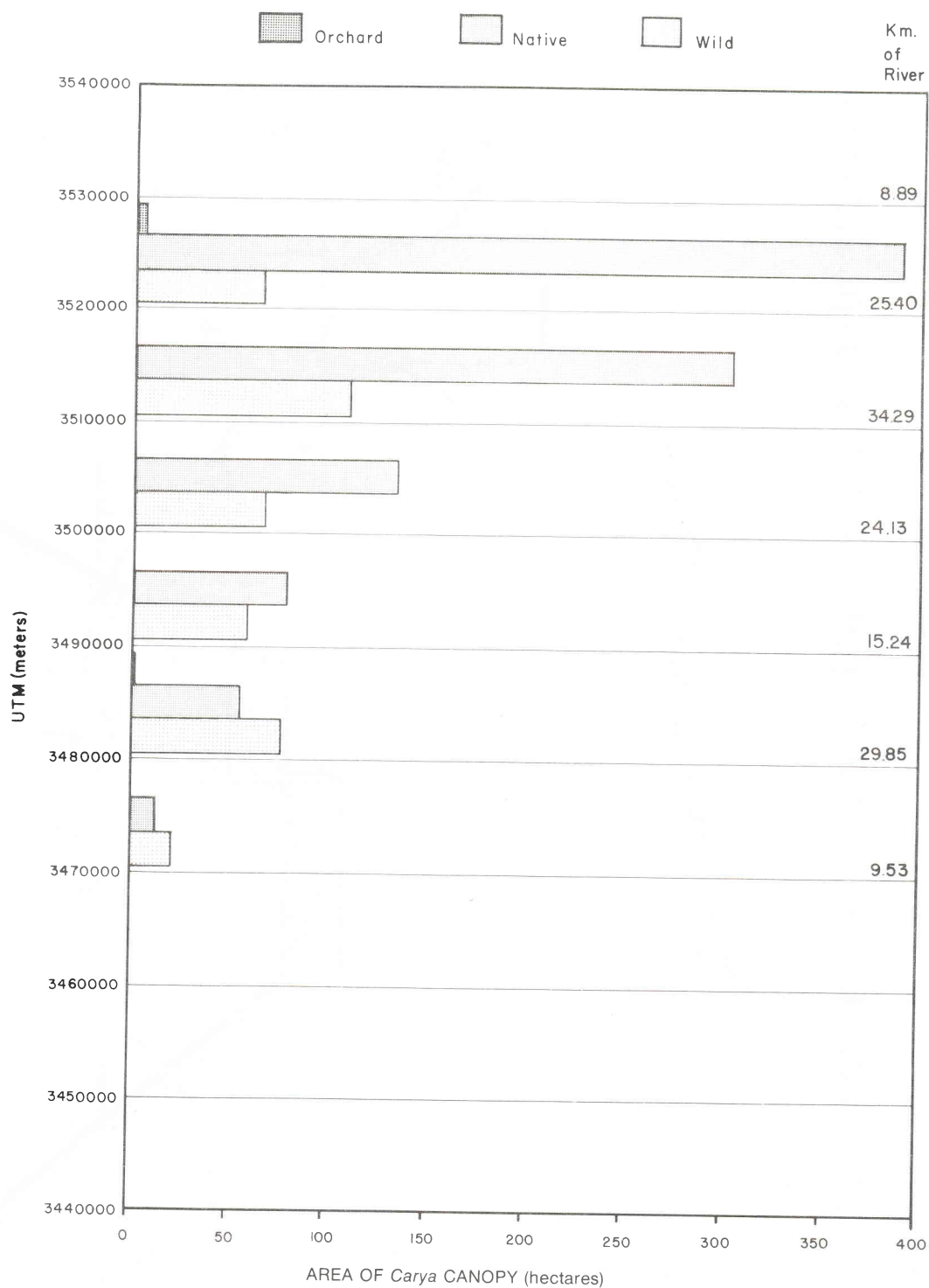
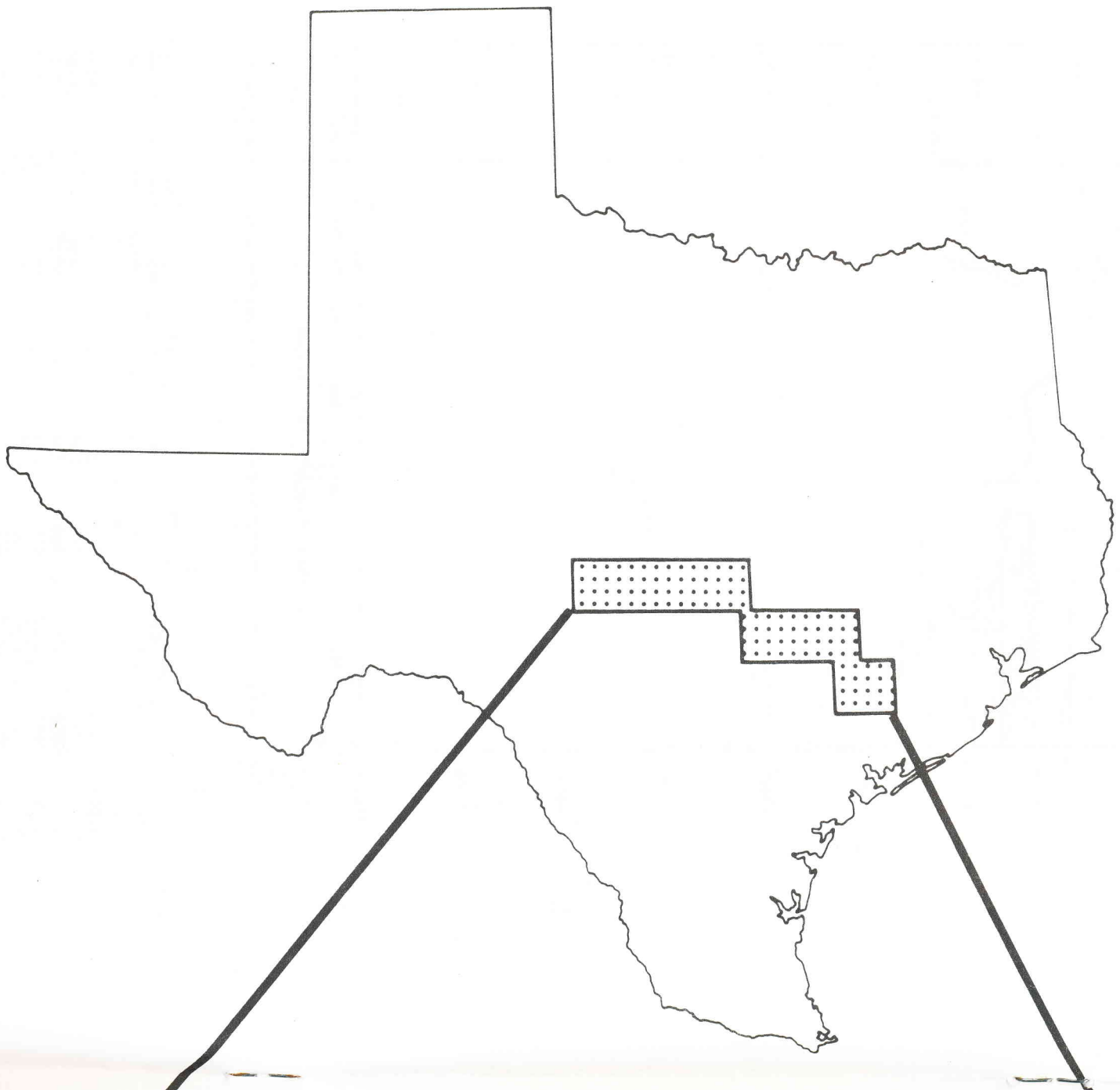


Table 5. Tabular listing of data base statistics for the portion of the Brazos River System covered by Figure 6

UTM	Native			Orchard		Wild		
	No. Ha Covered on Film	Canopy Ha of Pecan	No. of Ha Containing Pecan	Canopy Ha of Pecan	No. of Ha Containing Pecan	Canopy Ha of Pecan	No. of Ha Containing Pecan	No. of Ha of Other Trees
34700	1720	11.95	105	0.10	2	21.38	205	83.58
34800	6077	54.24	491	1.44	7	74.98	603	249.63
34900	3990	77.08	469	0.00	0	57.33	336	120.80
35000	5581	132.80	615	0.26	2	65.58	348	326.71
35100	7693	302.90	1208	0.45	1	108.52	612	254.46
35200	4994	388.74	1358	3.76	13	64.34	330	117.36



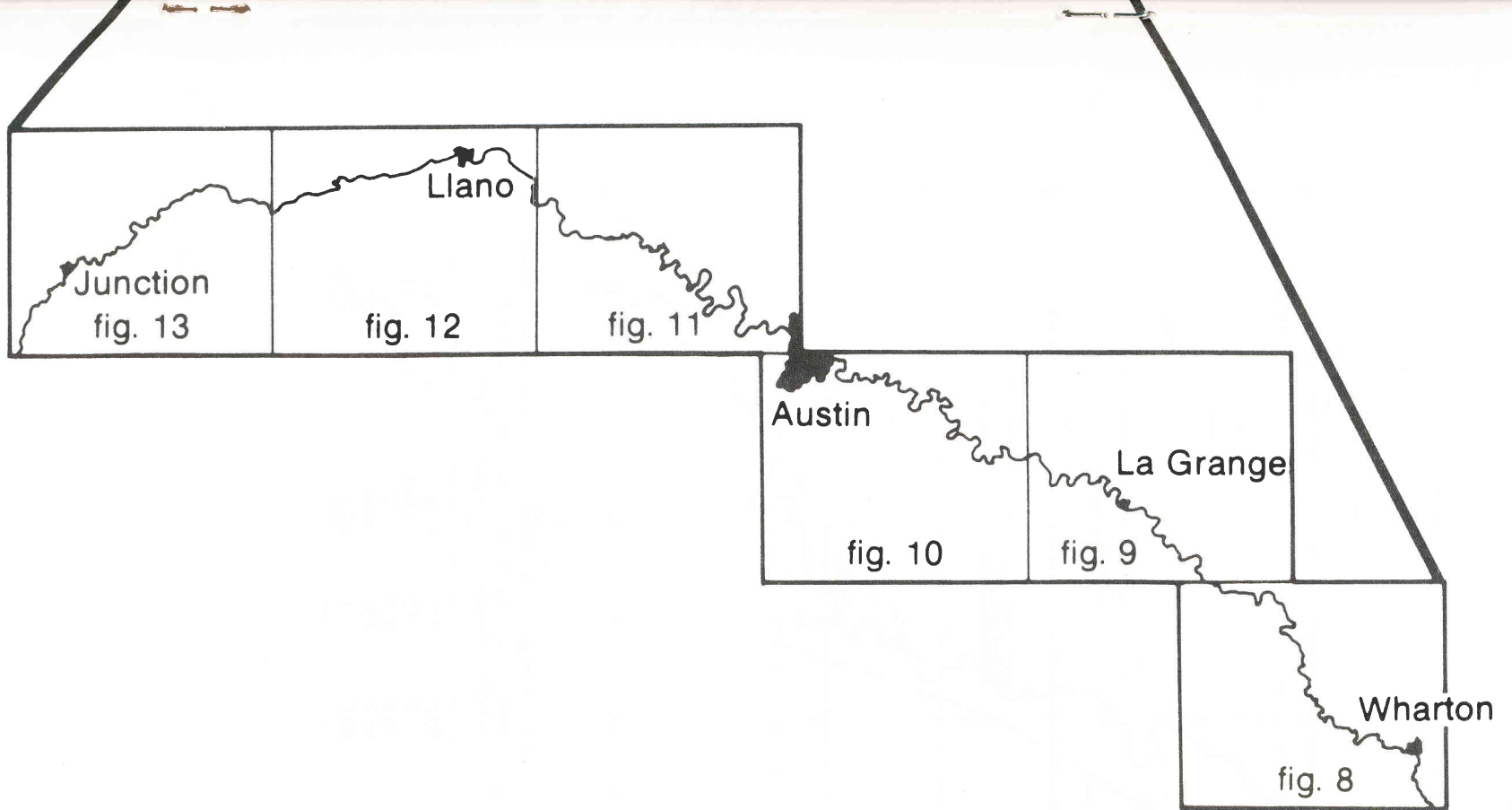


Figure 7: Index of Location and Abundance Maps, Colorado River System

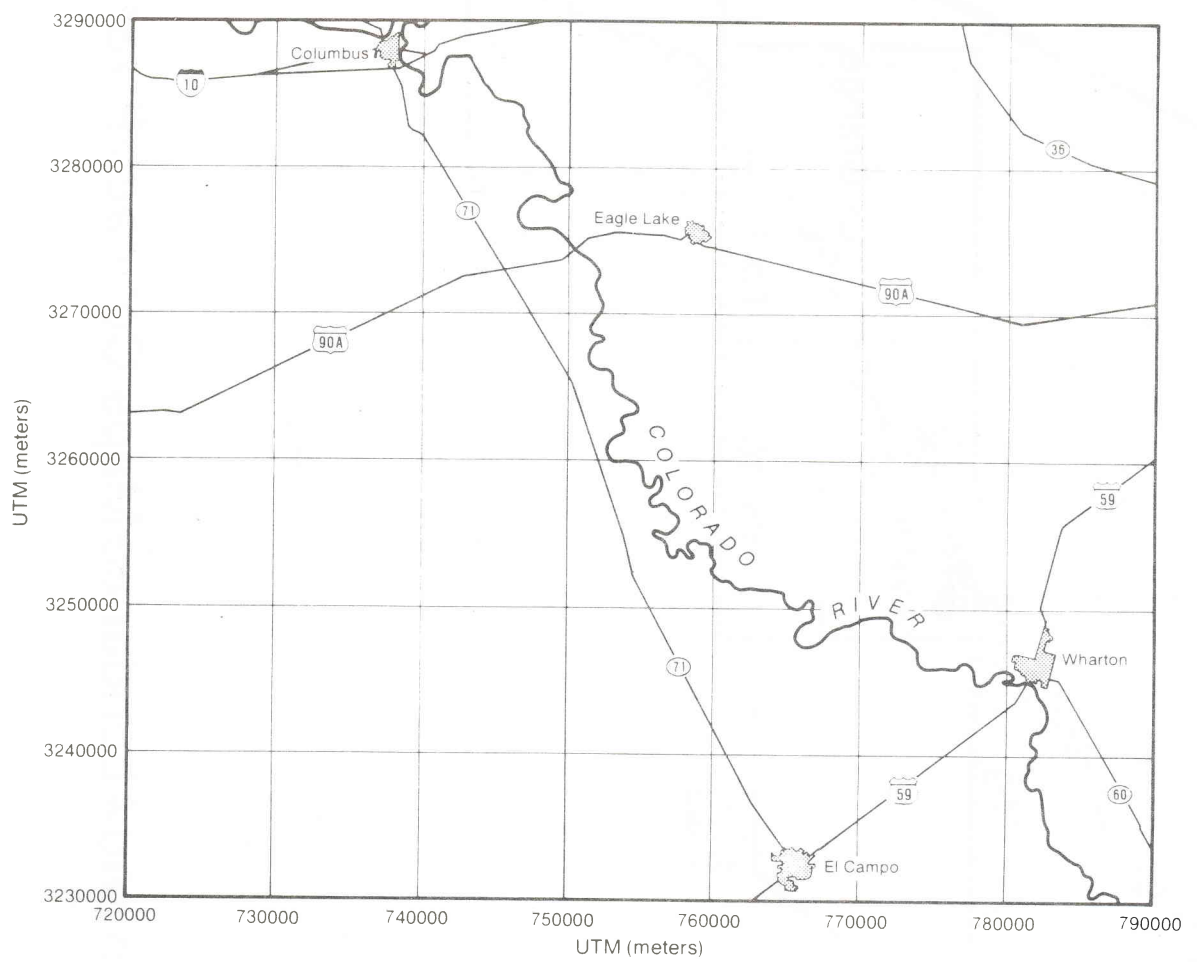


Figure 8: Location and Abundance of *Carya*, Colorado River System

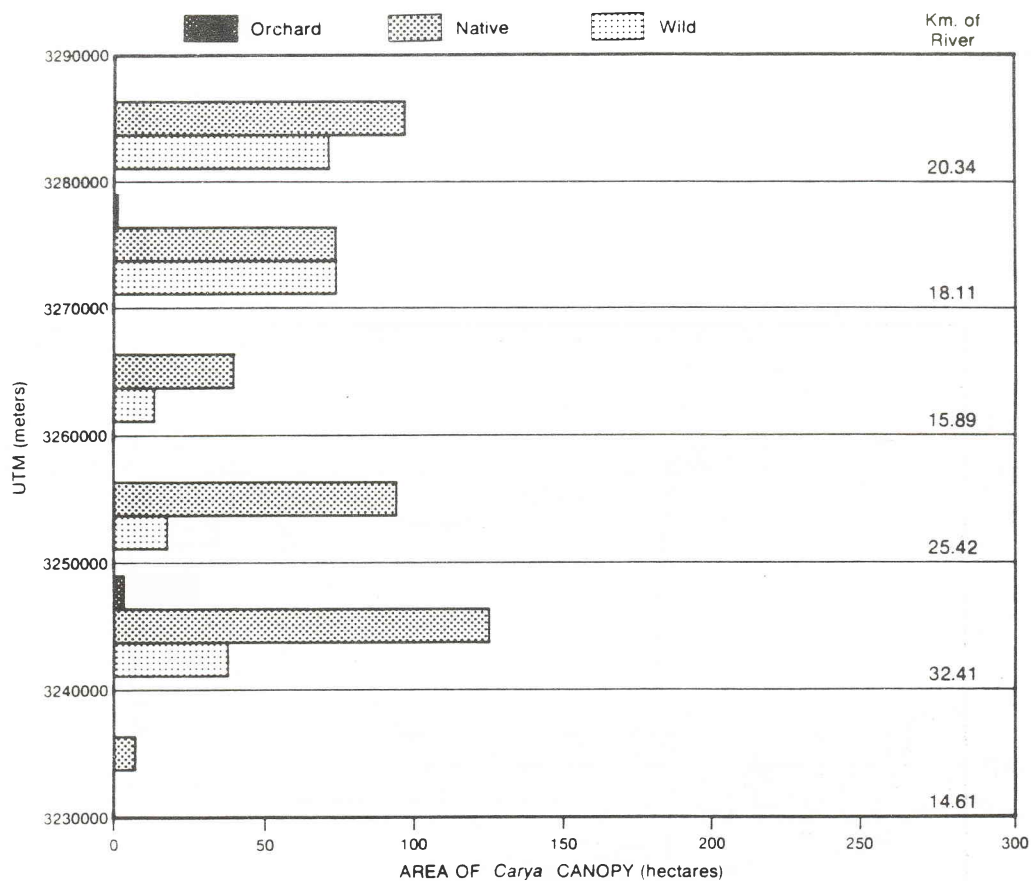


Table 6. Tabular listing of data base statistics for the portion of the Colorado River System covered by Figure 8

UTM	Native		Orchard		Wild		No. of Ha of Other Trees
	No. Ha Covered on Film	No. of Ha Canopy Ha of Pecan	No. of Ha Canopy Ha of Pecan	No. of Ha Containing Pecan	No. of Ha Canopy Ha of Pecan	No. of Ha Containing Pecan	
32300		8.33	21	0.00	0	0.25	2.24
32400		124.44	581	2.87	10	38.18	154.91
32500		112.44	678	0.00	0	17.09	204.08
32600		39.48	168	0.30	3	13.82	59.24
32700		71.29	446	1.06	4	71.84	297.69
32800		94.99	484	0.45	3	70.12	287.18

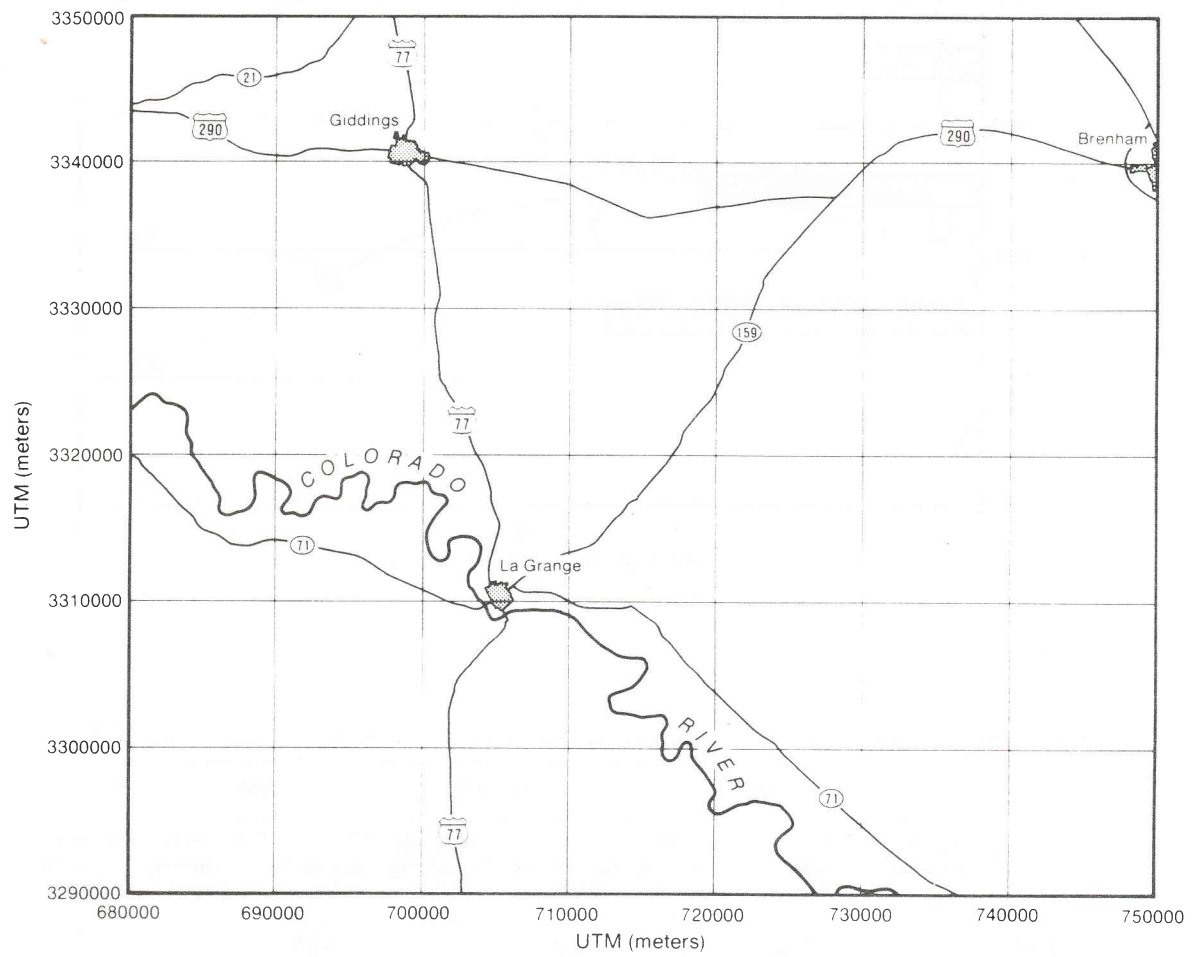


Figure 9: Location and Abundance of *Carya*, Colorado River System

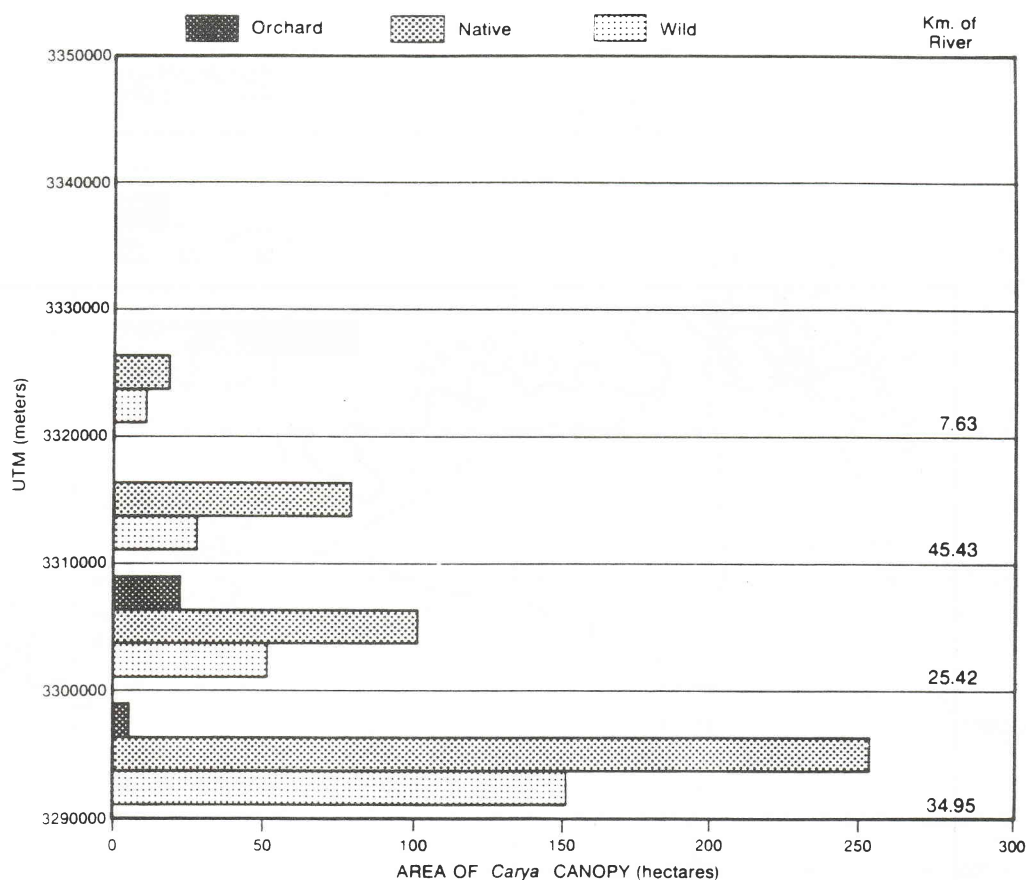


Table 7. Tabular listing of data base statistics for the portion of the Colorado River System covered by Figure 9

UTM	Native		Orchard		Wild		No. of Ha Containing Pecan	No. of Ha of Other Trees
	No. Ha Covered on Film	Canopy Ha of Pecan	No. of Ha Containing Pecan	Canopy Ha of Pecan	No. of Ha Containing Pecan	Canopy Ha of Pecan		
32900		253.70	1111	5.30	20	149.85	1009	440.25
33000		93.83	623	22.53	72	52.52	525	319.65
33100		78.20	448	0.30	3	28.39	225	94.70
33200		18.17	110	0.00	0	10.55	116	39.77
33300		0.00	0	0.00	0	0.00		
33400		0.00	0	0.00	0	0.00		

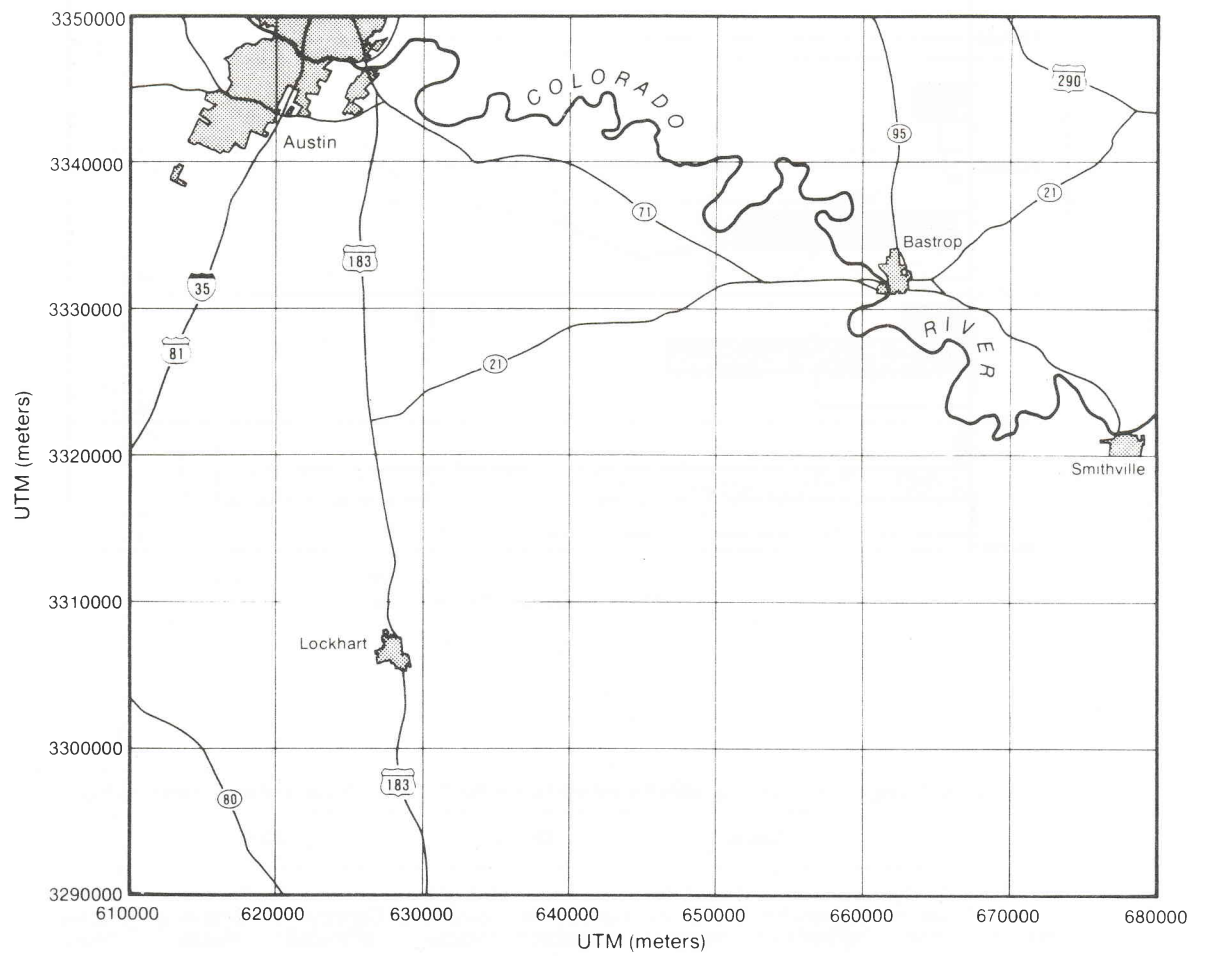


Figure 10: Location and Abundance of *Carya*, Colorado River System

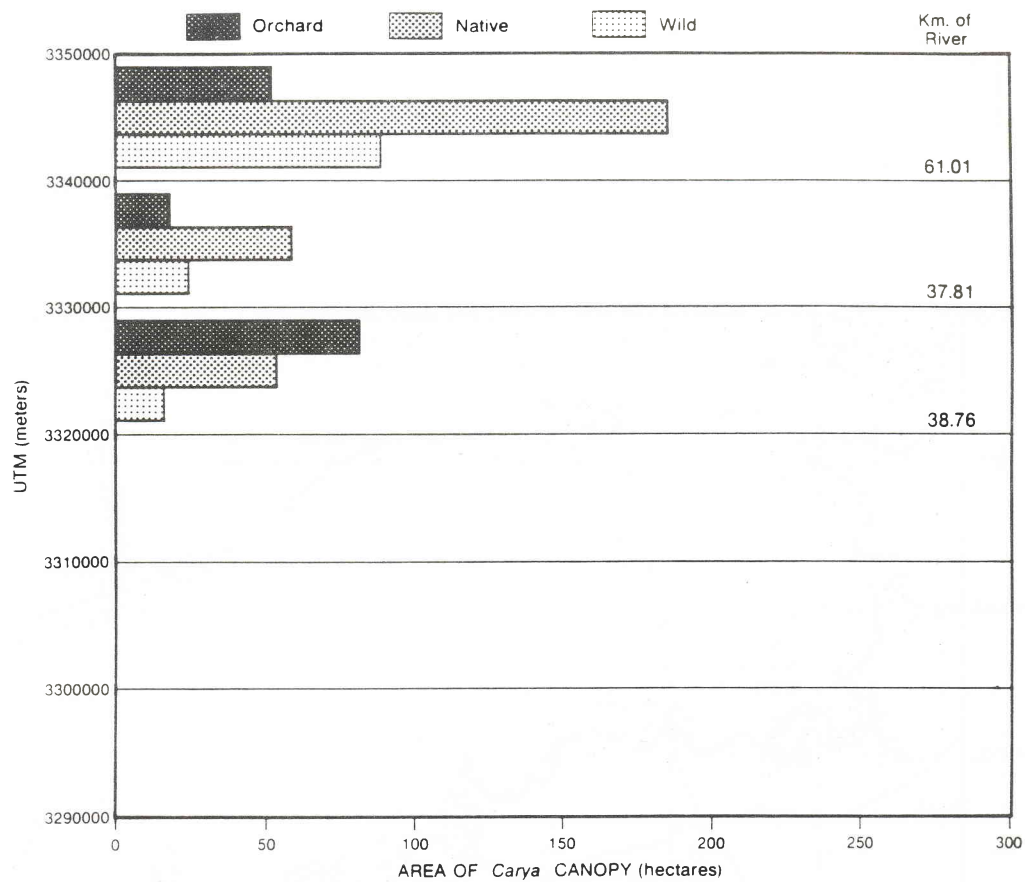


Table 8. Tabular listing of data base statistics for the portion of the Colorado River System covered by Figure 10

UTM	Native		Orchard		Wild		No. of Ha of Other Trees
	No. Ha Covered on Film	No. of Ha Containing Pecan	No. of Ha Containing Pecan	No. of Ha Containing Pecan	No. of Ha Containing Pecan	No. of Ha Containing Pecan	
32900		0.00	0	0.00	0	0.00	0.00
33000		0.00	0	0.00	0	0.00	0.00
33100		0.00	0	0.00	0	0.00	0.00
33200		52.81	384	16.59	178	79.93	77.36
33300		56.79	587	15.57	54	23.19	164.59
33400		183.91	1448	52.30	183	87.75	385.74

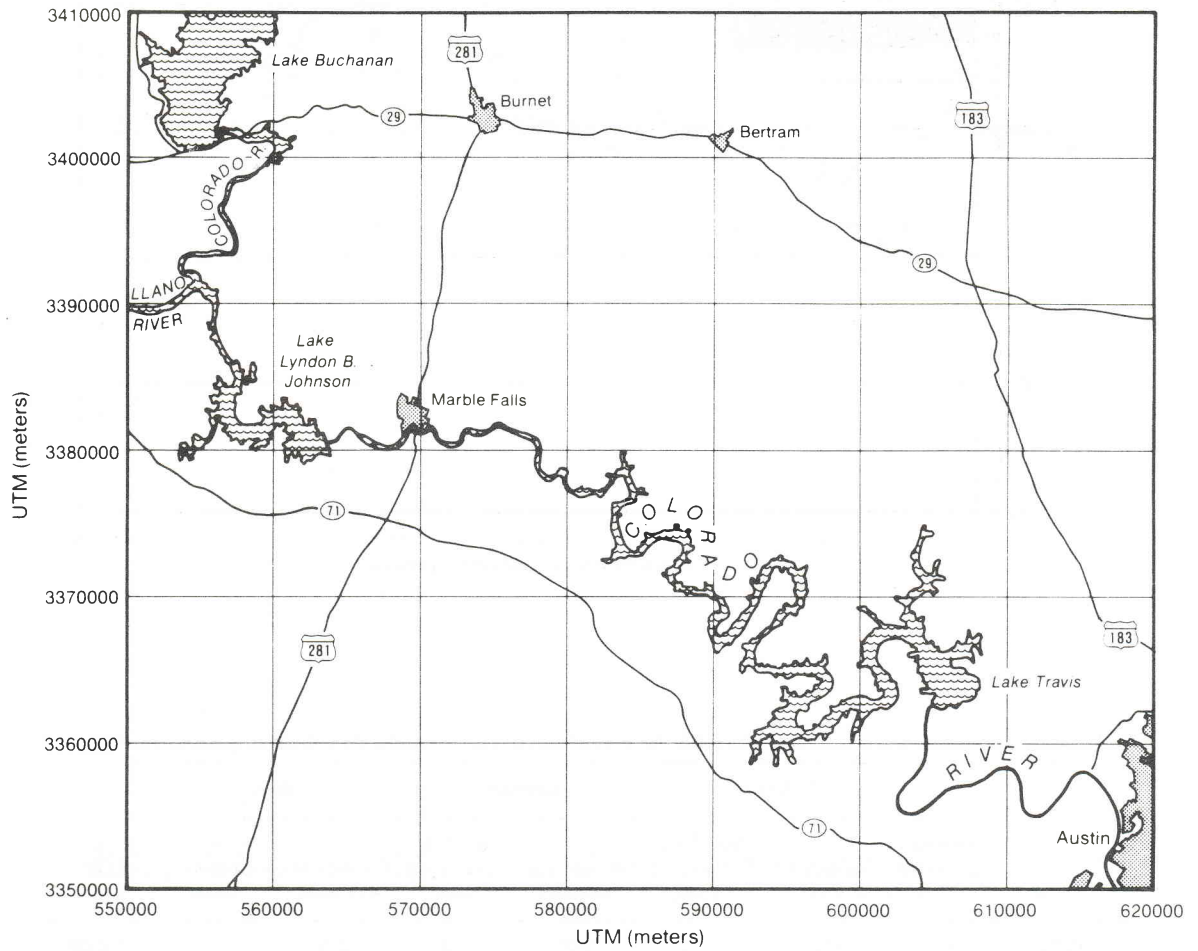


Figure 11: Location and Abundance of *Carya*, Colorado River System

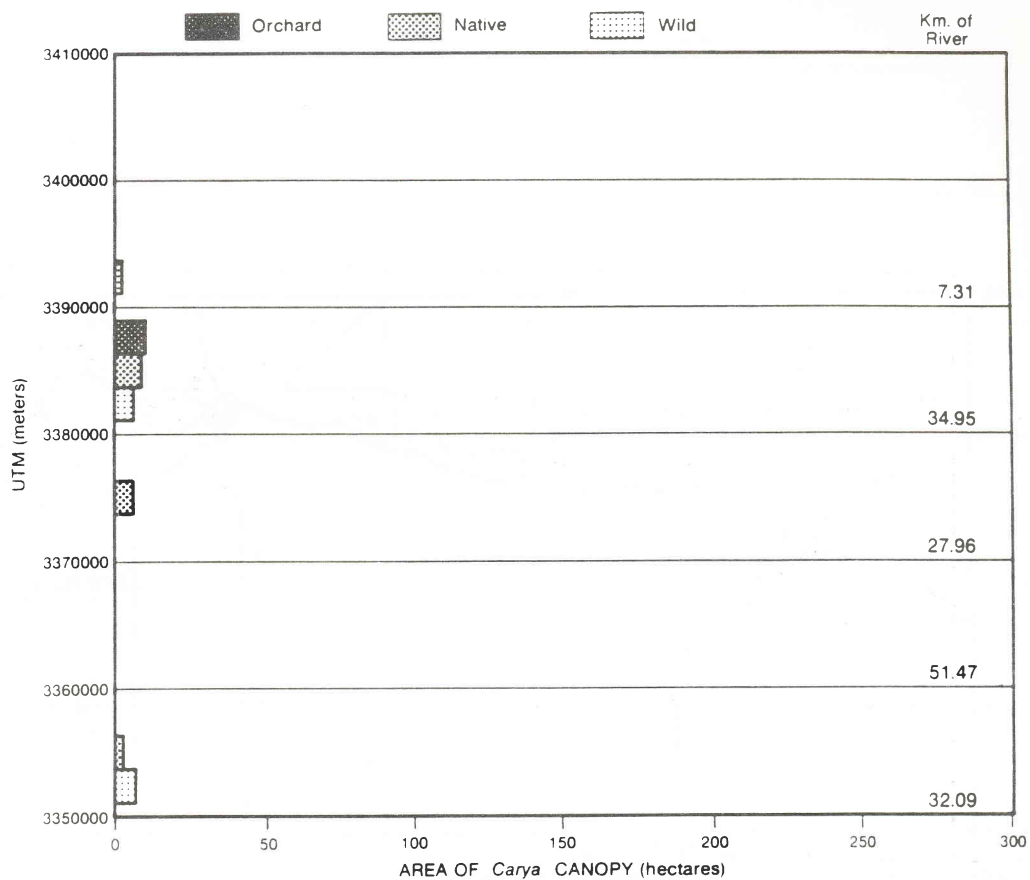


Table 9. Tabular listing of data base statistics for the portion of the Colorado River System covered by Figure 11

UTM	No. Ha Covered on Film	Native		Orchard		Wild		
		Canopy Ha of Pecan	No. of Ha Containing Pecan	Canopy Ha of Pecan	No. of Ha Containing Pecan	Canopy Ha of Pecan	No. of Ha Containing Pecan	No. of Ha of Other Trees
33500		3.22	30	0.00	0	7.52	45	19.82
33600		0.00	0	0.00	0	0.00	0	0.00
33700		5.55	24	0.14	6	0.05	1	1.10
33800		9.25	46	9.94	70	6.21	62	15.17
33900		0.45	2	0.00	0	1.63	23	4.04

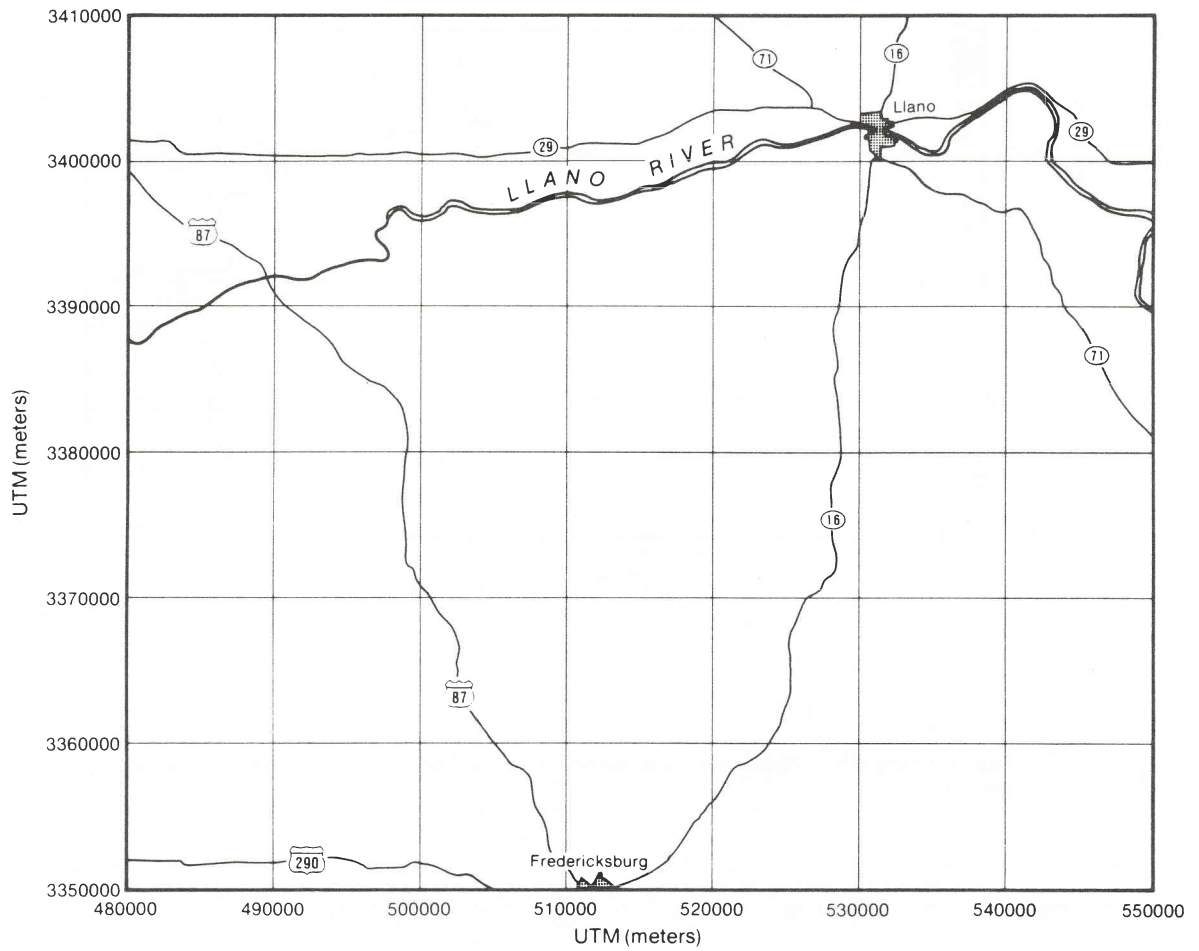


Figure 12: Location and Abundance of *Carya*, Colorado River System

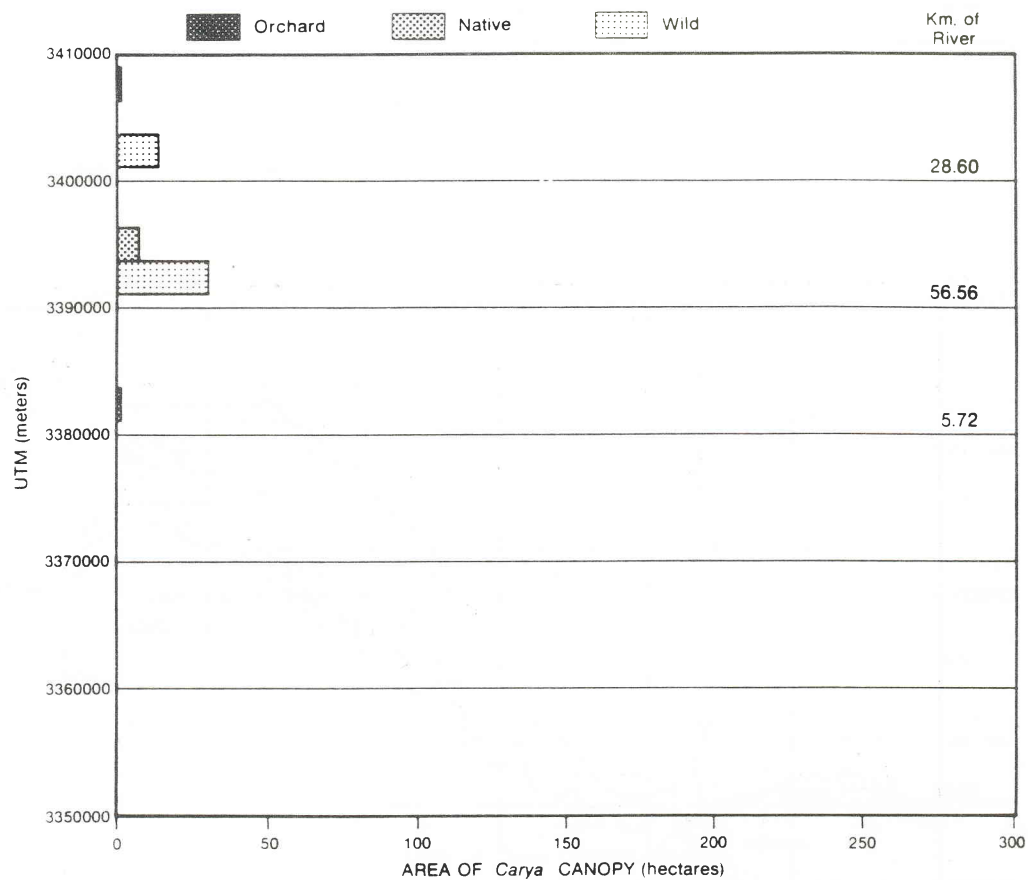


Table 10. Tabular listing of data base statistics for the portion of the Colorado River System covered by Figure 12

UTM	Native		Orchard		Wild		No. of Ha Containing Pecan	No. of Ha of Other Trees
	No. Ha Covered on Film	Canopy Ha of Pecan	No. of Ha Containing Pecan	Canopy Ha of Pecan	No. of Ha Containing Pecan	Canopy Ha of Pecan		
33500		0.00	0	0.00	0	0.00	0	0.00
33600		0.00	0	0.00	0	0.00	0	0.00
33700		0.00	0	0.00	0	0.00	0	0.00
33800		0.00	0	0.00	0	1.81	30	7.11
33900		7.41	34	0.01	1	30.18	378	56.59
34000		0.00	0	0.64	14	12.56	171	20.97

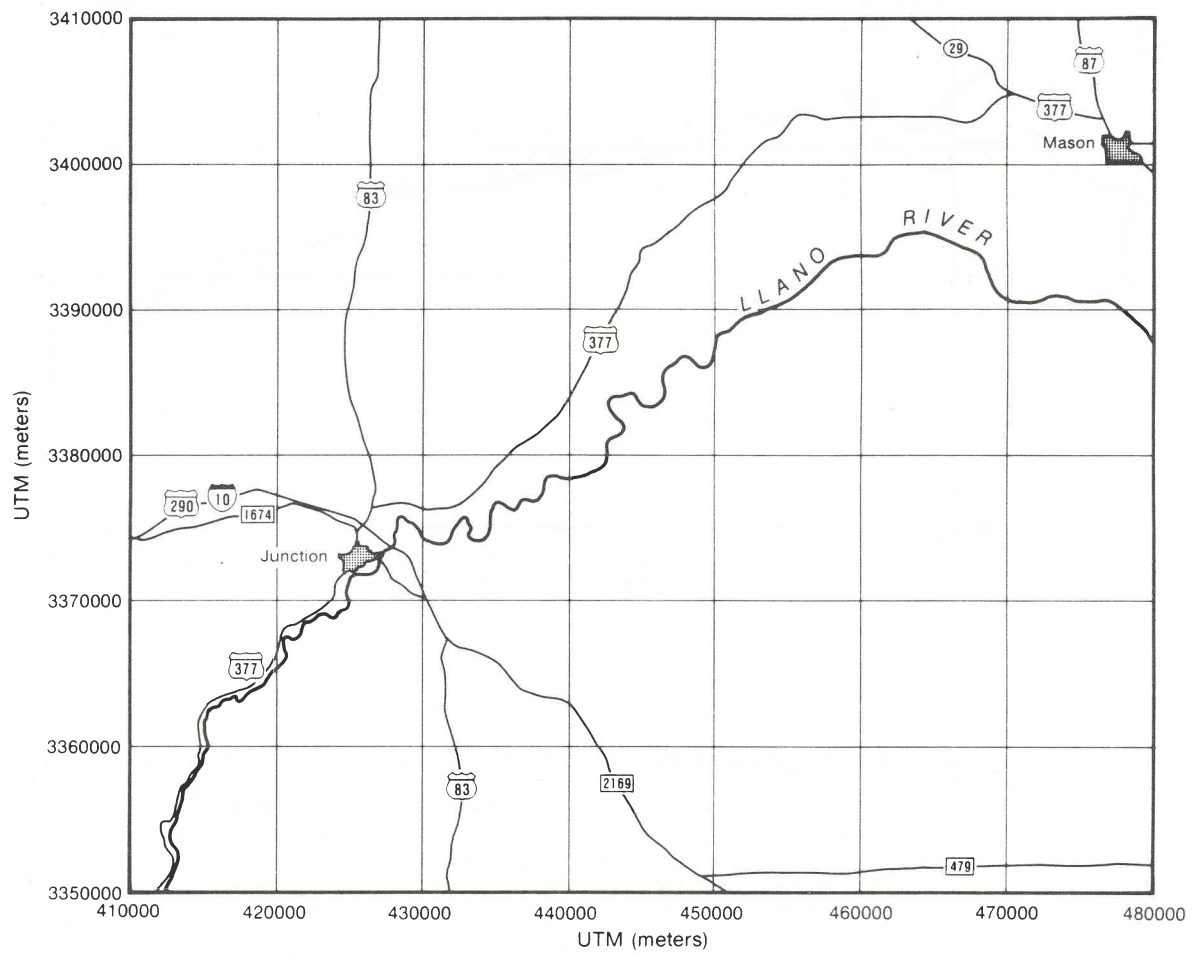


Figure 13: Location and Abundance of *Carya*, Colorado River System

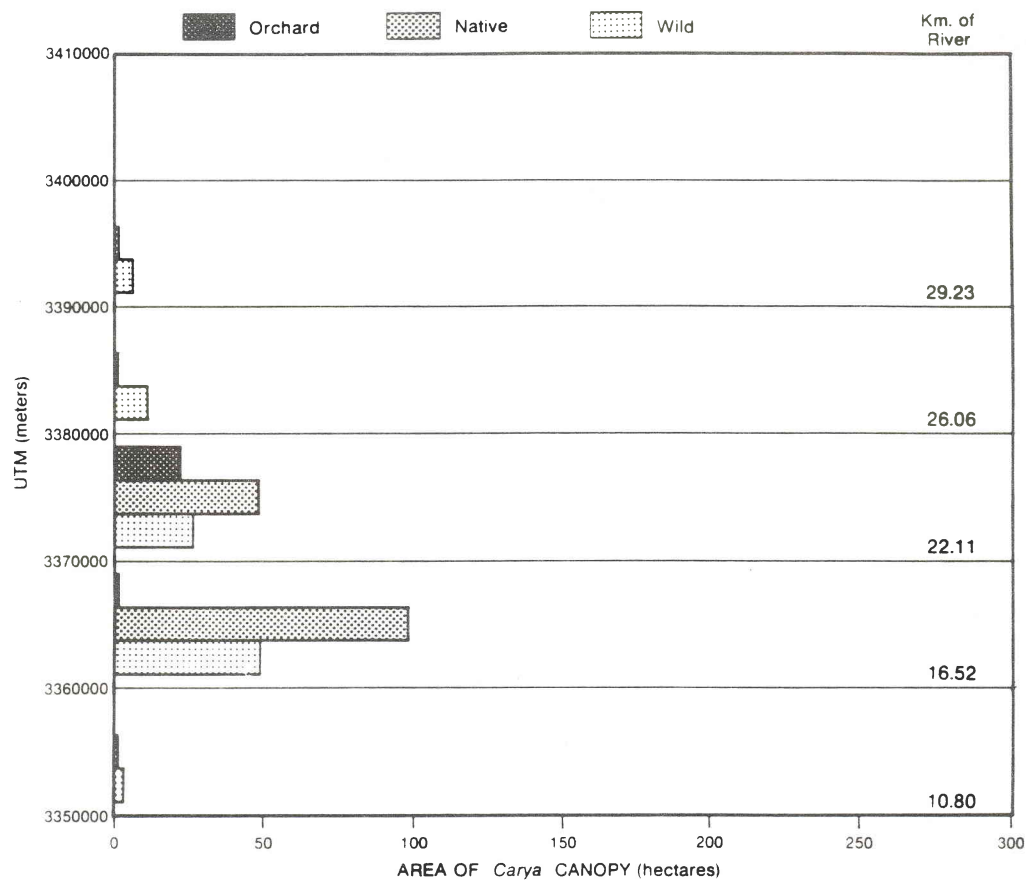


Table 11. Tabular listing of data base statistics for the portion of the Colorado River System covered by Figure 13

UTM	Native		Orchard		Wild		No. of Ha of Other Trees
	No. Ha Covered on Film	No. of Ha Canopy Ha of Pecan	No. of Ha Canopy Ha of Pecan	No. of Ha Containing Pecan	No. of Ha Canopy Ha of Pecan	No. of Ha Containing Pecan	
33500		1.02	10	0.00	0	3.12	9.88
33600		97.87	309	0.55	3	48.94	78.21
33700		47.61	210	21.62	78	25.69	55.47
33800		0.98	14	0.00	0	11.93	38.15
33900		0.58	9	0.00	0	6.37	32.37
34000		0.00	0	0.00	0	0.00	0.00