A Comparison of the Woody Vegetation in Adjacent Riparian

and Upland Areas Inhabited by Beaver (*Castor canadensis*)

A paper presented for completion

of Honors' Project

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February 2012

To the Honors' Committee:

I am submitting this paper written by Cullen Pressley entitled "A Comparison of the Woody Vegetation in Adjacent Riparian and Upland Areas Inhabited by Beaver (*Castor canadensis*)". I have read the final form and content of this manuscript and recommend that it be accepted in partial fulfillment of the requirements for my Honors' Project with a major in Biology.

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Abstract. Thirty quadrats, 15 each in a riparian and upland area, in an urban forest located in Marshall, TX (32°33'N; 94°22'W), were assessed for relative frequency, relative density, relative dominance, and importance. Additionally, the riparian area and adjacent upland area were assessed for the potential impact of beaver in the riparian area. The most important tree species in the canopy were white oak (*Quercus alba*), southern red oak (*Q. falcata*), loblolly pine (*Pinus taeda*), slippery elm (*Ulmus rubra*), and sweet gum (*Liquidambar styraciflua*). Beech (*Fagus grandifolia*) and red maple (*Acer rubrum*) were found in the understory in greater frequencies than in the canopy. Composite species richness was 16.9 ± 1.8 in the canopy. The species richness of the riparian area was moderately higher (12.8 ± 1.5) than the upland area (11.8 ± 1.5), but, not significantly different ($z = 0.577$; $P = 0.282$). The Shannon-Wiener index of diversity was greater for the upland area (2.86 bits) than the riparian area (2.57 bits). The Morisita coefficient of similarity between the two areas was 0.84 in the canopy and 0.97 in the understory.

The oak-pine region of eastern deciduous forests occurs within the southern mixed-forest of the eastern regions of Texas (Braun 1950, Dyer 2006). The region is bounded on the east by the Mississippi alluvial plain and the west by the end of the eastern deciduous forest region. Vegetation in the region is variable but contains considerable loblolly pine (*Pinus taeda*) with sweet gum (*Liquidambar styraciflua*), water oak (*Quercus nigra*), southern red oak (*Q. falcata*), and red maple (*Acer rubrum*) comprising the majority of deciduous trees in the region (Braun 1950, Dyer 2006).

The objective of this study is to assess canopy and understory vegetative layers of the forested area of the East Texas Baptist University's Environmental Studies Area (ETBU-ESA). The study site is located in an urban ecosystem and includes a riparian area impacted by beaver (*Castor canadensis*) through formation of canals, dams, and the corresponding ponds. Beaver pond complexes become beneficial through increasing plant diversity along the water edge (Hill 1982). This increases the attractiveness to other fauna through stabilizing a water source allowing for aquatic and amphibious species, as well as more water-dependent species of plant life (Sabo et al 2005). Additionally, riparian areas provide shelter and allow corridors for dispersal (Matos, 2008). However, there is a paucity of information concerning the action of beaver in urban systems. Therefore, a secondary objective of this study is to assess the impact of beaver in a secondary successional forest by comparing the understory and canopy of the beaver-impacted-riparian area with the adjacent upland area.

MATERIALS AND METHODS

The study was conducted on the ETBU-ESA located in Marshall, TX (32°33'N; 94°22'W). The ETBU-ESA is ca. 40 ha and is located in a larger urban ecosystem. There are houses located along the east and west sides of the study site, athletic fields on the south side, and a four-lane highway on the north. Woody vegetation on the ETBU-ESA is a maximum of 70 years of age making most of the area secondary succession. The soil in the riparian area is identified as Mooreville-Mantachie complex, which is frequently flooded (Golden et al 1994). These soils are deep and poorly drained (Golden et al 1994). Soils in the upland area are Kirvin gravelly fine sandy loam with 2 to 5 percent slopes (Golden et al 1994). Kirvin soils are deep with a thin, loamy surface layer and thick clay subsoil (Golden et al 1994).

Fifteen 10 m x 10 m quadrats randomly located in a riparian area defined by the presence of a beaver pond and the affluent and effluent streams of the pond. All sites defined as riparian are within 20 m of the defined area. Fifteen 10 m x 10 m quadrats randomly located in the adjacent upland area. These sites were selected in areas that are not in any riparian area and are on the top of the slope draining into the riparian areas on the ETBU-ESA.

Data measured on canopy trees in both areas are species, height, crown-width, and diameter at breast height (DBH). Species of trees in the understory are counted within each quadrat. Data for both canopy and understory trees are calculated for density, frequency, dominance, and importance. Dominance is calculated as the basal area of the tree. Importance is assessed by the total of absolute density + absolute frequency + absolute dominance.

Riparian quadrats are compared to upland quadrats using percent similarity and Morisita's Index. Species richness for the riparian and upland quadrats is analyzed using a jackknife estimation. Species richness using the Shannon-Wiener index was also analyzed for the 30 quadrats combined. Data for similarity of the areas and species richness were analyzed using Krebs Ecological Methodology Software (1999). Data for density, frequency, dominance, importance, and crown-width to height were analyzed using Microsoft Excel. Statistics are analyzed for the entire measured area (composite study area), and the riparian and upland areas separately.

RESULTS AND DISCUSSION

The most important canopy species in the composite study area (Table 1) are southern white oak (*Q. alba)*, southern red oak, and loblolly pine, slippery elm (*Ulmus rubra*), and sweet gum, and American elm (*U. americana*). All measures indicate the oak species are the most common species in the study area. While water oak (*Q. nigra*) was more common in the southern-mixed forest in the findings of Dyer (2006), it is only marginally important in the current study area (composite importance = 3.6). Water oak is found only in the riparian area of the current study and may have been selectively consumed by beaver, thus, decreasing the importance of the species. While stumps cut by beaver were not assessed in this study, there are indications of oak species being one of the more selected species (pers. observ). Other species of importance (Table 1) in the current study are also important in the oak-pine regions of Braun (1950) and Dyer (2006).

The composite richness for the canopy is 16.9 ± 1.8 with a 95% confidence interval (C. I) for different species (13.1 - 20.6). The richness of the canopy of the riparian area (12.8 ± 1.5; 95% C.I. – 9.6 - 16.0) did not significantly differ (z = 0.577; P = 0.282) from the richness of the canopy of the upland area (11.8 ± 1.5; 95% C.I. – 8.6 - 15.0). Shannon-Wiener diversity index indicating the evenness of the canopy is 2.86 bits per individual with the number of equally common species for the composite study area is 7.27. This indicates a system that is relatively diverse. Diversity is higher in the upland area (2.64 bits per individual) compared with the riparian area (2.57 bits per individual). The number of equally common species is higher in the upland area (6.23) when compared with the riparian area (5.94). These numbers indicate the impact of beaver may not be influential in the canopy area. Beaver prefer smaller trees for forage and construction purposes (Kienzler 1971). The canopy trees may have been established and larger than preferred prior to the arrival of beaver. It is not known when beaver inhabited the area. Morisita’s coefficient of similarity (0.84) between the upland area and the riparian area for the canopy layer appears to substantiate this conclusion. While there is some difference between the two locations (Table 2), the similarity of the canopy is such that it may have been established prior to the arrival of the beaver. Further substantiating this conclusion is the similarity (0.97) between the understory layer of the two locations.

Species of the understory layer (Table 3) were similar to those found in the canopy with some notable differences. As noted previously, the understory layers of the two locations were more similar than the canopy layers. Some of the differences between the understory and canopy layers are due to species that are not adapted to the wetter soil conditions (*e.g. Juglans nigra*, Teskey and Hinckley 1977; *Magnolia grandiflora*, Sykes 2012). Beaver are known to prefer species such as green ash (*Fraximus pennsylvanica*) and southern red oak (Roberts and Arner 1984). Therefore, the lack of these species in the understory of the riparian area (Table 2) may be due to the activity of beaver. Additionally, the lesser frequency of red maple in the riparian area of the current study (Table 3) could be explained through the action of beaver. Busher (1996) found red maple to be a preferred species.

CONCLUSION

The actions of beaver in an urban ecosystem appear to be similar to those found in other locations (see Jenkins and Busher 1979). Beaver have the ability to alter habitat in riparian areas to the benefit of several features of an ecosystem. These can improve water quality through trapping and storing water for wildlife use (including but not limited to increased waterfowl and other avian use; Rutherford 1955, Lochmiller 1979) , and elevating water tables (Hill 1982). While the current study did not observe an increase in biodiversity, it did observe a change in floral biodiversity. This can result in changes in the fauna of the region as well. While beaver potentially can do considerable damage to an area (Yeager and Rutherford 1957), if the urban system is able to accommodate a colony of beaver, the benefits of the presence of the species may outweigh undesirable consequences.

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Table 1. Six most important (importance < 10), dominant, frequent, and highest density trees of the East Texas Baptist University's Environmental Studies Area. See text for explanation of calculations

Species	Relative Importance	Relative Dominance	Relative Frequency	Relative Density
Quercus alba	87.2	31.4	28.6	27.3
Q. falcata	82.8	34.0	26.1	22.7
P. taeda	42.6	15.1	16.8	10.6
U. rubra	16.6	3.2	7.6	5.9
Liquidambar styraciflua	16.5	5.4	5.0	6.1
Ulmus americana	13.4	1.6	4.2	7.6

Table 2. Tree species of the canopy layer of the East Texas Baptist University's Environmental Studies Area showing the relative frequency, density, dominance, and importance of each species in the riparian and adjacent upland areas. Key for table: Freq. - relative frequency, Density - relative density, Domin. - Relative Dominance, Import. – importance, -- indicates species was not found in the canopy of selected area . See text for explanation of calculations

	Riparian Canopy				Upland Canopy			
Species	Freq.	Density	Domin.	Import.	Freq.	Density	Domin.	Import.
Acer rubrum	3.0	1.4	2.5	15.8	--	--	--	--
Carya ovata	--	--	--	--	6.3	4.3	4.9	29.2
Fagus grandifolia	--	--	--	--	6.3	4.3	0.8	11.3
Liquidambar styraciflua	6.1	2.8	4.8	13.7	6.3	8.5	6.2	20.9
Liriodendron tulipifera	--	--	--	--	3.1	4.3	4.8	12.2
Pinus echinata	3.0	4.2	5.0	12.2	--	--	--	--
P. taeda	18.2	26.8	25.3	70.2	3.1	2.1	1.4	6.7
Quercus alba	30.3	29.6	29.3	89.2	25.0	27.7	38.3	87.0
Q. falcata	18.2	22.5	60.4	71.1	28.1	31.9	39.0	99.1
Q. palustris	9.1	4.2	2.5	15.8	--	--	--	--
Q. nigra	3.0	2.8	0.9	9.8	--	--	--	--
Ulmus americana	6.1	2.8	0.9	9.8	9.4	6.4	2.5	18.2
U. rubra	3.0	2.8	1.0	6.8	12.5	10.6	6.1	29.2

Table 3. Tree species of the understory layer of the East Texas Baptist University's Environmental Studies Area showing the relative frequency, density, dominance, and importance of each species in the riparian and adjacent upland areas. Key for table: Frequency - relative frequency, Density - relative density, -- indicates species was not found in the canopy of selected area. See text for explanation of calculations

Species	Riparian Area		Upland Area	
	Frequency	Density	Frequency	Density
Acer rubrum	5.6	3.1	17.7	13.5
Carya ovata	2.8	1.2	1.8	5.8
Celtis laevigata	--	--	11.5	5.3
Cornus alternifolia	2.8	0.4	1.9	0.4
Diospyros virginiana	2.8	0.4	1.9	0.4
Fagus grandifolia	30.6	55.5	11.5	12.4
Fraximus pennsylvanica	--	--	1.9	0.4
Liquidambar styraciflua	2.8	0.4	7.7	3.5
Juglans nigra	--	--	1.9	1.1
Magnolia grandilfora	--	--	1.9	0.4
Pinus taeda	5.6	2.3	--	--
Quercus alba	2.8	0.4	1.9	0.7
Q. falcata	--	--	7.7	7.7
Ulmus americana	22.2	9.8	15.4	20.6
U. rubra	22.2	26.6	15.4	32.6

Appendix 1

Table 1. Data collected on canopy trees in selected upland areas on the East Texas Baptist University environmental studies area.

Table 2. Data collected on canopy trees in selected riparian areas on the East Texas Baptist University environmental studies area.

Table 3. Data collected on understory trees in selected upland areas on the East Texas Baptist University environmental studies area.

Table 4. Data collected on understory trees in selected riparian areas on the East Texas Baptist University environmental studies area.

Table 1. Data collected on canopy trees in selected upland areas on the East Texas Baptist University environmental studies area. C. W. – crown width

Quadrat	Species	DBH	C. W.	Height
1	*Carya ovata*	38.8	12.7	16.2
1	*Quercus alba*	36.9	5.5	16.4
1	*Quercus alba*	54.0	16.7	16.4
2	*Ulmus rubra*	17.0	6.0	17.3
2	*Quercus alba*	54.5	14.0	14.4
2	*Carya ovata*	49.0	14.8	13.0
3	*Liquidambar styraciflua*	30.2	2.8	14.1
3	*Ulmus rubra*	37.8	11.3	16.7
3	*Carya ovata*	38.7	11.3	12.4
3	*Carya ovata*	35.0	10.7	15.4
4	*Quercus alba*	62.6	5.3	16.4
4	*Quercus alba*	39.1	8.8	18.0
4	*Quercus falcata*	41.1	12.6	12.7
4	*Ulmus americana*	17.8	6.3	17.8
5	*Pinus taeda*	33.7	4.7	16.7
5	*Quercus alba*	55.8	12.4	17.6
5	*Quercus falcata*	13.1	6.2	18.8
5	*Quercus falcata*	15.6	3.3	18.4
5	*Ulmus americana*	23.1	8.3	19.1
6	*Quercus falcata*	43.1	4.3	15.7
6	*Quercus falcata*	44.3	6.5	15.2
6	*Quercus falcata*	55.2	11.3	14.9
6	*Quercus falcata*	31.8	5.1	15.7
7	*Quercus alba*	36.5	5.6	17.1
7	*Quercus alba*	37.5	6.3	18.2
7	*Quercus alba*	52.7	9.8	15.4
8	*Quercus falcata*	47.5	6.7	16.4
8	*Quercus falcata*	40.4	7.2	15.9
8	*Fagus grandifolia*	14.7	4.6	18.0
8	*Ulmus americana*	33.0	5.8	17.3
9	*Quercus alba*	48.4	8.2	17.3
9	*Fagus grandifolia*	19.8	9.9	17.8
9	*Quercus alba*	26.8	6.5	17.8
9	*Quercus alba*	40.8	4.6	18.0
9	*Quercus falcata*	37.7	7.1	18.0
10	*Quercus alba*	33.5	7.3	15.4
10	*Quercus falcata*	48.1	11.9	18.6
11	*Ulmus rubra*	19.7	8.1	21.8
11	*Quercus falcata*	62.5	11.6	18.5
12	*Liriodendron tulipifera*	41.4	4.7	22.3
12	*Liriodendron tulipifera*	45.7	4.2	21.8

Table 1. (cont.)

Quadrat	Species	DBH	C. W.	Height
13	*Liquidambar styraciflua*	26.6	5.2	20.4
13	*Liquidambar styraciflua*	40.8	11.0	19.2
14	*Liquidambar styraciflua*	39.9	5.3	22.5
14	*Quercus falcata*	70.0	18.7	17.9
14	*Quercus falcata*	40.0	9.6	20.7
15	*Quercus falcata*	53.6	15.4	20.4

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Table 1. Data collected on canopy trees in selected riparian areas on the East Texas Baptist University environmental studies area. C. W. – crown width

Quadrat	**Species**	**DBH**	**C. W.**	**Height**
1	*Quercus falcata*	31.4	4.2	7.2
1	*Quercus falcata*	44.0	10.8	15.7
1	*Quercus falcata*	54.8	12.4	15.7
1	*Quercus falcata*	42.0	6.1	15.2
2	*Pinus taeda*	10.0	2.8	19.3
2	*Pinus taeda*	28.8	6.4	15.2
2	*Pinus taeda*	21.1	1.2	18.4
2	*Quercus alba*	20.0	7.6	18.8
2	*Quercus alba*	48.7	12.4	18.9
2	*Liquidambar styraciflua*	34.6	6.4	16.9
2	*Fagus grandifolia*	15.7	6.6	20.1
3	*Pinus taeda*	36.3	5.6	14.7
3	*Quercus alba*	42.6	7.4	15.2
3	*Ulmus americana*	17.6	7.4	18.8
3	*Pinus taeda*	35.0	8.7	14.9
3	*Pinus taeda*	33.5	8.1	14.7
3	*Pinus taeda*	33.5	9.7	14.7
4	*Quercus palustris*	29.0	6.4	16.9
4	*Pinus taeda*	49.8	7.5	15.4
5	*Quercus falcata*	31.2	10.4	18.2
5	*Quercus falcata*	36.0	7.7	16.4
5	*Quercus falcata*	28.2	3.7	17.8
5	*Quercus falcata*	27.7	2.9	16.7
5	*Quercus falcata*	23.3	3.8	16.2
5	*Quercus palustris*	35.6	11.0	19.5
6	*Pinus taeda*	35.5	6.0	14.7
6	*Pinus taeda*	36.5	2.8	14.9
6	*Pinus taeda*	38.5	5.9	16.4
6	*Pinus taeda*	29.0	4.9	16.4
6	*Pinus taeda*	47.6	8.0	14.1
6	*Quercus palustris*	24.2	7.4	17.3
7	*Pinus taeda*	45.2	7.9	16.2
7	*Pinus taeda*	47.8	9.1	13.3
7	*Pinus taeda*	40.9	9.4	16.7
7	*Pinus taeda*	25.4	7.7	17.3
7	*Pinus taeda*	61.0	10.9	11.2
7	*Pinus taeda*	26.8	4.5	13.0
7	*Pinus taeda*	29.9	5.2	15.2
8	*Quercus alba*	23.7	6.7	17.3
8	*Ulmus rubra*	21.5	5.7	18.8
8	*Ulmus rubra*	24.5	7.8	18.4

Table 2. (cont.)

Quadrat	Species	DBH	C. W.	Height
8	*Quercus alba*	34.6	14.4	17.6
8	*Quercus alba*	15.5	3.7	17.8
9	*Quercus alba*	55.5	10.2	12.1
9	*Quercus alba*	33.7	16.8	15.7
9	*Quercus falcata*	77.9	18.2	12.4
10	*Quercus alba*	35.2	9.2	15.2
10	*Quercus falcata*	44.9	9.3	11.8
10	*Quercus alba*	26.0	3.4	16.4
10	*Quercus alba*	75.0	15.4	10.3
10	*Quercus alba*	25.5	9.8	18.6
10	*Quercus alba*	46.0	8.3	15.2
10	*Quercus falcata*	46.9	9.9	14.1
10	*Quercus nigra*	20.7	9.6	18.9
11	*Quercus falcata*	39.2	9.6	13.8
11	*Quercus falcata*	38.2	7.6	15.6
11	*Quercus alba*	22.5	8.1	19.3
12	*Quercus alba*	12.6	5.6	19.5
12	*Quercus alba*	45.5	14.3	14.4
13	*Quercus falcata*	47.4	9.9	17.6
13	*Quercus falcata*	71.2	16.9	12.7
13	*Quercus alba*	17.2	5.0	18.6
13	*Quercus alba*	22.5	10.1	18.9
13	*Ulmus americana*	26.6	6.7	19.5
14	*Pinus echinata*	28.2	13.1	15.9
14	*Pinus echinata*	41.0	8.2	15.9
14	*Pinus echinata*	53.4	9.0	16.9
14	*Liquidambar styraciflua*	62.8	10.0	17.1
14	*Quercus alba*	35.0	9.7	15.7
15	*Quercus alba*	70.3	12.8	14.1
15	*Acer rubrum*	16.5	8.5	19.9
15	*Quercus alba*	15.5	4.0	20.2

Table 3. Data collected on understory trees in selected upland areas on the East Texas Baptist University environmental studies area.

Quadrat	Species	Count / quadrat
1	*Acer rubrum*	19
1	*Carya ovata*	1
1	*Magnolia grandiflora*	1
2	*Ulmus americana*	5
2	*Ulmus rubra*	4
2	*Cornus alternifolia*	1
2	*Liquidambar styraciflua*	1
2	*Celtis laevigata*	1
3	*Ulmus rubra*	7
3	*Fagus grandifolia*	4
3	*Celtis laevigata*	5
3	*Liquidambar styraciflua*	1
4	*Carya ovata*	3
4	*Ulmus americana*	6
4	*Quercus falcata*	1
4	*Celtis laevigata*	4
4	*Fagus grandifolia*	5
5	*Acer rubrum*	4
5	*Quercus falcata*	2
5	*Ulmus americana*	7
5	*Ulmus rubra*	1
5	*Celtis laevigata*	2
6	*Acer rubrum*	12
6	*Ulmus americana*	1
7	*Ulmus americana*	17
7	*Fagus grandifolia*	1
7	*Carya ovata*	1
7	*Quercus falcata*	1
8	*Acer rubrum*	6
8	*Fagus grandifolia*	7
8	*Ulmus americana*	3
8	*Quercus falcata*	4
9	*Fagus grandifolia*	8
9	*Ulmus americana*	6
9	*Acer rubrum*	4
10	*Ulmus americana*	13
10	*Fagus grandifolia*	10
11	*Ulmus rubra*	25
11	*Juglans nigra*	3
11	*Acer rubrum*	1
12	*Ulmus rubra*	21

Table 3. (cont.)

Quadrat	**Species**	**Count / quadrat**
13	*Liquidambar styraciflua*	7
13	*white oak*	2
13	*Ulmus rubra*	10
13	*Celtis laevigata*	1
14	*Ulmus rubra*	11
14	*Acer rubrum*	4
14	*Celtis laevigata*	2
15	*Ulmus rubra*	13
15	*Liquidambar styraciflua*	1
15	*Diospyros virgiana*	1
15	*Fraximus pennsylvanica*	1

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Table 4. Data collected on understory trees in selected riparian areas on the East Texas Baptist University environmental studies area.

Quadrat	**Species**	**Count / quadrat**
1	*Ulmus rubra*	28
1	*Cornus alternifolia*	1
2	*Ulmus rubra*	1
2	*Quercus alba*	1
3	*Fagus grandifolia*	13
3	*Pinus taeda*	1
3	*Ulmus americana*	1
4	*Fagus grandifolia*	4
4	*Ulmus americana*	2
5	*Fagus grandifolia*	17
5	*Quercus palustris*	4
6	*Ulmus americana*	2
6	*Fagus grandifolia*	15
6	*Pinus taeda*	5
7	*Fagus grandifolia*	12
7	*Ulmus americana*	5
7	*Acer rubrum*	1
8	*Fagus grandifolia*	23
8	*Carya ovata*	3
8	*Ulmus rubra*	4
8	*Acer rubrum*	1
9	*Fagus grandifolia*	8
9	*Ulmus americana*	3
10	*Fagus grandifolia*	11
10	*Ulmus americana*	8
10	*Diospyros virgiana*	1
11	*Fagus grandifolia*	25
11	*Ulmus rubra*	4
11	*Ulmus americana*	2
12	*Fagus grandifolia*	8
12	*Ulmus rubra*	3
12	*Ulmus americana*	2
13	*Ulmus rubra*	9
13	*Fagus grandifolia*	3
14	*Fagus grandifolia*	3
14	*Acer rubrum*	4
14	*Ulmus rubra*	2
15	*Ulmus rubra*	18
15	*Acer rubrum*	4
15	*Liquidambar styraciflua*	1