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Environmental analysis of the habitat (biotic and abiotic factors) associated with Broadleaf Barbara's Buttons (Marshallia trinervia)

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Environmental analysis of the habitat (biotic and abiotic factors) associated with Broadleaf Barbara's Buttons (*Marshallia trinervia*)

A Thesis

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This thesis is dedicated in memory of Dr. Shea Penland 1954-2008

“Beware of Salt Water Wolves”

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Table of Contents

List of Tables

Table Page

List of Figures

Figure Page

Abstract

In June 2009 I conducted a study of the habitat associated with Broadleaf Barbara's Buttons (*Marshallia trinervia*) along Bird's Creek in Vernon Parish, LA. Twenty two plots were sampled for all vascular plants. Of these, 17 samples were from the area where *M. trinervia* was present and 5 samples were from the area where *M. trinervia* was absent. From each sampling plot a soil sample was collected and analyzed. There were significant differences in the species richness of all plant groups ($p=0.0075$), herbaceous plants ($p=0.056$), and woody vines ($p=0.083$) between the two locations. The soil texture was also significantly different in the percentage of sand ($p=0.021$), silt ($p=0.029$), and clay ($p=0.089$) between the study locations. The study found that the samples associated with *M. trinervia* were higher in species richness for all plant groups and the soils from these locations had a higher mean percentage of silt and clay particles.

Keywords: Marshallia trinervia, broadleaved Barbara's buttons, rare, plants, habitat

Section 1: Introduction

1.1 Introduction and Background

Broadleaf Barbara's buttons *Marshallia trinervia* (Walter) Trel. is an herbaceous perennial in the family Asteraceae. It is approximately 3-8dm in height. The stems develop from a short rhizomodous root system. The plant has alternate entire leaves with a prominate three-nerve veination. The blooming season of *M. trinervia* is May to July. The flowers are lilac purple, light pink, or white. Each disk flower is a conical tube terminating into a 5-lobed throat. The anthers are deep purple in color (Channell, 1957; Figure 1.1).

Figure 1.1 Photos of *M. trinervia* from populations on Bird's Creek, Vernon Parish, LA. The photos on left and top center were provided by Dr. Charles Allen. The photos to right and bottom center were taken by Jennifer Blanchard in August 2008 as part of a survey that was performed to determine the plants furthest distribution to the south on Bird's Creek.

This species was first described by Walter as early as 1788 from a field sample near his home in South Carolina under the name *Athanasia trinervia*. It was transferred into the genus *Marshallia* by Trelease in a published U.S. Geological survey of the plants of Arkansas performed by Branner and Coville (Channell, 1957). The range of this species is restricted to the southeastern U.S. in LA, MS, AL, GA, SC, NC, and TN (Figure 1.2) (NatureServe, 2008). In Channell's revisional study of the genus *Marshallia* (Compositae) 1957 he recorded specimens examined from Virginia without locality. The Channell publication indicates that there were populations of *M. trinervia* in Arkansas and Virginia historically. These historical records also indicate a specimen collected by Hartmann in 1877 in Louisiana with no specific location (Channell, 1957).

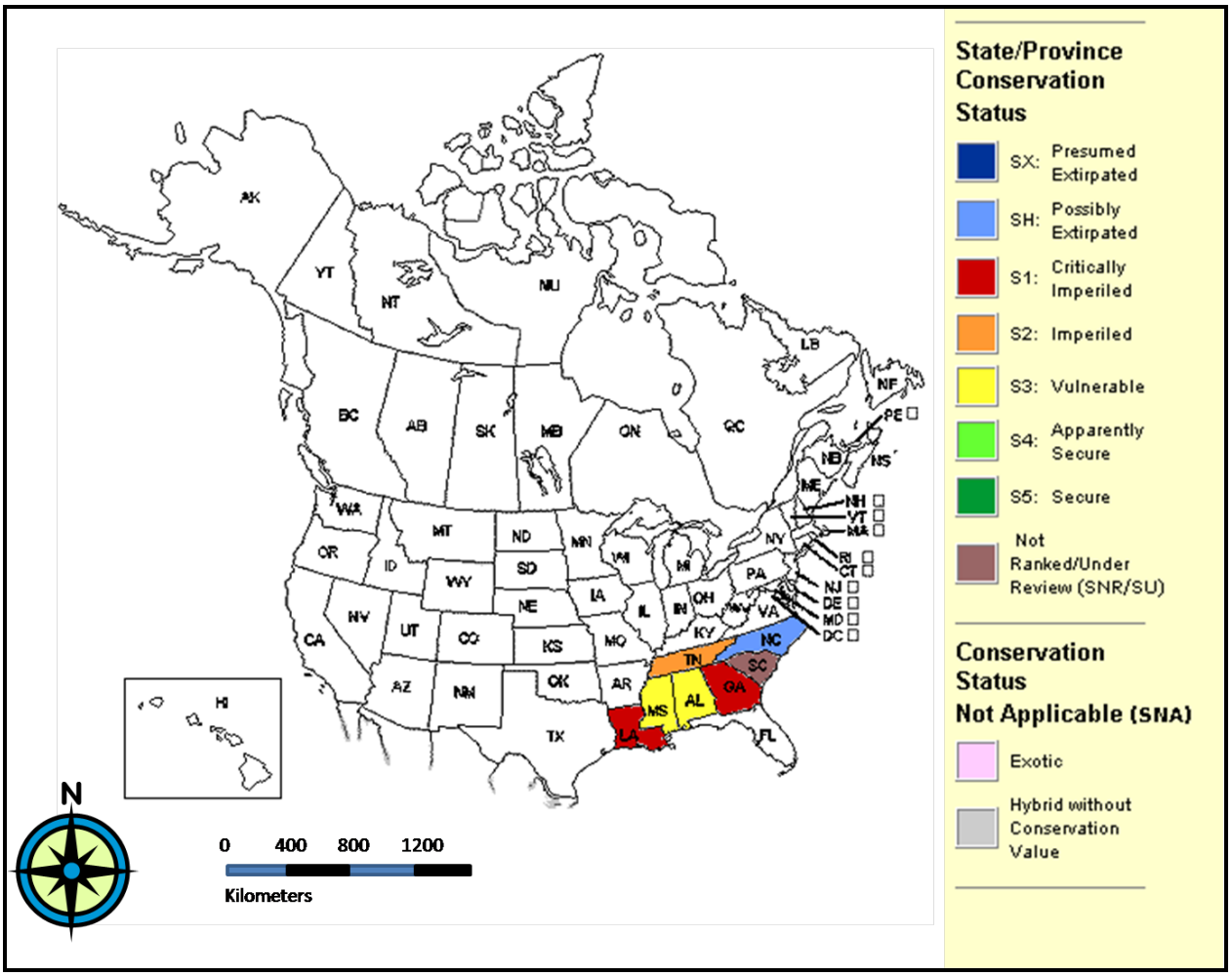

Figure 1.2 Map of U.S. and Canada illustrating the range of *Marshallia trinervia* in the U.S. and each states natural heritage program ranking of the plant. This map was adapted from NatureServe (2008).

There are only two modern locations of *M. trinervia* in Louisiana (Figure 1.3). These Louisiana locations were discovered by Dr. Charles Allen. The first identification of broadleaf Barbara's buttons (*M. trinervia*), by Dr. Charles Allen in 1971, in Louisiana was part of a thesis on the vascular flora of St. Helena Parish in southeast Louisiana (Allen, 1972). The plant hereinafter will be referred to as Barbara's buttons. This sample was collected from a roadside ditch in St. Helena Parish. The rarity of this find led to the belief that this plant was introduced at this location. It was not until 1996 while performing a vegetation survey that Dr. Allen and his associates discovered a second population of Barbara's buttons near Bird's Creek in Vernon

Parish west central Louisiana. This was the first time the species had been recorded west of the Mississippi River (Allen, 1996; Figure 1.3). This discovery confirmed the species as a native to Louisiana and led to the addition of this species to the rare and endangered plant list for the state that is maintained by the Louisiana Natural Heritage Program (LNHP) a division of the Louisiana Department of Wildlife and Fisheries (LDWF) (Allen, 1996; LDWF LNHP, 2007).

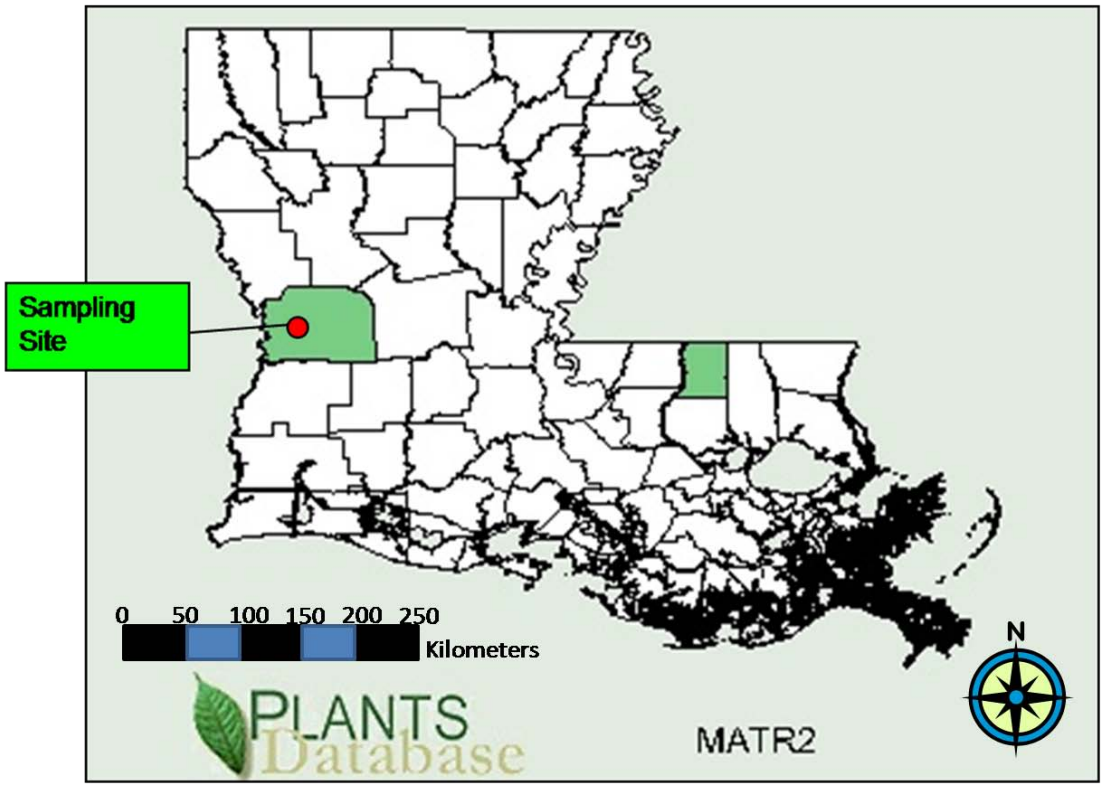

Figure 1.3 A map of Louisiana parishes where *Marshallia trinervia* has been reported. These parishes are highlighted in green and the red dot indicates the sampling site for this study. This map was adapted from a PLANTS Database map (USDA, NRCS.2008).

Broadleaf Barbara's buttons is ranked a rare plant at the global (G3) level. A G3 species is defined as "either very rare and local throughout its range or found locally (even abundantly at some of its locations) in a restricted range (e.g., a single physiographic region) or because of other factors making it vulnerable to extinction throughout its range (21 to 100 known extant populations)". Global rankings are made under the guidance of NatureServe (NatureServe, 2008). The state element ranking of rare plants is assigned by each states natural heritage program. This species is listed as an S1 in the states of Louisiana and Georgia (Figure 5). This

ranking is defined in Louisiana as “critically imperiled in Louisiana because of extreme rarity (5 or fewer known extant populations) or because of some factor(s) making it especially vulnerable to extirpation” (LDWF LNHP, 2007).

The habitat records for Barbara’s buttons lack in a detail and have a great variability over a broad range. Some of these habitat descriptions include specialized seepy calcareous habitats, woods (Gleason and Cronquist, 1963), creek banks, wooded slopes (Sorrie and Leonard, 1999), moist roadsides (Allen, 1972; Sorrie and Leonard, 1999), floodplains (Allen, 1996), damp woods (Fernald, 1950), moist rocky stream banks, calcareous clays (NatureServe, 2008; Weakley, 2008), and the understory of mixed hardwood forests often along sandy streams (Watson and Estes, 1990). Other habitat descriptions list the plant as sometimes associated with slightly-disturbed habitats (Allen, 1996; Watson and Estes, 1990), dry soil (Britton and Brown, 1913), pinelands (Fernald, 1950), limestone cliffs (Sorrie and Leonard, 1999), and unknown (Radford et al., 1968).

1.2 Research Justification

Botanists and ecologists rely greatly upon the studies such as this, the fossil record, journal entries, and the herbarium collections of their predecessors order to delineate the historical range of rare plants. For rare plants of the woody form such as Sequoias the historical range of the species can be found in the fossil record (Griggs, 1940). These woody specimens are preserved by the slow replacement of organic material by mineralization or carbonization. For small non-woody herbaceous species such as Barbara’s buttons the rate of decay is far greater than the rate of replacement. This leads to a bias in the fossil record towards organisms with hard structures and the decreased preservation of soft tissue organisms in the fossil record (Poort and Carlson, 2005).

In the process of performing an extensive literature review on the habitat and range for Barbara’s buttons a detailed thesis on the ecology of rare plants was found (Griggs, 1940). The article by Griggs provides research on the occurrence of rare species that provides an explanation for the presence and absence of rare plant species. Griggs ascribes the competitive competency of rare plants as the sole factor influencing distribution and succession. The competition is directly related to habitat factors. Therefore in order to determine the level of competition one

must first collect data on the vegetation associated with the presence of a rare species. From this data set significant differences in the vegetation can be determined. Upon further analysis the relationships of these significant findings in relation to the presence or absence of a rare species can be explored. The next step of the study is to measure the abiotic factors of soil properties and chemistry in the two locations to attempt in describing one or any combination of factors sharing a relationship with the presence or absence of a species.

1.3 Study Area Description

The study area is located in west central Louisiana in Vernon Parish, Calcasieu District, Kisatchie National Forest. The study area is approximately 2,260 meters in length along the west bank of Bird's Creek. There is a gap in plant distribution of approximately 1,100m (Figure 1.4).

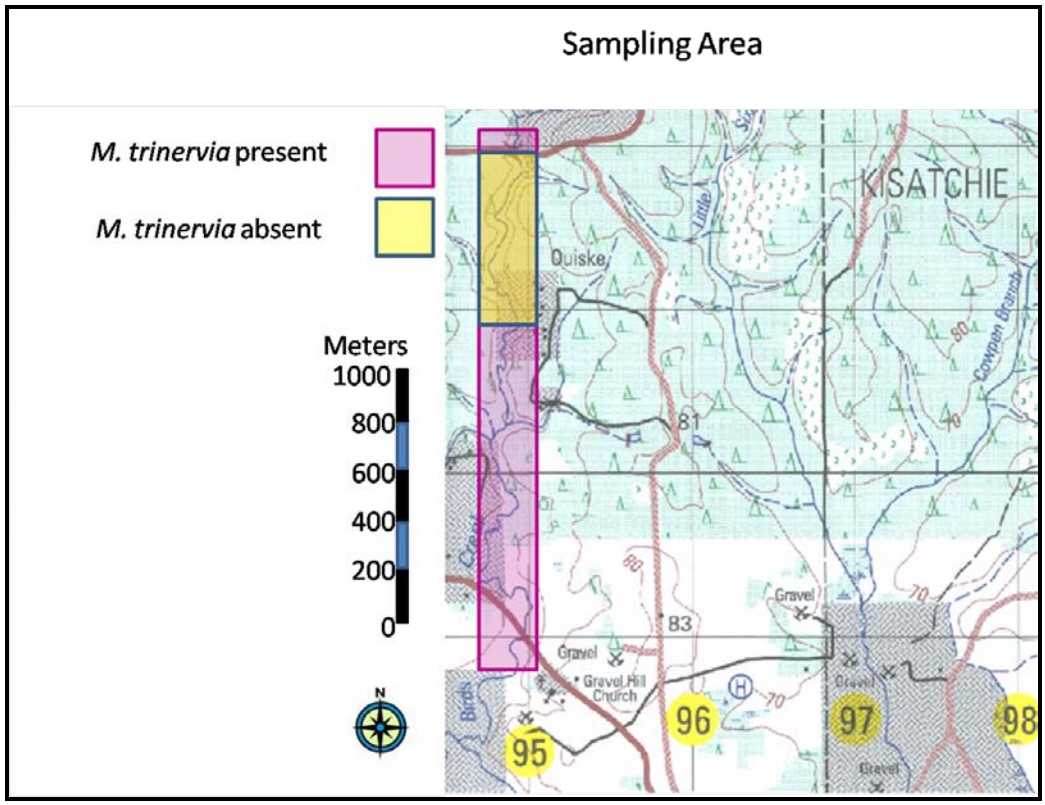

Figure 1.4 Map of sampling area on Bird's Creek in Vernon Parish, Calcasieu District, Kisatchie National Forest. This map was adapted from the Defense Mapping Agency (1999). Contour interval 10m.

The soils adjacent to Bird's Creek are described as Guyton-luka complex, frequently flooded (USDA NRCS, 2003). These soils are further described as Guyton-low flats; Iuka-convex natural levees. Barbara's buttons mostly occur on the Iuka portion. Iuka is described as having a surface layer between 0-27.9 centimeters-brown fine sandy loam, moderately well drained, and low soil fertility (USDA NRCS, 2003; Figure 1.5).

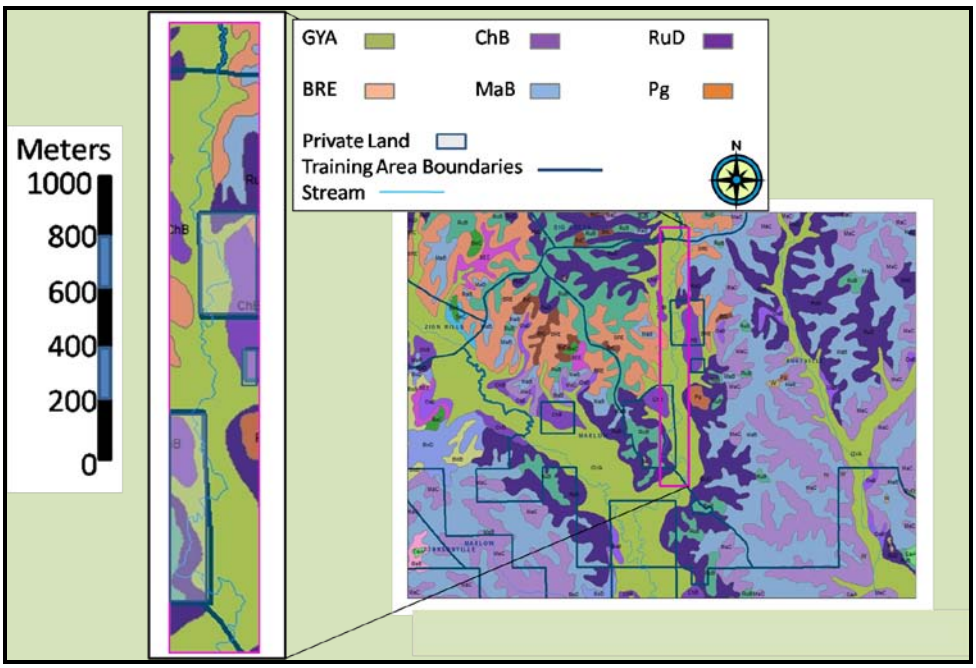

Figure 1.5 Soils map of the sampling area on Bird's Creek. This soils map is adapted from the Soil Survey of Vernon Parish USDA NRCS (2003). The map illustrates the soils adjacent to Bird's Creek in the sampling area. The soil types are defined as the following: BRE- Briley loamy fine sand, 5 to 12 percent slopes; ChB- Chaba fine sandy loam, 1 to 3 percent slopes; GYA- Guyton-Iuka complex, frequently flooded; MaB- Malbis fine sandy loam, 1 to 3 percent slopes; RuD- Ruston fine sandy loam, 3 to 8 percent slopes; Pg- Pits.

1.4 Study Objectives

The first objective of this study was to quantitatively and qualitatively describe the habitat (biotic and abiotic factors) of broadleaf Barbara's buttons in this region. A second objective was to determine if there were any differences in the habitat where this species is

absent. These two sampling locations will be identified from this point in the document onward as areas where Barbara's buttons were present and Barbara's buttons were absent.

Section 2: Methodology

2.1 Sampling Methods

2.1.1 Vegetation Sampling

From June 1st through June 4th 2009 twenty two plots (17 plots were sampled where Barbara's buttons was present and 5 plots in the gap where Barbara's buttons is absent) were sampled using a circular nested plot method (Allen, 2004; Figure 2.1). Nested circular sampling plots of 1m, 2m, and 5m radii were used to sample the vegetation. The center of the plot was located at the center of the Barbara's button population. If the population occurred less than 5m from Bird's creek then the center of the 1m, 2m, or 5m circles were offset to record vegetation surrounding the Barbara's buttons population. In the area where Barbara's buttons was absent, the plots were spaced at 200m intervals and the center of the plot was placed 5m from the stream. All of the herbaceous species in a 1m radius circle were identified, the above ground stems counted, and the length and width of each stem measured. All of the shrubs and saplings (woody non-vine species less than 1.83m in height) and woody vines in a 2m radius circle were identified, the above ground stems counted, and the length and width of each stem measured. All trees greater than 1.83m in height within a 5m radius circle were identified, the above ground stems counted, and the diameter at breast height (dbh) measured. The dbh was measured with a diameter tape in centimeters at a standard breast height of 1.37m from the base of the tree/shrub. All of the field data were recorded on data sheets.

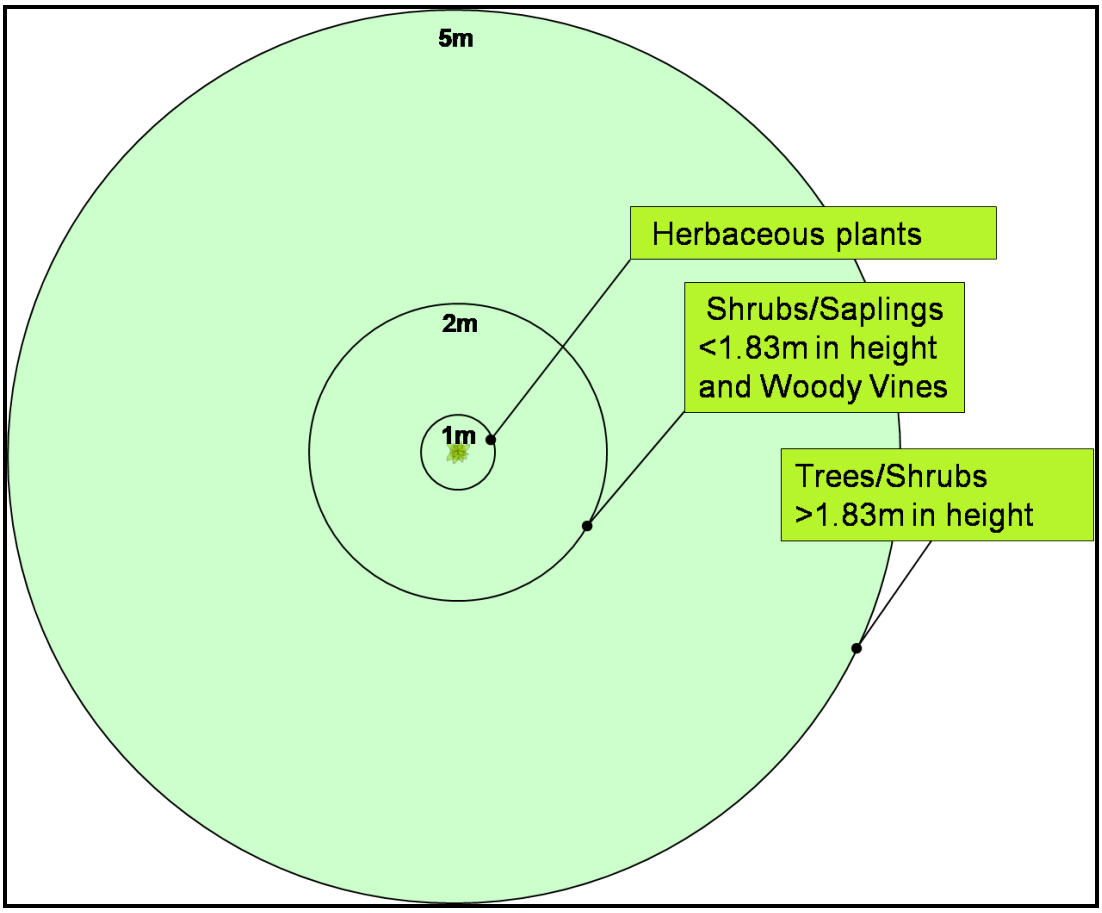

Figure 2.1 Diagram illustrating circular nested plot method for vegetation sampling adapted from Allen (2004). Three circles of 1m, 2m, and 5m radii with the center placed at the center of the plant population where *M. trinervia* is present and at a distance of 5m from the stream where *M. trinervia* is absent.

2.1.2 Soil Sampling and Analysis

A soil sample was collected from all 22 plots by extracting two, quart-sized samples (2.2L) of soil from the area within 0.5m of the center of the plot (Figure 2.2). All soil samples were taken in the upper 0.15m of the soil profile.

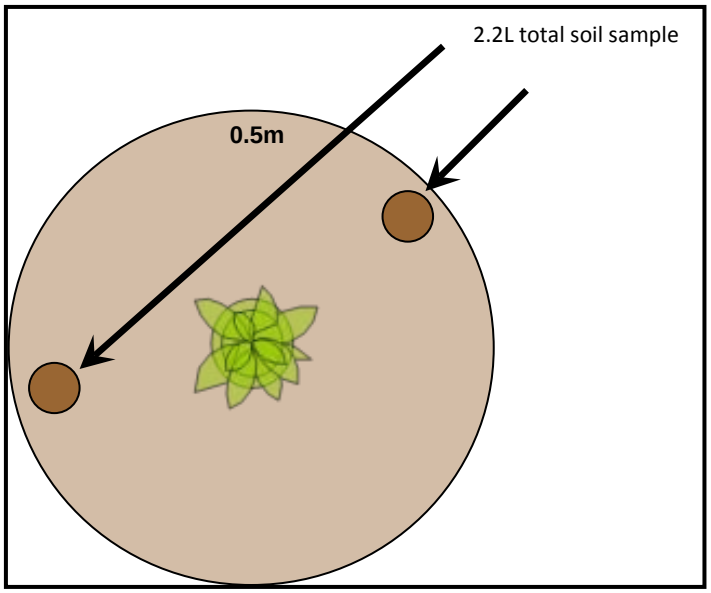

Figure 2.2 Soil sampling method diagram. This diagram illustrates the method used in collecting soil for chemical and textural analysis.

The soil was placed into a plastic resealable bag and labeled. The soils were air dried then passed through a 2mm sieve. The samples were separated into two portions equally by weight: one that was packed and delivered to Louisiana State University (LSU) Ag Center Soil Testing and Plant Analysis Laboratory, and a second portion that was brought to the MP2 Research Group geochemistry lab at UNO's Department of Earth and Environmental sciences. The LSU Ag Center Soil Testing and Plant Analysis Laboratory analyzed each sample for soil pH, and extractable: soil organic matter content; nutrient content; macronutrients: phosphorus, potassium, calcium, magnesium, sulfur; micronutrients: copper, zinc, iron, manganese, sodium, nickel; total nitrogen and carbon; and heavy metal concentration: arsenic, cadmium, and lead. The procedure for each extraction performed by LSU Ag centers laboratories is located in Appendix A (Table 1).

The soil texture testing was performed by Dr. Manoch Kongchum utilizing the pipette method. The pipette method employs Stoke's Law to determine soil texture. This law states that larger soil particles will settle at a faster rate than smaller particles in a liquid. Each dried sample was placed into a 1L cylinder and 1L of distilled water was added. Then over a period of five hours three samples were drawn using a 50ml pipette. The first two were taken at a depth of

10cm and the last sample was drawn at a depth of 7cm. The first was taken within the first five minutes. This sample was used to determine the percentage of sand. The second sample was taken after the first hour had passed and was used to determine the percentage of silt. The last sample was taken just before the five hours ended and this sample was used to determine the percentage of clay. Each sample was dried and weighed and then percentage of each variable was calculated.

The soil analysis of mercury concentration was performed by Al Falster with the MP2 Research Group at UNO's Department of Earth and Environmental sciences. For this analysis the dried soil samples were first weighed into testing vials using an analytical balance, the mass was recorded in grams. Then 20% nitric acid solution was added to the vial until a total volume of the digestate was at 35ml. The vials were sealed and agitated for a period of approximately four hours. Then this solution was filtered and the remaining filtrate was analyzed for mercury concentration using the Direct-coupled Plasma spectrophotometer (DCP). The detection limit was 0.02ppm. All of the sampling and soil data were recorded and then entered into a Microsoft Excel spread sheet for archival and data analysis.

2.2 Vegetation and Soil Data Calculations

The community physiognomy variables were calculated for each plot for all species including species richness, density, cover percent, and diameter breast height (dbh) (Table 2). The appropriate community physiognomy variables were calculated for each group; herbaceous species, shrubs/saplings, woody vines, and trees/shrubs. The species richness for each plot was calculated by summing the total number of species, density by summing the number of stems of each species, and the dbh by summing the dbh for each species. Cover percent was determined by first calculating the area (cm^2) occupied by each plant by multiplying the length times the width. The area of each plant was divided by the area of the sample circle ($314cm^2$, $1256cm^2$, or $7850cm^2$). The area of cover was converted to a percent by multiplying this value by 100. The mean and standard deviation were calculated for each variable for the 17 plots where Barbara's buttons was present and also for the 5 plots where this species was absent. An independent groups t-test for means was used to compare the means of each sampling variable between the

two areas. The t-test is a standard calculation used to determine if there is a significant difference in the means of two sets of data. The formula used for this calculation was:

$$t = \frac{(\bar{X}_1 - \bar{X}_2)}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

$\bar{X}$ = mean

s = standard deviation

n = sample size

The degrees of freedom (DF) were calculated by summing the sample sizes of both locations and subtracting 2 from this total:

$$DF = (17+5) - 2 = 20$$

Once the value for t and DF were calculated a standard table of significance was used the two determine the statistical differences if any, of each variable. Appropriate variables were calculated for each species in a plant group (herbaceous, shrubs/saplings, woody vines, and trees/shrubs for both locations (Barbara's buttons present and Barbara's buttons absent). The frequency was calculated for each species by dividing the number of samples in which each species occurred by the total number of sample plots (17 or 5). Frequency was converted to a percent by multiplying by 100. The mean density was calculated by summing the number of stems for each species and dividing by the number of plots (17 or 5). The mean cover percent was calculated by summing the cover percent for each species and dividing by the number of plots (17 or 5). The mean dbh was calculated by summing the dbh for each species and dividing by the number of plots. Relative values for each variable (frequency, mean density, mean cover percent, and mean dbh) were calculated by summing the value for each variable in the plant group within the sample set (17 or 5) and dividing by the value for each species by the total. Relative values were converted to a percent by multiplying by 100. Importance value for each species was calculated by summing the appropriate three relative values, relative frequency, relative density, and relative cover percent or in the case of the trees/shrubs group relative dbh. An unpaired t-test was used to compare variables (mean and standard deviation) for the community data and the top three species of greatest importance value for each plant group between the two locations. The results are discussed in sections 3 and 4.

For soil samples the mean and standard deviation for each element tested, pH, texture (percent: sand, silt, and clay), percent nitrogen, percent carbon, and percent organic matter were calculated for the samples in a set (17 or 5). The values were compared between the two sets of sampling data using a student's t-test. The calculation for determining the amount the amount of total Hg in soil samples was:

(digestate concentration mg L^{-1}) x (digestate L) / sample weight (kg) = sample concentration (mg/kg)

There was no detection of mercury in the samples collected where Barbara's buttons were absent, due to the lack of a positive result no statistical comparison of mercury concentration could be made between the two locations.

Section 3: Results

3.1 Community Physiognomy Data

The mean diversity for all plant groups surveyed was 24.06 for the samples where Barbara's buttons was present and 19.40 for the samples where Barbara's buttons was absent (Table 2). The mean diversity where Barbara's buttons was present ranged from 5.18 for woody vines to 9.47 for shrubs and saplings. The mean diversity where Barbara's buttons was absent ranged from 3.60 for woody vines to 8.40 for shrubs and saplings. The mean diversity for all plant groups was significantly higher where Barbara's buttons were present ($p=0.012$). The community physiognomy data for the herbaceous plants diversity was significantly higher where Barbara's buttons was present ($p=0.056$). The community physiognomy data for the woody vines diversity was significantly higher where Barbara's buttons was present ($p=0.083$).

The mean density for all plant groups surveyed was 139.35 for the samples where Barbara's buttons was present and 100.40 where Barbara's buttons was absent. The mean density where Barbara's buttons was present ranged from 20.53 for trees to 52.76 for shrubs and saplings. The mean density where Barbara's buttons was absent ranged from 14.20 for trees to 45.60 for shrubs and saplings. The mean cover percent for all plant groups surveyed was 71.61 for the samples where Barbara's buttons was present and 60.03 where Barbara's buttons was absent. The mean cover percent ranged from 12.24 for woody vines to 30.08 for herbaceous

plants where Barbara's buttons was present. The mean cover percent where Barbara's buttons was absent ranged from 4.46 for woody vines to 28.88 for shrubs and saplings. The cover percent for woody vines was significantly higher where Barbara's buttons was present (p=0.074). The mean dbh was 150.54 where Barbara's buttons was present and 126.76 where Barbara's buttons was absent.

3.2 Population

The four herbaceous plant species with the greatest importance value from the plots sampled where Barbara's buttons was present in decreasing order were *Chasmanthium sessiliflorum* (56.49), *Chasmanthium latifolium*, *Dicanthelium commutatum*, and *Mitchella repens* (Table 3). The three herbaceous plant species with the greatest importance value from the sites sampled where Barbara's buttons was absent in decreasing order were *Chasmanthium sessiliflorum* (72.57), *Mitchella repens*, and *Dicanthelium commutatum* (Table 4). The herbaceous plant species with the greatest mean density and mean cover percent from the area where Barbara's buttons was present were *Chasmantium sessiliflorum* (5.35) and (8.60) respectively. For mean density the next three species were *Dicanthelium commutatum* (5.00), *Mitchella repens* and *Viola spp.* (4.88). For mean cover percent the next two species were *Chasmanthium latifolium* (6.94) and *Dicanthelium commutatum* (3.43). The herbaceous plant species with the greatest mean density where Barbara's buttons was absent was *Mitchella repens* (7.20). The next two species with the greatest mean density in decreasing order were *Chasmanthium sessiliflorum*(5.00) and *Dicanthelium commutatum* (4.40). The herbaceous plant species with the greatest mean cover percent where Barbara's buttons was absent was *Chasmanthium sessiliflorum* (8.48). For mean cover percent the next two species were *Mitchella repens* (5.56) and *Dicanthelium communtatum* (4.66).

The shrub/sapling species with the highest importance value from the area where Barbara's buttons was present was *Carpinus caroliniana* (36.64). The next three species with the greatest importance value in decreasing order are *Quercus hemisphaerica*, *Hamamelis virginiana*, and *Halesia diptera* (Table 5). The shrub/sapling species with the greatest importance value from the area where Barbara's buttons was absent was *Hamamelis virginiana* (67.83). The next two species with the greatest importance value in decreasing order were *Ilex vomitoria* and

Acer rubrum (Table 6). The species with the highest mean density from the area where Barbara's buttons was present was *Carpinus caroliniana* (11.35). The next two species with the greatest mean density in decreasing order were *Quercus hemispaerica* (7.59) and *Hamamelis virginiana* (4.88). The species with the highest mean density from the area where Barbara's buttons was absent was *Acer rubrum* (9.80). The next two species with the greatest mean density in decreasing order were *Carpinus caroliniana* (7.40) and *Hamamelis virginiana* (5.80). The species with the highest cover percent from the area where Barbara's buttons was present was *Halesia diptera* (4.91). The next two species in decreasing order with the greatest mean cover percent where Barbara's buttons was present were *Vaccinium elliottii* (4.18) and *Hamamelis virginiana* (2.58). The species with the highest cover percent from the area where Barbara's buttons was absent was Hamamelis virginiana (45.58). The next two species with the greatest cover percent in decreasing order were *Ilex vomitoria* (26.14) and *Acer barbatum* (11.63).

The top three woody vine species with the highest importance value from the area where Barbara's buttons was present were Smilax smallii (58.50), *Gelsemium sempervirens*, and *Bignonia caprelata* (Table 7). The top three woody vine species with the highest importance value from the area where Barbara's buttons was absent in decreasing order were *Smilax glauca* (103.97), *Gelsemium sempervirens* and *Smilax smallii* (Table 8). The woody vine species with the highest mean density where Barbara's buttons was present was *Gelsemium sempervirens* (8.06). The next two species with the greatest mean density from this area were *Bignonia capreolata* (7.94) and *Smilax smallii* (4.53). The woody vine species with the highest mean density where Barbara's buttons was absent was *Smilax glauca* (7.20). The next two species of greatest mean density from this area in decreasing order were *Bignonia capreolata* (3.00) and *Gelsemium sempervirens* (2.20).The woody vine species with the greatest cover percent where Barbara's buttons was present was *Smilax smallii* (3.29). The next two species in decreasing order with the greatest cover percent from this area were *Vitis rotundifolia* (2.40), and *Gelsemium sempervirens* (1.81). The woody vine species with the greatest cover percent where Barbara's buttons was absent was *Smilax glauca* (1.80). The next two species with the greatest cover percent from this area in decreasing order were *Gelsemium sempervirens* (1.27) and *Smilax rotundifolia* (0.86).

The top three tree species with the greatest importance value from the area where Barbara's buttons was present were *Hamamelis virginiana* (56.38), *Carpinus caroliniana*, and *Ilex vomitoria* (Table 9). The top three tree species with the greatest importance value from the area where Barbara's buttons was absent in decreasing order were *Hamamelis virginiana* (74.10), *Fagus grandifolia*, and *Pinus taeda* (Table 10). The tree species with the greatest mean density where Barbara's buttons was present was *Hamamelis virginiana* (6.24). The next two species with the greatest mean density from this area in decreasing order were *Ilex vomitoria* (3.00) and *Carpinus caroliniana* (2.76). The tree species from the area where Barbara's buttons was absent with the greatest mean density was *Hamamelis virginiana* (6.20). The tree species with the greatest mean Dbh from the area where Barbara's buttons was present was *Carpinus caroliniana* (28.66). The next two tree species with the greatest mean Dbh from this area in decreasing order were *Hamamelis virginana* (27.46) and *Liquidambar styraciflua* (16.87). The tree species with the greatest mean dbh from the area where Barbara's buttons was absent was *Fagus grandifolia* (38.16). The next two species from this area with the greatest mean dbh in decreasing order were *Pinus taeda* (24.20) and *Hamamelis virginiana* (19.08).

The comparison of species of greatest importance value in the herbaceous layer determined no significant differences in mean density or mean cover percent between the two sampling locations where Barbara's buttons was present and where Barbara's buttons was absent. A comparison of top species of importance value for the shrub/sapling found that the mean cover percent for *Hamamelis virginiana* was significantly higher were Barbara's buttons was absent ($p=0.097$). A comparison of the species of greatest importance value of woody vines found that the mean density of *Smilax glauca* was significantly higher where Barbara's buttons was absent ($p=0.053$). For the tree/shrub group a comparison of top species of importance value revealed that the mean density ($p=0.087$) and mean cover percent ($p=0.002$) of *Fagus grandifolia* were both significantly higher where Barbara's buttons was absent. A list of the species identified in this study is presented in Appendix B. A total of 75 species were identified including 14 species of herbaceous plants, 48 species of trees, shrub, and saplings, and 12 species of woody vines.

3.3 Soils Data

Analysis of the soil testing data determined that the level of lead (p=0.058), nickel (p=0.072), calcium (p=0.078), magnesium (p=0.082), and sodium (p=0.053) was significantly higher where Barbara's button's were present (Table 11). There was a significant difference in the mean percent of sand, silt, and clay between the two sampling locations (Table 13). The mean percent of sand was significantly higher where Barbara's buttons was absent (p=0.021). The mean percent of silt (p= 0.029) and clay (p=0.089) were both significantly higher where Barbara's buttons was present (Plate 1). In the soil samples analyzed for mercury concentration three of seventeen samples where Barbara's buttons was present tested positive for mercury concentration (Table 12). None of the samples collected where Barbara's buttons was absent had concentrations above the detection limit. In the study area where Barbara's buttons were present the mean distance to the stream was 5.50m and the standard deviation was 4.46.

Section 4: Discussion

The Barbara's buttons in this study are found along the natural levee of Bird's creek in a forest dominated by *Carpinus caroliniana, Liquidambar styraciflua, Quercus hemisphaerica,* and *Acer rubrum*. The mid-story (taller shrubs and shorter tree species) includes *Hamamelis virginiana, Halesia diptera,* and *Ilex opaca*. The under-story of shorter shrub species is dominated by *Vaccinium elliottii, Rhododendron canescens* and *Ilex vomitoria*. The commonly associated herbaceous species includes *Chasmanthium sessiliflorum, Chasmanthium latifolium,* and *Dichanthelium commutatum*.

The study of rare plants provides a greater understanding of ordinary vegetation. It is rather difficult to discern the reasons contributing to the presence of a rare plant in any region (Griggs, 1940). In this study the objective was not in defining why Barbara's buttons are present in one location and absent in another. The objectives are to qualitatively and quantitatively describe the habitat (biotic and abiotic factors) of Barbara's buttons along Bird's Creek plant and to determine differences between the two study locations throughout the species range in this area. The results of a descriptive investigation may provide plausible answers to the contributing factors influencing the absence of this species.

Raup reported in 1934 from a study of rare alpine species from Peace River that he found two common factors in the habitat of rare plants. These two factors were flooding frequency/soil instability and the hazardous nature of the habitat for any plant species. These two common factors decrease the level of competition by tree species in these habitats. Raup (1934) states that in his study that the rare plants occur on damp sand and mud near the bank of the river. He also preludes to a frequency of rare plants among young pioneer stage vegetation in unstable environments these include bogs, cliffs, rocky regions, talus, shores, beaches, and barrens. Marie-Victorin (1938) provides the analogy that a beach is like a garden where plants exist without competition. He continues to further support Roup's findings by describing rare plants as confined to habitats of soil instability along banks of rivers and marshes in the St. Lawrence River basin. Griggs (1940) lists the habitats of rare plant occurrences as rocky hills, cliffs, or ravines (Griggs, 1940). In this study Barbara's buttons are found on the sandy levees of Bird's creek with a proximity to the stream at an average of approximately 5.5m.

The careful examination of associated species in the habitat of a rare plant will uncover clues about its ecological status. Categorization of weeds and rare plants together reveals the deficiency in ability to compete with species in a habitat of higher succession (Griggs, 1940). The differences in soils can perhaps explain the differences observed in vegetation. Possibly the presence of *Marshallia trinervia* is related to the percentage of silt, clay or the combined percentage of these two factors. The percentage of sand could possibly account for diversity differences. Some plant species found in the area where Barbara's buttons are absent may better suited to survive in well drained soils. The findings for *Fagus grandifolia* (American Beech) may indicate that the gap in which Barbara's buttons were absent is a habitat of later stage of succession. It has been found that mature stands of *Fagus grandifolia* are indicative of a habitat at a climactic stage in succession (Abrams and Downs, 1990). This region may represent a relic old-growth Beech forest. From a study of the American Beech in the lake states of the Northeastern U.S. the dbh can be taken to estimate the age of the tree (Tubbs and Houston, 1990). The mean dbh where Barbara's buttons were absent (38.16cm) and the mean dbh where Barbara's buttons was present (2.44cm) in comparison with the data from the lake states study (taking into consideration of differences in the length of the growing season between our southerly site and the data of the north) a dbh of 2cm ages a Beech at 20 years old and a dbh of

29cm ages a Beech at 150 years old. Illustrating that the study location where Barbara's buttons are absent may be a forest that is at least one hundred years older than that of where Barbara's buttons are present. This could also be a contributing factor to observed differences in the vegetation of the two study locations.

The presence of more than one rare plant species found near the locality of the plant in question is not an uncommon observance in rare plant study (Griggs, 1940). For instance on Bird's creek in Vernon Parish, LA there have been collections of at least three other rare plant species the Yellow lady-slipper (*Cypripedium kentuckiense*) G3 S1, Sessel-leaf bellwort (*Uvularia sessilifolia*) G5 S2, and Yellow pimpernel (*Taenidia integerrima*) G5 S2. Just to the west on a tributary to the Whiskey Chitto Creek approximately 2000m from the sampling area Yellowroot (*Xanthorhiza simplicissima*) G5 S1 has been collected (Allen et al., 1987). Some of these plants are found with a relative abundance in their restricted range similar to that of the Barbara's buttons in question. It should be noted that the habitat is highly variable between these species.

Could the distribution of rare plants be based purely upon chance? Griggs (1940) sticking to his botanical knowledge and competitive competency principle states that there are few cases in which climate or physio-chemical properties of the soil explain the occurrence of a rare species (Griggs, 1940). The finding of no significant differences in the community physiognomy of the herbaceous plants group could possibly support the theory that Barbara's buttons occur with a distribution along Bird's creek that is based on chance alone. However, the highly sensitive nature of technology at present is capable of detecting soil properties at extremely low concentrations and with great precision and accuracy in contrast with the instruments used in Griggs era. There are several relationships of soil chemistry that have been demonstrated to influence the distributions of plant species. The presence of an element such as copper in elevation may be highly toxic to one species but another species may be found to have a tolerance for the metal and example of this is *Agrostis tenius* (Walker et al., 2005). Because of this relationship the plant can be found in abundance on the soil heaps that surround a copper mine. Soil pH alone has been a determining factor in the presence of a plant species. The level of pH also influences the solubility of metals in soil and water (Walker et al., 2005). Although there was no appreciable difference in soil pH between the two sites we studied. In our study we found

the level of the five elements: Lead, Nickel, Calcium, Magnesium, and Sodium; was higher where Barbara's buttons was present. This result could have a possible correlation with the percentage of silt and mainly clay particles that were also found to also be higher in the samples collected from the area where Barbara's buttons were present.

Section 5: Conclusion

This study was the first in describing the habitat for *Marshallia trinervia* in Louisiana. The results of this study could be used to assist in the conservation and management of this species. The methods used and data collected in this study may provide assistance to the future study of rare plants. Bird's creek has an interesting ecology and in the future a study of the other rare plant species from this area may provide greater insight on the ecology of rare plants. Further study of the data collected on *Marshallia trinervia* could include the other biotic factors such as seed fertility, plant genetics, abiotic factors such as water holding capacity of the soils, distance from stream, and the underlying relationships of soil texture and the concentration of specific elements.

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Appendix A

Table 1.

Soil Sample Tests and Procedures

From LSU Ag Center Soil Testing and Plant Analysis Lab (STPAL)

Soil Test		
Analysis	**Sample Size**	**Procedure**
pH	10 g	Add 10 ml deionized water, equilibrate 2 hr, read on pH meter.
Routine Includes: Phosphorus, Potassium, Calcium, Magnesium, Sodium, Sulfur, Copper, Zinc	2 g	Add 20 ml of Mehlich 3 extractant solution, shake 5 min on fast speed, read on ICP.
Organic matter	1 g	Add 10 ml 1 N K2Cr2O7 and 20 ml concentrated sulfuric acid (wait 2 hr) then add 90 ml water, equilibrate 16 hr, read on colorimeter.
Copper, Iron, Manganese, Zinc (DTPA)	10 g	Add 20 ml pH 7.3 0.005 M DTPA solution, shake 2 hrs, read on ICP.
Arsenic, Lead, Cadmium, Nickel, Zinc (HCl)	2 g	Add 20 ml 0.1 M HCl solution, shake15 min, read on ICP.
Nitrogen	0.4 g	Dry combustion by Leco CN analyzer.
Carbon	0.4 g	Dry combustion by Leco CN analyzer.
Texture	5 g	Add water and empirically determine.

Table 2. Community Physiognomy variables (diversity (species richness), density, percent cover, and dbh) for 22 samples (17 samples where M. trinervia was present and 5 where M. trinervia was absent) from Bird's Creek in Vernon Parish, LA.

All Plants

M. trinervia Present	**Species Richness	Density	Dbh	Cover %
mean	24.06	139.35	150.54	71.61
STD	3.01	53.49	95.10	27.07
M. trinervia Absent	**Species Richness	Density	Dbh	Cover %
mean	19.40	100.40	126.76	60.03
STD	4.34	37.21	30.69	25.71

Herbaceous Plants

M. trinervia Present	*Species Richness	Density	Dbh	Cover %
Mean	6.76	32.29	-	30.08
STD	1.39	15.50	-	16.74
M. trinervia Absent	*Species Richness	Density	Dbh	Cover %
Mean	5.20	23.20	-	26.69
STD	1.92	6.14	-	9.38

Shrubs and Saplings less than 1.83m in height

M. trinervia Present	Species Richness	Density	Dbh	Cover %
Mean	9.47	52.76	-	29.29
STD	2.74	38.58	-	24.30
M. trinervia Absent	Species Richness	Density	Dbh	Cover %
Mean	8.40	45.60	-	28.88
STD	2.07	18.12	-	31.56

Woody Vines

M. trinervia Present	*Species Richness	Density	Dbh	*Cover %
Mean	5.18	33.76	-	12.24
STD	1.63	21.16	-	08.31
M. trinervia Absent	*Species Richness	Density	Dbh	*Cover %
Mean	3.60	17.40	-	4.46
STD	1.95	19.79	-	7.26

Trees and Shrubs greater than 1.83m in height

M. trinervia Present	Species Richness	Density	Dbh	Cover %
Mean	6.06	20.53	150.54	-
STD	2.44	19.12	95.09	-
M. trinervia Absent	Species Richness	Density	Dbh	Cover %
Mean	5.20	14.20	126.76	-
STD	1.10	5.93	30.69	-

*Indicates a significant difference between study locations at a Confidence Level of 90%

**Indicates a significant difference between study locations at a Confidence Level of 95%

Table 3. Herbaceous plants population variables for species in 17 samples where *M. trinervia* was present along Bird's Creek, Vernon Parish,LA.

Scientific Name	Frequency	Relative Frequency	Density	Relative Density	Cover %	Relative Cover %	Importance Value
Chasmanthium sessiliflorum	76.47	11.30	5.35	16.58	8.60	28.61	56.49
Chasmanthium latifolium	88.24	13.04	3.82	11.84	6.94	23.08	47.96
Dichanthelium commutatum	94.12	13.91	5.00	15.48	3.43	11.39	40.79
Mitchella repens	82.35	12.17	4.88	15.12	3.24	10.76	38.05
Viola primulifolia	58.82	8.70	4.88	15.12	1.62	5.40	29.21
Solidago caesia	70.59	10.43	2.94	9.11	1.40	4.66	24.20
Elephantopus carolinianus	70.59	10.43	2.00	6.19	2.23	7.41	24.04
Aster lateriflorus	58.82	8.70	0.94	2.91	1.11	3.69	15.30
Carex spp.	47.06	6.96	1.35	4.19	0.90	2.99	14.13
Viola spp.	11.76	1.74	0.88	2.73	0.28	0.92	5.39
Ipomoea pandurata	5.88	0.87	0.12	0.36	0.24	0.81	2.04
Passiflora lutea	5.88	0.87	0.06	0.18	0.07	0.25	1.30
Boehmeria cylindrica	5.88	0.87	0.06	0.18	0.01	0.04	1.09
Total	676.47	100.00	32.29	100.00	30.08	100.00	300.00

Table 4. Herbaceous plants population variables for species in 5 samples where *M. trinervia* was absent along Bird's Creek, Vernon Parish, LA.

Scientific Name	Frequency	Relative Frequency	Density	Relative Density	Cover %	Relative Cover %	Importance Value
Chasmanthium sessiliflorum	100.00	19.23	5.00	21.55	8.48	31.79	72.57
Mitchella repens	80.00	15.38	7.20	31.03	5.56	20.82	67.24
Dichanthelium commutatum	100.00	19.23	4.40	18.97	4.66	17.46	55.66
Chasmanthium latifolium	60.00	11.54	2.20	9.48	3.84	14.37	35.39
Carex spp.	40.00	7.69	1.20	5.17	1.56	5.84	18.71
Elephantopus carolinianus	40.00	7.69	0.60	2.59	1.34	5.01	15.29
Viola primulifolia	40.00	7.69	0.60	2.59	0.16	0.60	10.87
Passiflora lutea	20.00	3.85	1.20	5.17	0.45	1.67	10.69
Solidago caesia	20.00	3.85	0.60	2.59	0.49	1.85	8.28
Epifagus virginiana	20.00	3.85	0.20	0.86	0.16	0.60	5.30
Total	520.00	100.00	23.20	100.00	26.69	100.00	300.00

Table 5. Shrub/Sapling (less than 1.83m in height) plant population variables for species in 17 samples where *M. trinervia* was present along Bird's Creek, Vernon Parish, LA.

Scientific Name	Frequency	Relative Frequency	Density	Relative Density	Cover %	Relative Cover %	Importance Value
Carpinus caroliniana	88.24	9.32	11.35	21.52	1.70	5.80	36.64
Quercus hemisphaerica	88.24	9.32	7.59	14.38	2.06	7.03	30.72
Hamamelis virginiana	58.82	6.21	4.88	9.25	2.58	8.82	24.28
Halesia diptera	47.06	4.97	1.24	2.34	4.91	16.77	24.08
Vaccinium elliottii	41.18	4.35	1.94	3.68	4.18	14.27	22.30
Acer rubrum	76.47	8.07	4.41	8.36	0.42	1.44	17.88
Ilex vomitoria	29.41	3.11	1.06	2.01	2.33	7.95	13.06
Rhododendron canescens	23.53	2.48	0.94	1.78	2.29	7.81	12.08
Viburnum dentatum	47.06	4.97	1.47	2.79	0.62	2.11	9.86
Callicarpa americana	17.65	1.86	0.41	0.78	2.06	7.02	9.67
Magnoilia grandiflora	23.53	2.48	1.82	3.46	0.87	2.98	8.92
Ilex opaca	35.29	3.73	1.12	2.12	0.68	2.32	8.17
Hypericum hypericoides	35.29	3.73	1.00	1.90	0.70	2.40	8.03
Acer barbatum	17.65	1.86	2.71	5.13	0.14	0.49	7.48
Euonymus americana	5.88	0.62	2.94	5.57	0.25	0.86	7.05
Itea virginica	17.65	1.86	1.00	1.90	0.54	1.85	5.60
Liquidambar styraciflua	23.53	2.48	1.12	2.12	0.14	0.48	5.09
Carya ovata	17.65	1.86	0.41	0.78	0.57	1.95	4.59
Nyssa biflora	29.41	3.11	0.41	0.78	0.19	0.64	4.52
Prunus serotina	23.53	2.48	0.41	0.78	0.32	1.09	4.36
Fagus grandifolia	29.41	3.11	0.47	0.89	0.04	0.15	4.15
Arundinaria gigantea	5.88	0.62	1.00	1.90	0.46	1.56	4.08
Symplocos tinctoria	29.41	3.11	0.29	0.56	0.04	0.14	3.80
Magnolia virginiana	17.65	1.86	0.59	1.11	0.21	0.72	3.70
Crataegus marshallii	17.65	1.86	0.29	0.56	0.08	0.26	2.68
Vaccinium arboreum	11.76	1.24	0.12	0.22	0.35	1.19	2.65

Table 5(cont.) Shrub/Sapling (less than 1.83m in height) plant population variables for species in 17 samples where *M. trinervia* was present along Bird's Creek, Vernon Parish, LA.

Scientific Name	Frequency	Relative Frequency	Density	Relative Density	Cover %	Relative Cover %	Importance Value
Quercus nigra	11.76	1.24	0.35	0.67	0.06	0.20	2.11
Quercus laurifolia	5.88	0.62	0.29	0.56	0.18	0.63	1.81
Ligustrum sinense	11.76	1.24	0.24	0.45	0.02	0.08	1.77
Cornus florida	5.88	0.62	0.18	0.33	0.03	0.11	1.07
Cephalanthus occidentalis	5.88	0.62	0.06	0.11	0.08	0.29	1.02
Triadica sebifera	5.88	0.62	0.18	0.33	0.01	0.05	1.00
Sambucus nigra	5.88	0.62	0.06	0.11	0.01	0.03	0.76
Persea palustris	5.88	0.62	0.06	0.11	0.01	0.02	0.76
Sassafras albidum	5.88	0.62	0.06	0.11	0.00	0.02	0.75
Smilax rotundifolia	5.88	0.62	0.06	0.11	0.00	0.00	0.74
Pinus taeda	5.88	0.62	0.06	0.11	0.00	0.00	0.73
Total	947.06	100.00	52.76	100.00	29.29	100.00	300.00

Table 6. Shrub/Sapling (less than 1.83m in height) plant population variables for species in 5 samples where *M. trinervia* was absent along Bird's Creek, Vernon Parish, LA.

Scientific Name	Frequency	Relative Frequency	Density	Relative Density	Cover %	Relative Cover %	Importance Value
Hamamelis virginiana	80.00	9.52	5.80	12.72	13.17	45.58	67.83
Ilex vomitoria	60.00	7.14	3.00	6.58	7.55	26.14	39.86
Acer rubrum	100.00	11.90	9.80	21.49	0.34	1.18	34.57
Carpinus caroliniana	100.00	11.90	7.40	16.23	0.25	0.88	29.01
Acer barbatum	40.00	4.76	4.40	9.65	3.36	11.63	26.05
Pinus taeda	80.00	9.52	3.80	8.33	0.03	0.09	17.95
Quercus hemisphaerica	40.00	4.76	2.00	4.39	1.05	3.62	12.77
Quercus alba	40.00	4.76	2.60	5.70	0.38	1.32	11.78
Halesia diptera	20.00	2.38	1.20	2.63	1.84	6.37	11.38
Viburnum dentatum	40.00	4.76	1.40	3.07	0.08	0.28	8.12
Vaccinium elliottii	40.00	4.76	1.00	2.19	0.23	0.80	7.75
Symplocos tinctoria	40.00	4.76	0.40	0.88	0.03	0.11	5.75
Rhododendron canescens	20.00	2.38	0.80	1.75	0.10	0.34	4.48
Styrax grandifolius	20.00	2.38	0.40	0.88	0.16	0.54	3.80
Hypericum hypericoides	20.00	2.38	0.40	0.88	0.08	0.28	3.53
Liquidambar styraciflua	20.00	2.38	0.40	0.88	0.02	0.08	3.34
Crataegus spathulata	20.00	2.38	0.20	0.44	0.13	0.44	3.26
Arundinaria gigantea	20.00	2.38	0.20	0.44	0.06	0.22	3.04
Fagus grandifolia	20.00	2.38	0.20	0.44	0.02	0.08	2.90
Cornus florida	20.00	2.38	0.20	0.44	0.01	0.03	2.85
Total	840.00	100.00	45.60	100.00	28.88	100.00	300.00

Table 7. Woody Vines plant population variables for species in 17 samples where *M. trinervia* was present along Bird's Creek, Vernon Parish, LA.

Scientific Name	Frequency	Relative Frequency	Density	Relative Density	Cover %	Relative Cover %	Importance Value
Smilax smallii	94.12	18.18	4.53	13.41	3.29	26.90	58.50
Gelsemium sempervirens	76.47	14.77	8.06	23.87	1.81	14.80	53.44
Bignonia capreolata	94.12	18.18	7.94	23.52	0.47	3.86	45.56
Vitis rotundifolia	52.94	10.23	2.29	6.79	2.40	19.60	36.62
Smilax rotundifolia	41.18	7.95	1.47	4.36	1.70	13.89	26.20
Parthenocissus quinquefolia	52.94	10.23	3.18	9.41	0.35	2.88	22.52
Smilax glauca	52.94	10.23	1.59	4.70	0.53	4.35	19.28
Smilax bona-nox	17.65	3.41	0.88	2.61	0.56	4.61	10.63
Rubus argutus	11.76	2.27	1.24	3.66	0.41	3.36	9.30
Lonicera japonica	5.88	1.14	2.00	5.92	0.15	1.20	8.26
Berchemia scandens	5.88	1.14	0.18	0.52	0.48	3.94	5.60
Brunnichia ovata	11.76	2.27	0.41	1.22	0.07	0.61	4.10
Total	517.65	100.00	33.76	100.00	12.24	100.00	300.00

Table 8. Woody Vines plant population variables for species in 5 samples where *M. trinervia* was absent along Bird's Creek, Vernon Parish, LA.

Scientific Name	Frequency	Relative Frequency	Density	Relative Density	Cover %	Relative Cover %	Importance Value
Smilax glauca	80.00	22.22	7.20	41.38	1.80	40.37	103.97
Gelsemium sempervirens	40.00	11.11	2.20	12.64	1.27	28.41	52.16
Smilax smallii	80.00	22.22	1.80	10.34	0.40	8.97	41.54
Smilax rotundifolia	40.00	11.11	1.60	9.20	0.86	19.26	39.57
Bignonia capreolata	40.00	11.11	3.00	17.24	0.06	1.42	29.78
Smilax pumila	40.00	11.11	0.80	4.60	0.04	0.91	16.61
Parthenocissus quinquefolia	40.00	11.11	0.80	4.60	0.03	0.66	16.37
Total	360.00	100.00	17.40	100.00	4.46	100.00	300.00

Table 9. Tree/Shrub (greater than 1.83m in height) plant population variables for species in 17 samples where *M. trinervia* was present along Bird's Creek, Vernon Parish, LA.

Scientific Name	Frequency	Relative Frequency	Density	Relative Density	DBH	Relative DBH	Importance Value
Hamamelis virginiana	47.06	7.77	6.24	30.37	27.46	18.24	56.38
Carpinus caroliniana	82.35	13.59	2.76	13.47	28.66	19.04	46.10
Ilex vomitoria	47.06	7.77	3.00	14.61	4.89	3.25	25.63
Liquidambar styraciflua	41.18	6.80	0.94	4.58	16.87	11.21	22.59
Quercus hemisphaerica	47.06	7.77	0.65	3.15	16.68	11.08	22.00
Ilex opaca	41.18	6.80	1.18	5.73	7.95	5.28	17.81
Nyssa biflora	41.18	6.80	0.71	3.44	8.75	5.81	16.04
Pinus taeda	23.53	3.88	0.24	1.15	12.12	8.05	13.08
Acer rubrum	35.29	5.83	0.82	4.01	4.45	2.96	12.79
Quercus nigra	17.65	2.91	0.35	1.72	3.59	2.39	7.02
Halesia diptera	23.53	3.88	0.35	1.72	0.60	0.40	6.00
Vaccinium elliottii	17.65	2.91	0.53	2.58	0.51	0.34	5.83
Magnolia grandiflora	11.76	1.94	0.35	1.72	2.65	1.76	5.42
Prunus serotina	17.65	2.91	0.24	1.15	1.88	1.25	5.31
Fagus grandifolia	11.76	1.94	0.18	0.86	2.44	1.62	4.42
Platanus occidentalis	5.88	0.97	0.06	0.29	3.94	2.62	3.88
Viburnum dentatum	5.88	0.97	0.41	2.01	0.68	0.45	3.43
Quercus michauxii	11.76	1.94	0.12	0.57	1.12	0.74	3.26
Rhododendron canescens	5.88	0.97	0.29	1.43	1.15	0.76	3.17
Quercus laurifolia	11.76	1.94	0.18	0.86	0.41	0.27	3.07
Acer barbatum	5.88	0.97	0.18	0.86	1.41	0.94	2.77
Amelanchier arborea	5.88	0.97	0.12	0.57	0.76	0.51	2.05
Quercus alba	5.88	0.97	0.12	0.57	0.49	0.32	1.87
Vaccinium arboreum	5.88	0.97	0.12	0.57	0.24	0.16	1.70
Arundinaria gigantea	5.88	0.97	0.12	0.57	0.05	0.04	1.58

Table 9 (cont.). Tree/Shrub (greater than 1.83m in height) plant population variables for species in 17 samples where *M. trinervia* was present along Bird's Creek, Vernon Parish, LA.

Scientific Name	Frequency	Relative Frequency	Density	Relative Density	DBH	Relative DBH	Importance Value
Chionanthus virginicus	5.88	0.97	0.06	0.29	0.38	0.25	1.51
Catalpa bignonioides	5.88	0.97	0.06	0.29	0.18	0.12	1.37
Carya ovata	5.88	0.97	0.06	0.29	0.12	0.08	1.34
Ulmus alata	5.88	0.97	0.06	0.29	0.09	0.06	1.32
Alnus serrulata	5.88	0.97	0.06	0.29	0.03	0.02	1.28
Total	605.88	100.00	20.53	100.00	150.54	100.00	300.00

Table 10. Trees/Shrubs (greater than 1.83m in height) plant population variables for species in 5 samples where *M. trinervia* was absent along Bird's Creek, Vernon Parish, LA.

Scientific Name	Frequency	Relative Frequency	Density	Relative Density	DBH	Relative DBH	Importance Value
Hamamelis virginiana	80.00	15.38	6.20	43.66	19.08	15.05	74.10
Fagus grandifolia	80.00	15.38	1.40	9.86	38.16	30.10	55.35
Pinus taeda	20.00	3.85	1.20	8.45	24.20	19.09	31.39
Acer rubrum	80.00	15.38	1.20	8.45	6.54	5.16	28.99
Magnolia grandiflora	20.00	3.85	0.80	5.63	11.46	9.04	18.52
Ilex vomitoria	40.00	7.69	1.20	8.45	2.58	2.04	18.18
Quercus alba	20.00	3.85	0.20	1.41	11.40	8.99	14.25
Carpinus caroliniana	40.00	7.69	0.40	2.82	2.84	2.24	12.75
Halesia diptera	40.00	7.69	0.40	2.82	0.26	0.21	10.71
Liquidambar styraciflua	20.00	3.85	0.20	1.41	5.10	4.02	9.28
Rhododendron canescens	20.00	3.85	0.40	2.82	1.00	0.79	7.45
Ostrya virginiana	20.00	3.85	0.20	1.41	2.30	1.81	7.07
Nyssa biflora	20.00	3.85	0.20	1.41	1.48	1.17	6.42
Crataegus spathulata	20.00	3.85	0.20	1.41	0.36	0.28	5.54
Total	520.00	100.00	14.20	100.00	126.76	100.00	300.00

Table 11. Soil testing results for 22 samples (17 samples where M. trinervia was present and 5 where M. trinervia was absent) from Bird's Creek in Vernon Parish, LA. All results listed as a mean percent for each variable except for the pH which is a log value.

	Carbon %	Nitrogen %	% Organic Matter	pH (1:1 Water)
M. trinervia present				
MEAN	0.59	0.04	1.12	4.93
STD	0.55	0.03	0.88	0.30
M. trinervia absent				
MEAN	0.42	0.03	0.92	4.69
STD	0.23	0.01	0.42	0.18

Table 11 (cont.). Soil testing results for 22 samples (17 samples where M. trinervia was present and 5 where M. trinervia was absent) from Bird's Creek in Vernon Parish, LA. All results are listed as a mean concentration of the element in parts per million (ppm).

Diethylene triamine pentaacetic acid (DTPA) extractable ppm				
	Copper	Iron	Manganese	Zinc
M. trinervia present				
MEAN	0.29	70.30	20.10	1.08
STD	0.16	45.58	15.17	0.81
M. trinervia absent				
MEAN	0.16	69.18	11.91	0.62
STD	0.03	23.15	2.41	0.20

0.1 M Hydrochloric acid (HCL) extractable pmm					
	Arsenic	Cadium	*Lead	*Nickel	Zinc
M. trinervia present					
MEAN	0.03	0.02	0.87	0.22	1.05
STD	0.02	0.01	0.45	0.14	0.71
M. trinervia absent					
MEAN	0.02	0.01	0.46	0.09	0.58
STD	0.01	0.00	0.10	0.02	0.16

Routine Test Results: Mehlich 3 extractable pmm								
M. trinervia present	*Calcium	Copper	*Magnesium	Phosphorus	Potassium	*Sodium	Sulfur	Zinc
MEAN	325.34	0.48	71.65	4.33	24.25	19.46	6.15	1.27
STD	165.24	0.17	33.22	0.98	9.91	4.62	2.33	0.79
M. trinervia absent								
MEAN	183.50	0.38	43.70	4.08	19.08	15.10	6.01	0.85
STD	54.77	0.10	9.74	0.92	3.19	1.05	1.35	0.14

* Indicates a significant difference between study locations at a Confidence Level of 90%

Table 12. Results of soil analysis of extractable mercury (Hg) in 22 samples (17 where *M. trinervia* was present and 5 where *M. trinervia* was absent) from Bird's Creek in Vernon Parish, LA.

Sample id #	mass, g	volume, ml	ppm Hg in solution	Total Hg for Sample $mgKg^{-1}$
M. trinervia present				
MS-1	20.72	20	nd	
MS-2	20.73	20	nd	
MS-3	20.01	23	nd	
MS-4	20.84	23	nd	
MS-5	20.46	18	0.03	0.03
MS-6	20.83	22	nd	
MS-7	20.30	21	nd	
MS-8	20.25	22	0.03	0.03
MS-9	20.46	22	nd	
MS-10	20.13	23	nd	
MS-11	20.58	24	nd	
MS-12	20.78	25	nd	
MS-13	20.99	20	nd	
MS-14	20.06	17	nd	
MS-15	20.87	26	nd	
MS-16	20.84	22	nd	
MS-17	20.59	17	0.04	0.03
M. trinervia absent				
Nms-100	20.40	23	nd	
Nms-111	20.90	19	nd	
Nms-112	20.25	22	nd	
Nms-113	20.82	21	nd	
Nms-114	20.46	21	nd	

Table 13. Soil texture analysis results comparison using a Student's T-Test in 22 samples (17 where M. trinervia was present and 5 where M. trinervia was absent) from Bird's Creek in Vernon Parish, LA.

	Particle Size Distribution (%)		
	*Sand	*Silt	*Clay
M. trinervia present			
Mean	79.25	17.01	3.73
STD	13.01	11.01	2.35
M. trinervia absent			
Mean	94.15	5.22	0.62
STD	1.45	1.35	0.25
(p)	0.02	0.02	0.09

*Indicates a significant difference between study locations at a confidence level of 95%
**Indicates a significant difference between study locations at a confidence level of 99%

Appendix B

GYMNOSPERMS

Pinaceae

Pinus taeda L.

ANGIOSPERMS

Aceraceae

Acer barbatum Michx.

Acer rubrum L.

Asteraceae

Aster lateriflorus (L.) Britton

Elephantopus carolinianus Raeusch.

Marshallia trinervia (Walter) Trel.

Solidago caesia L.

Aquifoliaceae

Ilex opaca Aiton

Ilex vomitoria Aiton

Betulaceae

Alnus serrulata (Aiton) Willd.

Carpinus caroliniana Walt.

Ostrya virginiana (P. Mill.) K. Koch

Bignoniaceae

Bignonia capreolata L.

Catalpa bignonioides Walt.

Caprifoliaceae

Lonicera japonica Thunb.

Sambucus nigra L. ssp. canadensis (L.) R.

Viburnum dentatum L.

Celastraceae

Euonymus americana L.

Clusiaceae

Hypericum hypericoides (L.) Crantz

Convolvulaceae

Ipomoea pandurata (L.) G. Mey.

Cornaceae

Cornus florida L.

Cyperaceae

Carex spp.

Ericaceae

Rhododendron canescens (Michx.) Sweet

Vaccinium arboreum Marsh.

Vaccinium elliottii Chapman

Euphorbiaceae

Triadica sebifera (L.) Small

Fagaceae

Fagus grandifolia Ehrh.

Quercus alba L.

Quercus hemisphaerica Bartr.

Quercus laurifolia Michx.

Quercus michauxii Nutt.

Quercus nigra L.

Grossulariaceae

Itea virginica L.

Hamamelidaceae

Hamamelis virginiana L.

Liquidambar styraciflua L.

Juglandaceae

Carya ovata (P. Mill.) K. Koch

Lauraceae

Persea palustris (Raf.) Sarg.

Sassafras albidum (Nutt.) Nees.

Loganiaceae

Gelsemium sempervirens (L.) St. Hil.

Magnoliaceae

Magnolia grandiflora L.

Magnolia virginiana L.

Nyssaceae

Nyssa biflora Walt.

Oleaceae

Chionanthus virginicus L.

Ligustrum sinense Lour.

Orobanchaceae

Epifagus virginiana (L.) Bart.

Passifloraceae

Passiflora lutea L.

Platanaceae

Platanus occidentalis L.

Poaceae

Arundinaria gigantea (Walt.) Muhl.

Chasmanthium latifolium (Michx.) Yates

Chasmanthium sessiliflorum

Dichanthelium commutatum (Schult.) Gould

Polygonaceae

Brunnichia ovata (Walt.) Shinners

Rhamnaceae

Berchemia scandens (Hill) K. Koch

Rosaceae

Amelanchier arborea (Michx. f.) Fern.

Crataegus marshallii Eggleston

Crataegus spathulata Michx.

Prunus serotina Ehrh.

Rubus argutus Link

Rubiaceae

Cephalanthus occidentalis L.

Mitchella repens L.

Smilacaceae

Smilax bona-nox L.

Smilax glauca Walt.

Smilax pumila Walt.

Smilax rotundifolia L.

Smilax smallii Morong

Styracaceae

Halesia diptera Ellis

Styrax grandifolius Ait.

Symplocaceae

Symplocos tinctoria (L.) L'Hér.

Ulmaceae

Ulmus alata Michx.

Utricaceae

Boehmeria cylindrica (L.) Sw.

Verbenaceae

Callicarpa americana L.

Violaceae

Viola primulifolia L. (pro sp.) [*lanceolata* × *macloskeyi*]

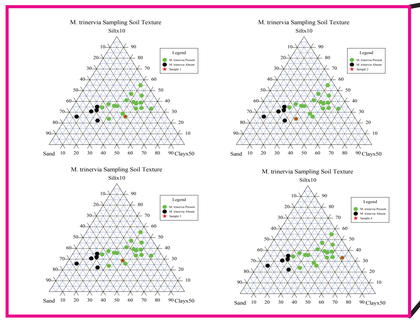
Viola spp. Blue?

Vitaceae

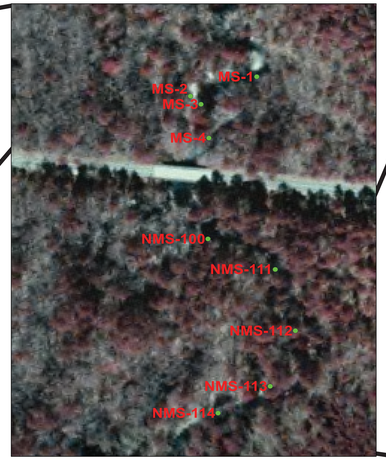
Parthenocissus quinquefolia (L.) Planch.

Vitis rotundifolia Michx.

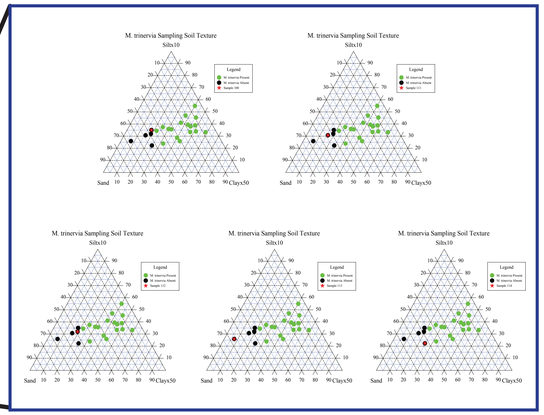
Appendix C



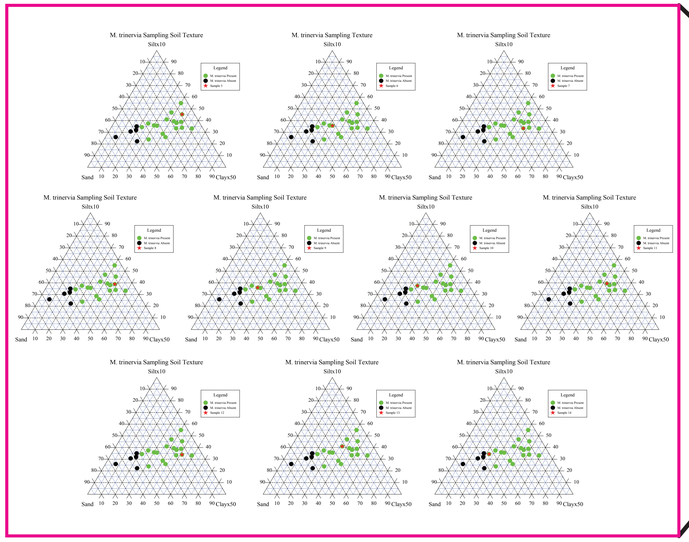
Ternary diagrams of the soil texture results, illustrating the percentage of sand, silt, and clay, collected from the four sampling plots at the northern most distribution of Marshallia trinervia on Bird's Creek, Vernon Parish, LA.



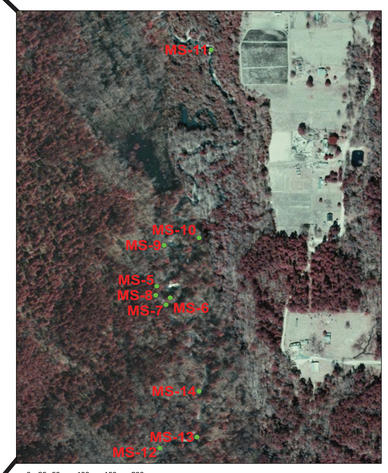
Aerial photo of samples 1-4 where Marshallia trinervia is present north of Lookout Rd. and samples 100, 111-114where Marshallia trinervia is absent south of Lookout Rd. on Bird's Creek, Vernon Parish, LA.



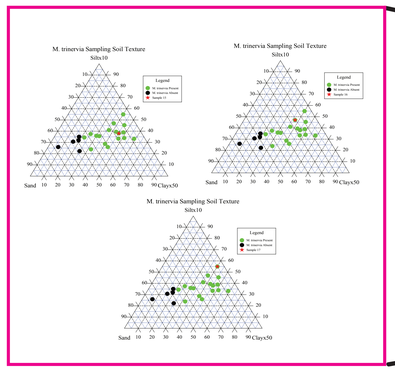
Ternary diagrams of the soil texture results, illustrating the percentage of sand, silt, and clay, collected from the study area where Marshallia trinervia is absent on Bird's Creek, Vernon Parish, LA.



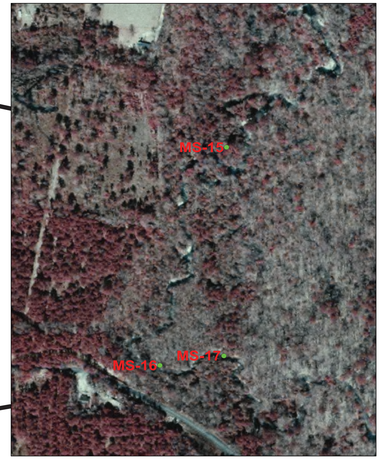
Ternary diagrams of the soil texture results, illustrating the percentage of sand, silt, and clay, collected from the ten sampling plots where Marshallia trinervia reappears on Bird's Creek, Vernon Parish, LA



Aerial photo of samples 5-14 where Marshallia trinervia reappears approximately 1,100 meters from the sample 4 population on Bird's Creek, Vernon Parish, LA.



Ternary diagrams of the soil texture results, illustrating the percentage of sand, silt, and clay, collected from the three sampling plots from the southern most distributions of Marshallia trinervia on Bird's Creek, Vernon Parish, LA

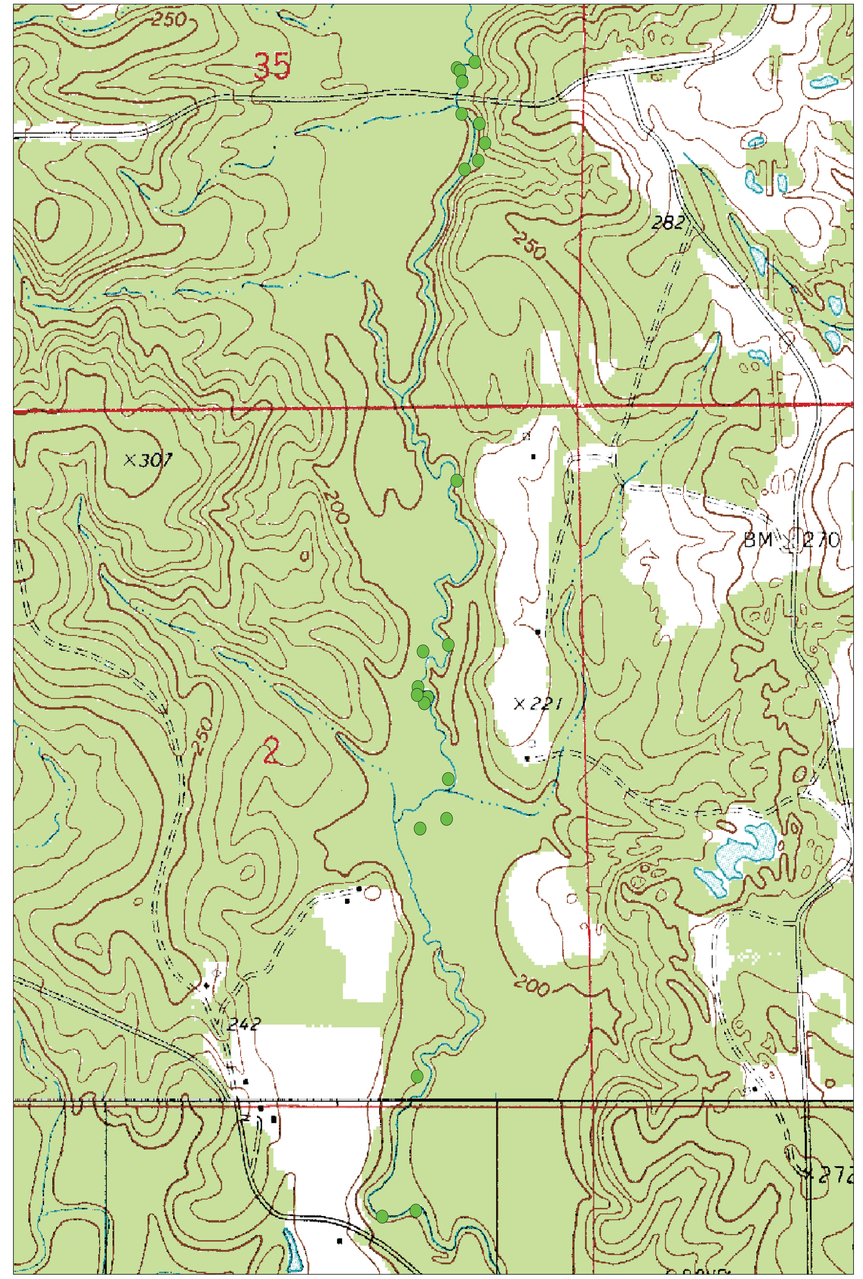


Aerial photo of samples 15-17 where Marshallia trinervia is present representing the southern most sampling plots on Bird's Creek, Vernon Parish, LA.

Plate 1

J.L.Blanchard 12-09

Soil Texture Results for Marshallia trinervia Sampling on Bird's Creek, Vernon Parish, LA.



Topography map of the entire study area on Bird's Creek, Vernon Parish, LA with GPS data of sampling points superimposed on image.

Recommended Citation: Topography basemap and aerial photos distributed by "Atlas: The Louisiana Statewide GIS" LSU CADGIS Research Laboratory, Baton Rouge, LA, 109. http://atlas.LSU.Edu

Vita

Jennifer Lynn Blanchard was born in Slidell, Louisiana, May 6th, 1977, the daughter of Robert E. Blanchard and Diane M. Blanchard. At the age of five her parents separated, Jennifer and her two sisters were raised spending the school year with their mother in the suburbs of Minneapolis, Minnesota and the summers with their father in the Honey Island Swamp of Pearl River, Louisiana. At the age of thirteen she decided to move to her father's home in Pearl River, LA. She graduated from Pearl River High School in 1995. She attended The University of Southern Mississippi from May 2002 to August 2006 and received her Bachelor of Science Degree in Environmental Biology. In January 2007, she began graduate school at the University of New Orleans. Jennifer is currently employed as a botanist by Colorado State University's Center for Environmental Management of Military Lands in Fort Polk, LA.

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