US Army Corps of Engineers
Vicksburg District

Gulf South Research Corporation
Baton Rouge, Louisiana

Final Report

Survey Report
Re-evaluation of Pondberry (*Lindera melissifolia*) in the Big Sunflower River and Yazoo River Backwater Areas

September 2005

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Final

Survey Report
Re-evaluation of Pondberry (*Lindera melissifolia*) in the Big Sunflower River and Yazoo River Backwater Areas

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1.0 INTRODUCTION

The U.S. Army Corps of Engineers (USACE), Vicksburg District, is currently investigating potential flood control alternatives in the Big Sunflower River and Yazoo River backwater areas. The presence of known pondberry (*Lindera melissifolia*) colonies in the project vicinity warrants investigation of the potential for the proposed project to affect extant pondberry communities. The Vicksburg District completed several pondberry surveys in the early 1990s on the Upper Yazoo Projects, Upper Steele Bayou, Yazoo Backwater Project, and Big Sunflower River Maintenance Projects. In 2000, Gulf South Research Corporation (GSRC) re-surveyed many of these colonies as well as additional locations and completed the survey report "Re-evaluation of Pondberry in Mississippi" to update the pondberry profile that was developed by the USACE in 1991.

The U.S. Fish and Wildlife Service (USFWS) listed the pondberry as endangered on July 31, 1986. Pursuant to Section 7 of the Endangered Species Act (ESA) of 1973, as amended, Federal agencies are required to insure that actions authorized, funded or carried out are not likely to jeopardize the continued existence of any endangered species or result in adverse modifications of critical habitat as determined by the USFWS. This report has been generated as partial compliance with Section 7 of the ESA with respect to the endangered pondberry.

The purpose of this study is to resample the 62 pondberry colonies documented in the 2000 "Re-evaluation of Pondberry in Mississippi" report prepared by GSRC for the USACE and update the existing pondberry profile relative to these previously surveyed colonies. Additionally, changes in pondberry colony characteristics will be evaluated.

The study area for this survey includes portions of the Delta National Forest (DNF), a 59,000-acre tract of bottomland hardwood forest managed by the U.S. Forest Service (USFS), and several parcels of bottomland hardwood forest on private land located in Bolivar County and Sunflower County (Figure 1-1). Pondberry colonies were surveyed between June 7, 2005 and July 13, 2005. This report was prepared for the USACE, Vicksburg District, under Contract No. W912EE-04-D-0005, Delivery Order No. 001.

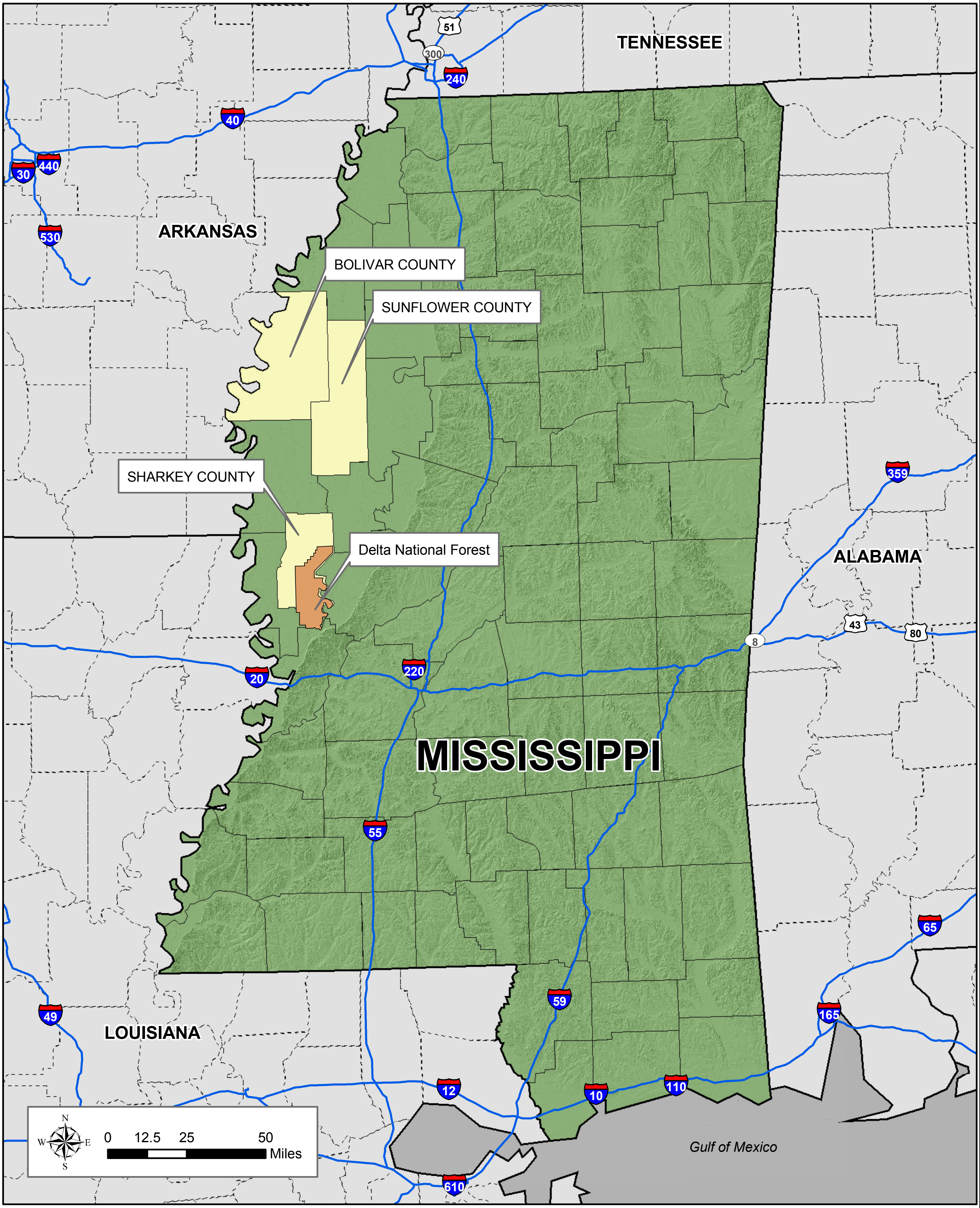

Figure 1-1: Study Area

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2.0 BIOLOGICAL PROFILE

Pondberry (*Lindera melissifolia*) is currently listed as a Federally endangered species under the Endangered Species Act of 1973. Pondberry was officially listed on July 31, 1986 in the Federal Register (51(47):27495-27500). A Final Recovery Plan was completed by the U.S. Fish & Wildlife Service (USFWS) in September of 1993. The species was assigned the Global Heritage Status Rank of G2 on June 1, 1996. Its current State Heritage Status Ranking includes Alabama (S1), Arkansas (S2), Florida (State Extirpated), Georgia (S1), Louisiana (State Reported), Mississippi (S2), Missouri (S1), North Carolina (S1), and South Carolina (S1) (NatureServe Explorer 2003 and Alabama Natural Heritage Program [ALNHP] 2005).

Pondberry is a member of the Laurel family. It is one of three members of the genus *Lindera* found in the southeastern United States (U.S.), which also includes common spicebush (*L. benzoin*) and bog spicebush (*L. subcoriacea*). Pondspice (*Litsea aestivalis*) may be found growing near or in the same habitat as pondberry. All four species are deciduous shrubs exhibiting bright red fruits commonly called pondberries (Photograph 2-1).

Photograph 2-1. Mature Fruit

In the southeastern U.S., pondberry can be distinguished from the other two members of the genus *Lindera* and pondspice by its clonal growth habit that produces cane-like clusters of short-lived stems; the leaves are large (over 2 inches long and 0.6 inches wide) leaves; and bears ellipsoid fruits, 4 to 4.5 inches long (Patrick et al. 1995). The one-seeded fruit is elliptical, bright scarlet red, with mature fruit evident by October. Fruit stalks are often present until next year's flowering (USFWS 1992, 1990; Klomps 1980; Tucker 1984; NOAA 2001). The thin, membraneous pondberry leaves extrude a sassafras-like odor when crushed.

Pondberry is a low growing, deciduous shrub ranging in height from 1.5 to 6.5 feet in height. Pondberry typically grows in clumps of numerous, un-branched, scattered stems and reproduces vegetatively by means of underground stems. The older portions of the stems are dark green to almost black with numerous, irregularly spaced, but prominent lenticels, or blisterlike breaks in the surface. The stems appear very similar to saplings or young stems of sassafras (*Sassafras albidum*). The leaves are drooping and range from 0.75 to 2.5 inches in width, and 2.0 to 6.5 inches in length with a round to cordate base. The leaf veins are prominent and the undersurfaces of the leaves are hairy. Pondberry flowers in the second to fourth years of growth. The small, pale yellow flowers of both sexes are found on separate plants and emerge prior to the development of the leaves (Photograph 2-2). The flower stalks and buds are often hairy. Photographs of each of the re-surveyed colonies as well as representative photographs of leaves, flowers, and berries are depicted in Appendix A.

Photograph 2-2. Flowering Clone

2.1 ECOLOGY AND LIFE HISTORY

Pondberry is presently found in the Mississippi River alluvial plains of Missouri, Arkansas, and Mississippi, and the Coastal Plains region of Alabama, Georgia, South Carolina, and North Carolina (USFWS 1993; Tucker 1984; ALNHP 2005).

Pondberry populations are generally associated with the shade of a mature forest and may be shade dependent (Klomps 1980; Tucker 1984). Pondberry in Mississippi has been reported to be stunted when growing if full sun (USACE 1996); however, Devall et al. (2000) reported that one population near McRae, Georgia is thriving despite the plants growing in a very open area and receiving practically full sun. Field investigations have indicated that vigorous healthy colonies were found in homogeneous clumps with shrub associates growing adjacent to but not within the clumps. In less vigorous colonies, shrub/herbaceous/vine associates were usually growing within the clumps.

2.1.1 Reproductive Biology

Individual stems of pondberry begin flowering by their third year of growth (Tucker 1984). Flowering begins in late February to early March in Mississippi and generally lasts no longer than two weeks. Pondberry is a dioecious species (male and female flowers on separate plants). A typical colony in Mississippi is composed primarily of male stems with a few to several female stems. In some instances, the entire colony is composed of male plants. In general, seed production in relation to the total number of stems is low. Because flowering occurs in late February to early March, frost or near freezing temperatures often damage flowers, thereby further reducing fruit production. In a study of 73 colonies from the Honey Hill region of South Carolina, Rayner and Ferral (1988) reported that only 22 percent (%) of all colonies surveyed produced fruit, with production averaging only 22 fruits per colony. They also noted that fruit production did not seem to improve with plant health since sexual reproduction appeared to be poor even in large, healthy plants.

Few details are known about pondberry reproduction; however, pondberry is suspected to be insect pollinated. Tucker (1984) noted small bees and flies on flowers when observing plants in Arkansas. The fruit contains many oils and similar compounds, which are suspected to make the fruit unpalatable to most wildlife. Therefore, seed dispersal is likely accomplished by seeds merely falling to the ground or by animals picking the fruit and depositing elsewhere (USFWS 1990). Extremely rare occurrences of seedlings have been documented in the wild. Seed germination beneath parent plants was reported as being successful if the seeds were depressed beneath the soil surface (USFWS 1993; Wright 1989). In addition, cleaned and scarified seeds have been reportedly germinated by McCartney (in litt.) as reported by the USFWS (1993). No hybrids are currently known to occur with pondberry.

2.1.2 Habitat

Tucker (1984) reported that pondberry populations in Mississippi are associated with "…mature bottomland hardwood forests in low depressions." Morris (1986) made two collections of pondberry in Mississippi from a 21.2-acre parcel of hardwood forest containing two different pondberry habitats. The western section of the pondberry habitat, located on high ground, contained five colonies containing a total of approximately 200 individuals. The eastern section of the pondberry habitat was described as a periodically inundated swamp. The pondberry stems ranged in height from 2.46 to 6.56 feet and 3.28 to 4.92 feet in height.

The habitat of Mississippi pondberry is similar to that in Arkansas and Missouri (USFWS 1990). USACE (1991) reported that pondberry colonies in Mississippi are typically found on slight ridges in ridge and swale communities that are either frequently or periodically flooded or are in proximity to a permanent water body. GSRC determined in its August 2000, Revised Final Survey Report, Re-evaluation of Pondberry in Mississippi that "The average distance of a colony from a standing body of water, as measured by surveyors, was approximately 64 feet". The report goes on to state that of 50 colonies in the DNF, which GSRC studied, the average distance of a colony from a body of water was approximately 80 feet and only colonies found in Bolivar County were found in inundated areas or where areas that were recently inundated. None of the colonies surveyed in the DNF were found in standing water; however, approximately half of the colonies surveyed were in areas that could potentially hold water.

The extant populations in Mississippi are associated with bottomland hardwoods at elevations where rainfall/local hydrology dominates the hydrologic conditions at the pondberry colony site (Photograph 2-3). According to the 1996 Biological Assessment (USACE 1996), Mississippi populations on the DNF are shade tolerant and found at elevations ranging from the 0 to 2-year floodplain to the 15 to 20-year floodplain of the lower Big Sunflower River. The major population of pondberry on the DNF occurs in the Red Gum Research Natural Area. The Red Gum Research Natural Area is a remnant of virgin forest which is slightly higher in elevation than most of the DNF and is only occasionally flooded (Devall et al. 2001).

Photograph 2-3. Typical Mississippi Habitat

The USACE (1991) reported that of 44 pondberry colonies surveyed, 41% were located in surface soils classified as silty clay, 32% in silty clay loams, and 21% in silt loam soils. This indicates that pondberry colonies will not likely be found on strictly heavy Alligator, Sharkey, or Dowling clay soils. Extant pondberry colonies are found on soils with a mixture of heavy clays and lighter soils.

2.2 POPULATION SIZE

Approximately 259 colonies/populations of pondberry are currently known to exist across its 7-state range. Approximately 194 colonies have been reported in Mississippi, primarily in the DNF (182 colonies in the DNF and 12 colonies on private lands approximately 65 miles north of the Forest); 2 colonies in Alabama; 36 colonies in Arkansas; 8 populations in Georgia (includes new colony found in March 2004); 15 colonies in South Carolina; 2 populations in North Carolina; and 5 colonies composing 1 natural population in Missouri (NCNHP 2003; SCNHT 2003; Georgia National Heritage Program [GNHP] 2003; GNHP 2004; ARNHP 2003; Missouri Natural Heritage Program [MONHP] 2003; USACE 2001; ALNHP 2005).

3.0 METHODS

3.1 DATA COLLECTION

GSRC personnel revisited 62 pondberry colony locations, 50 of which are located in Sharkey County and 12 of which are located on several parcels of private land in Bolivar County and Sunflower County. These colonies were previously surveyed in 2000 by a team from GSRC at which time each colony was given a unique ID number and global positioning system (GPS) coordinates were collected from the center of each colony (USACE 2001). From June 7 to July 13, 2005 the same colonies were located using USFS compartment maps and a Trimble Recon GPS. This is the same general time frame during which field surveys were conducted in the 2000 study. At each colony the team recorded numerous physical and biological data. A sample data sheet is presented in Appendix B.

Ocular estimates for percent canopy cover and percent herbaceous cover were made by each member of the field crew to develop a consensus. Associated plant species were recorded at each vegetation layer (i.e., overstory, understory, shrubs, and herbaceous cover) within a 0.1-acre plot surrounding the colony. Average tree stand maturity was recorded and the diameter of overstory species was measured using a diameter at breast height (dbh) tape, also within a 0.1-acre plot surrounding the colony.

Topographical information recorded included water depth on each plot and distance to the nearest body of water. Distance to nearest body of water was recorded if it could be determined visually from the site; otherwise, these data were obtained from the 2000 survey. Evidence of any localized depressions was also noted on the data sheet. For this study a localized depression was defined as an area greater than 10 square feet that is slightly lower than the surrounding area and contains ponded water or evidence of ponded water (e.g., water stained leaves) at some time. Average colony elevation and corresponding, slope-adjusted flood frequencies were carried forward from the 2000 data set. Elevation alone does not adequately describe flooding conditions. Two colonies at the same elevation might flood at different frequencies due to the slope of the floodplain at the landscape scale (i.e., downstream colonies generally flood more frequently than upstream colonies at the same elevation) or due to conditions of the local topography (i.e., a ridge of higher elevation surrounding a colony at a low elevation could prevent inundation). The slope-adjustment of elevation to obtain flood frequency provides a more accurate estimate of inundation due to overbank flooding, but still does not account for local variation in topography. Furthermore, many colony sites are inundated due to localized rainfall events and the poor drainage of soils, and this frequency is not accounted for by elevation or slope-adjusted flood frequency.

A hand auger was used to obtain a soil sample and the general soil type (silt, loam, clay, etc.) was recorded. Analysis of soils and Munsell soil color was obtained from the 2000 report.

Individual stems of each pondberry colony were counted as well as the number of clumps within each colony. Stems were considered to be individuals if there was no connection with other stems at or near the ground. Female plants were identified by the presence of fruit. The number of female plants and number of fruit were recorded for each plot. Average height and diameter of stems were recorded as well as colony health. This method was consistent with the 2000 survey. For one very large colony near Shelby, Mississippi, the number of stems was estimated by sub-sampling five randomly selected one meter plots within the colony. The area of this large colony was determined using the Trimble Recon GPS.

The general health of the colony was determined by the consensus of the field crew and was based upon physical appearance of the colony, density of the colony and the ratio of dead stems to live stems within the colony. This was also consistent with the 2000 survey. Furthermore, any fungal damage, insect damage and dieback were noted.

Each colony was marked near the center with a wooden stake with the ID number of the colony. A photograph of each colony was taken and the photo number was recorded along with the direction of the shot.

3.2 STATISTICAL ANALYSIS

These data were compiled into a database and statistical analyses were performed on pertinent quantitative field data using Microsoft Excel™ software. The analyses include the comparison of descriptive statistics (minimum, maximum, average, standard deviation) paired with graphical comparisons, correlation analysis, a paired t-test, and analysis of variance (ANOVA). The significance of each analysis was tested using the appropriate statistic. The significance threshold, or the probability of an observed relationship being a result of chance alone (p), was set at 0.05. Thus, there is a 5% chance that relationships reported as statistically significant are erroneous.

The calculation of descriptive statistics included values for which both the number of stems and the corresponding variable were reported. However, some data were not reported from a few colonies during the 2000 survey. Therefore, some analyses may include less than 62 colonies. There were five colonies for which no above ground evidence was observed at the colony location in 2005. These colonies were not included in the calculation of descriptive statistics. Colony 52, at which 16,638 stems were reported, was treated as an outlier, but comparison of the statistics are provided with and without this outlier removed.

Correlation analysis was used to test for a relationship between the number of stems observed and both physical and biological data. The linear relationship between two variables can be described using a Pearson's correlation coefficient (r). Values of r range between -1 and +1. A positive r indicates that colonies with a greater number of stems will be associated with greater values of canopy cover, average elevation, etc., and colonies with a lower number of stems will be associated with sites with lower values of canopy cover or average elevation, etc. The relationships are considered strong if the absolute value of $r > 0.6$, moderate if $r < 0.6$ and > 0.3 or less, and weak if $r < 0.3$. Important assumptions include a nearly normal distribution of values and a linear relationship between tested data. The distribution of the statistic used for significance testing is such that large data sets are often significant; thus, a strong r value and graphical analysis should support any conclusions. Furthermore, statistical significance does not necessarily mean biological significance. In order to be biologically significant, any observed relationship should be supported by the known biology and ecology of pondberry.

A paired t-test was used to evaluate the difference between the number of stems observed at a colony in 2000 and the number of stems observed at a colony in 2005. An ANOVA was used to test for a difference among the average values of pondberry data when colonies are grouped by their associated values of physical data. For example, ANOVA was used to determine if the average of the average number of stems observed at a colony is affected by flood frequency.

4.0 RESULTS

4.1 GENERAL DATA

A total of 62 pondberry locations were revisited. Of these, all but 5 colonies were located. Appendix C presents the data collected from all of the pondberry sites surveyed. Within the DNF, 50 pondberry sites were located in 13 compartments (Figure 4-1). The 6 sites located in Bolivar County and 6 colonies located Sunflower County (Figure 4-2) were on private lands that supported small bottomland hardwood communities surrounded by croplands, primarily cotton, soybean, and rice. Aerial photographs showing the location of pondberry colonies surveyed and the colonies not found are presented in Appendix D.

The values of the biological and physical data collected in 2000 and 2005 typically had a nearly normal distribution. However, the values of average colony elevation and flood frequency for sites on private land were not within the range of values collected at sites in the DNF. Most of the pondberry data collected in 2000 and 2005 has a positively skewed distribution. This means that the values of most variables were a set of generally low values with a few outlying colonies having very high values for the same variable. For example, the average number of stems found within a colony in 2005 was 169, yet more than 75% of colonies had less than 150 stems and 66% had less than 100 stems. This does not include colony 52 (near Shelby), which was estimated to have more than 16,000 stems. However, values of observed average stem height and average stem diameter were both nearly normally distributed.

4.2 PHYSICAL ENVIRONMENT

4.2.1 Soils

The two dominant soil associations found in the DNF are the Sharkey-Alligator-Dowling and the Forestdale-Dundee-Dowling Associations (USDA 1962). The Sharkey-Alligator-Dowling Association consists of poorly drained, clayey soils in slack water areas. This association is found in areas where the slope is less than 2%, but may be as much as 5% along streambanks and depressions. The Forestdale-Dundee-Dowling Association consists of poorly drained soils that formed in moderately fine textured alluvium from the Mississippi River and its tributaries.

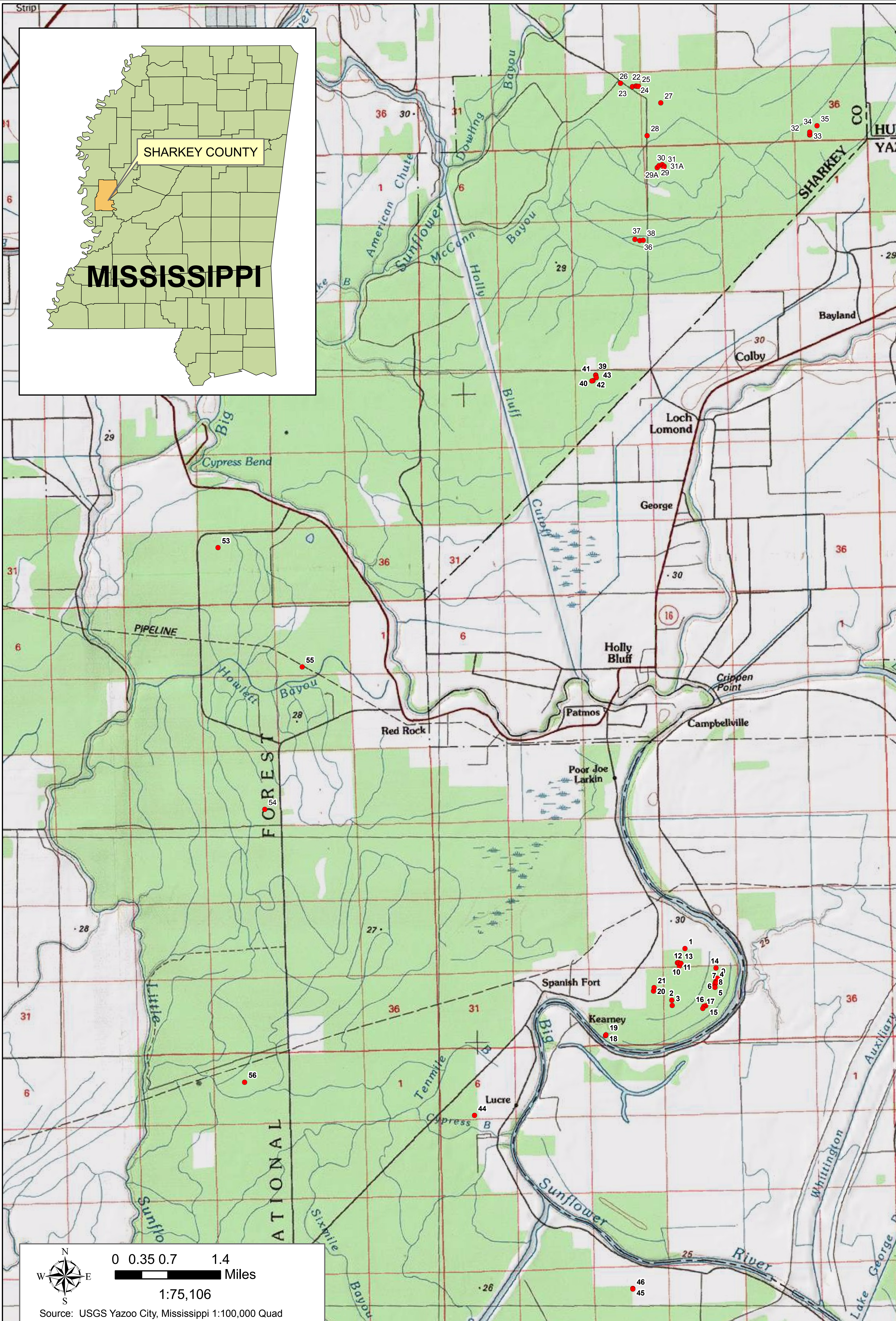

Figure 4-1: Pondberry Site Locations on DNF in Sharkey County

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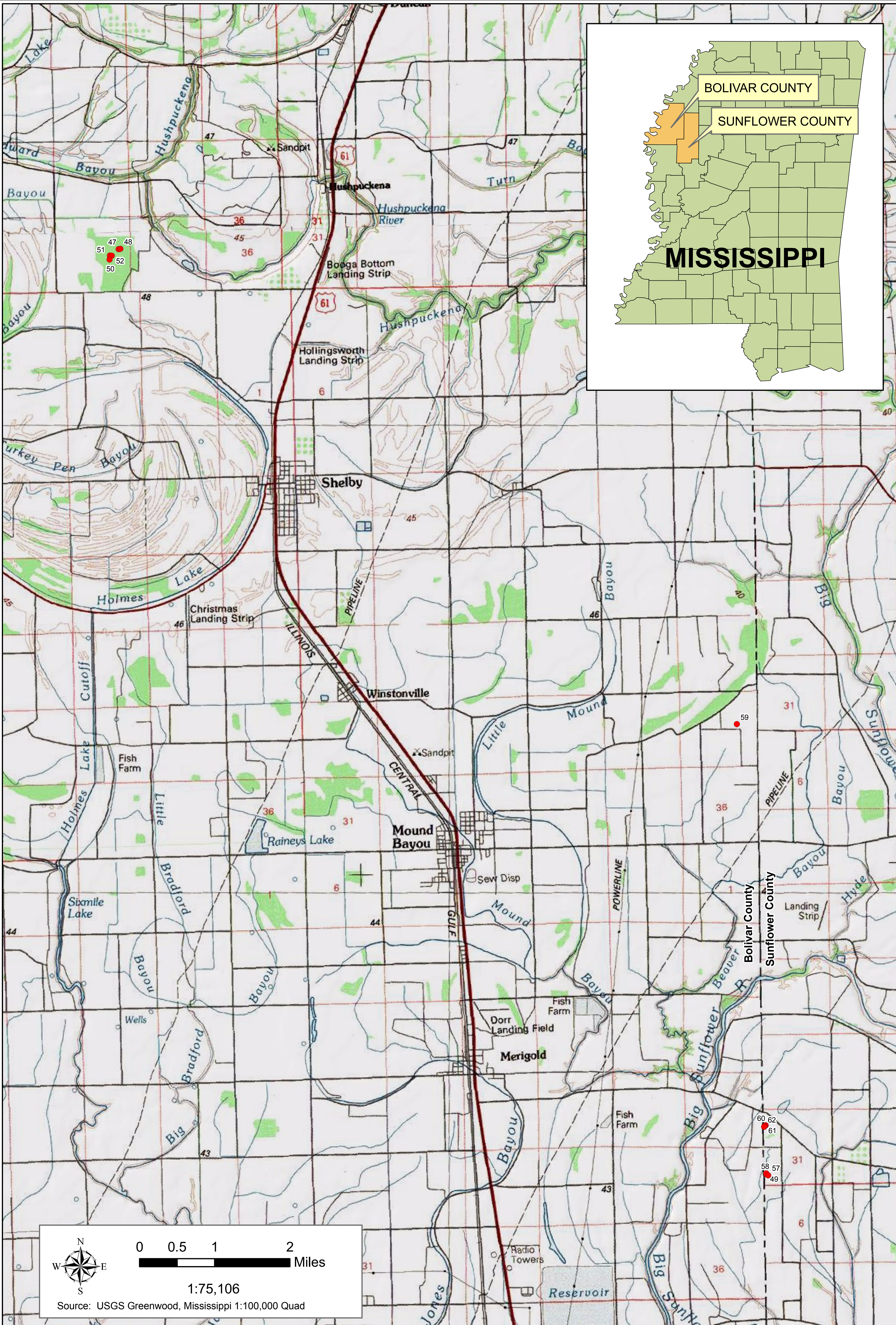

Figure 4-2: Pondberry Site Locations on Private Lands in Bolivar and Sunflower County

GSRC

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The soil survey of Bolivar County (USDA 1958) places the pondberry colonies near Shelby, Mississippi in the Sharkey silty clay loam, level phase and the Dowling soils overwash phases. Sharkey silty loam level phase have slowly permeable surface soils and very plastic, mottled subsoils. It has a gray-brown silty clay loam surface and is underlain with dark gray clay that greatly retards the percolation of water and inhibits plant roots. Dowling soils overwash phase are poorly drained soils that occur in depressions. The surface layers range from silty loam to clay and are dark gray to brownish gray. The one pondberry colony near Mound Bayou also had Dowling soils overwashed phase as the dominant association although it was surrounded by Alligator clay, gently sloping phase. The dominant soil association of the sites in Sunflower County was Dowling soils overwash phases (USDA 1959). The soils found at all the colony sites were classified as clay loams or silty clay.

4.2.2 Flood Frequency

The maximum and average of the number of stems observed at a colony was lowest at colonies in the 6 - 10 year and the 11 - 20 year flood frequency groups in both 2000 and 2005 (Table 4-1). Except for colonies in the > 100 year flood frequency group (all colonies on private lands), the maximum and average number of stems observed at a colony was lower in 2005 than in 2000. In both 2000 and 2005, approximately 40% of colonies are in the 3 - 5 year flood frequency group. Five colonies for which no above ground evidence of pondberry was observed were situated within each flood frequency group except the 3-5 year group, and these colonies were not used to calculate descriptive statistics. The average number of stems observed at these 5 colonies in 2000 was 5 stems in the 0 - 2 year floodplain, 12.5 stems in the 11 - 20 year floodplain, and 375 stems in the > 100 year floodplain. Therefore, the maximum and average number of stems reported in these flood frequency groups increased in 2005, to some extent, due to the absence of above ground evidence at these colonies.

Table 4-1. Number of Colonies; and Minimum, Maximum, Average, and Standard Deviation of Number of Stems; Within Flood Frequency Groups (2000, 2005)

Flood Frequency (years)	Number of Stems									
	2000					2005				
	n	min	max	avg	stdv	n	min	max	avg	stdv
0 - 2	9	5	2,064	272.67	672.30	8	4	1,280	336.75	472.76
3 - 5	23	2	3,791	368.13	836.48	23	2	1,274	160.70	280.39
6 - 10	8	6	161	41.00	50.54	8	3	43	20.50	16.23
11- 20	9	2	148	55.44	64.98	7	6	82	31.57	31.64
> 100	11	37	900	255.73	245.65	10	94	16,638 (617)*	1,901.30 (263.89)*	5,180.69 (178.89)*

* outlier removed

The relationship between the number of stems observed at a colony and flood frequency is illustrated graphically in Figure 4-3 for colonies in the DNF and in Figure 4-4 for colonies on private land. It appears from the figure that the number of stems observed at each colony decreased from 2000 to 2005, except for two colonies (54 and 56) which were at the lowest elevations. From Figure 4-4, it is not immediately clear that the number of stems at colonies in the > 100 flood frequency group were greater in 2005 than in 2000. However, Colony 52, which had 16,638 stems is not depicted in the graph, and the average number of stems was greater in 2005 with or without this outlier (see Table 4-1).

Figure 4-3. Relationship Between Number of Stems and Flood Frequency at Sites in DNF (2000, 2005)

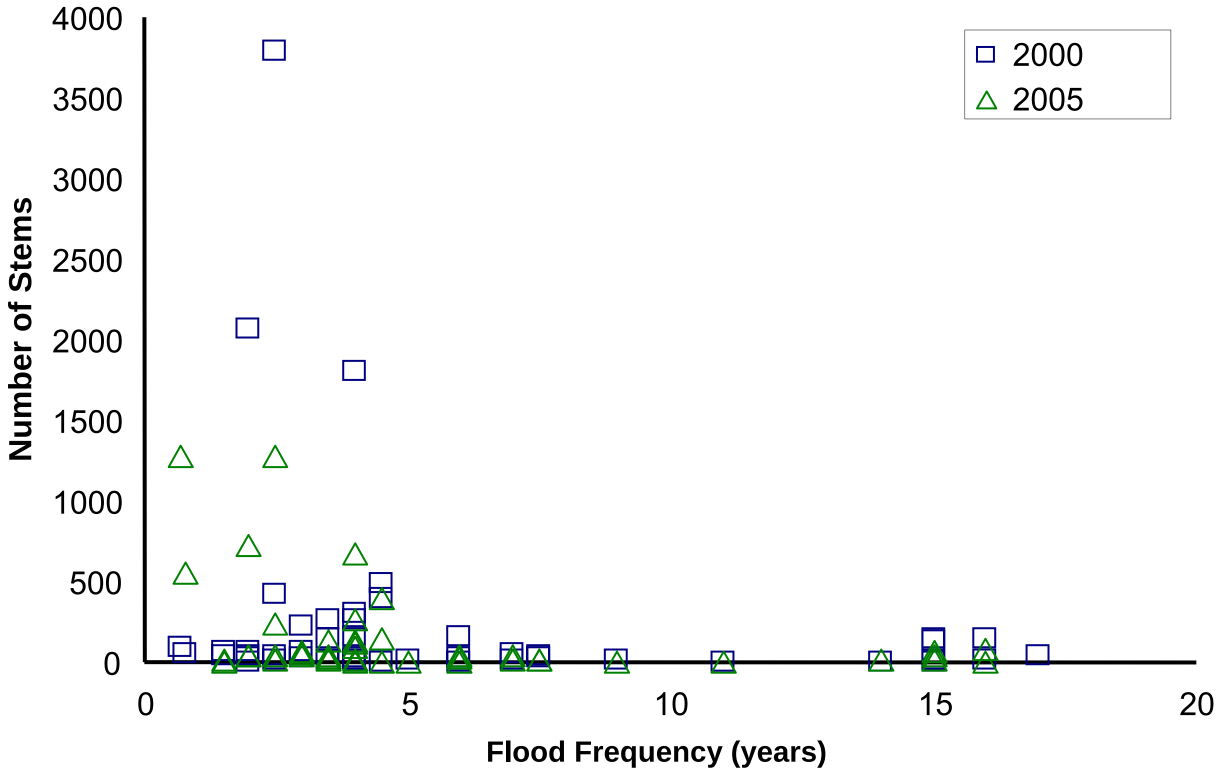
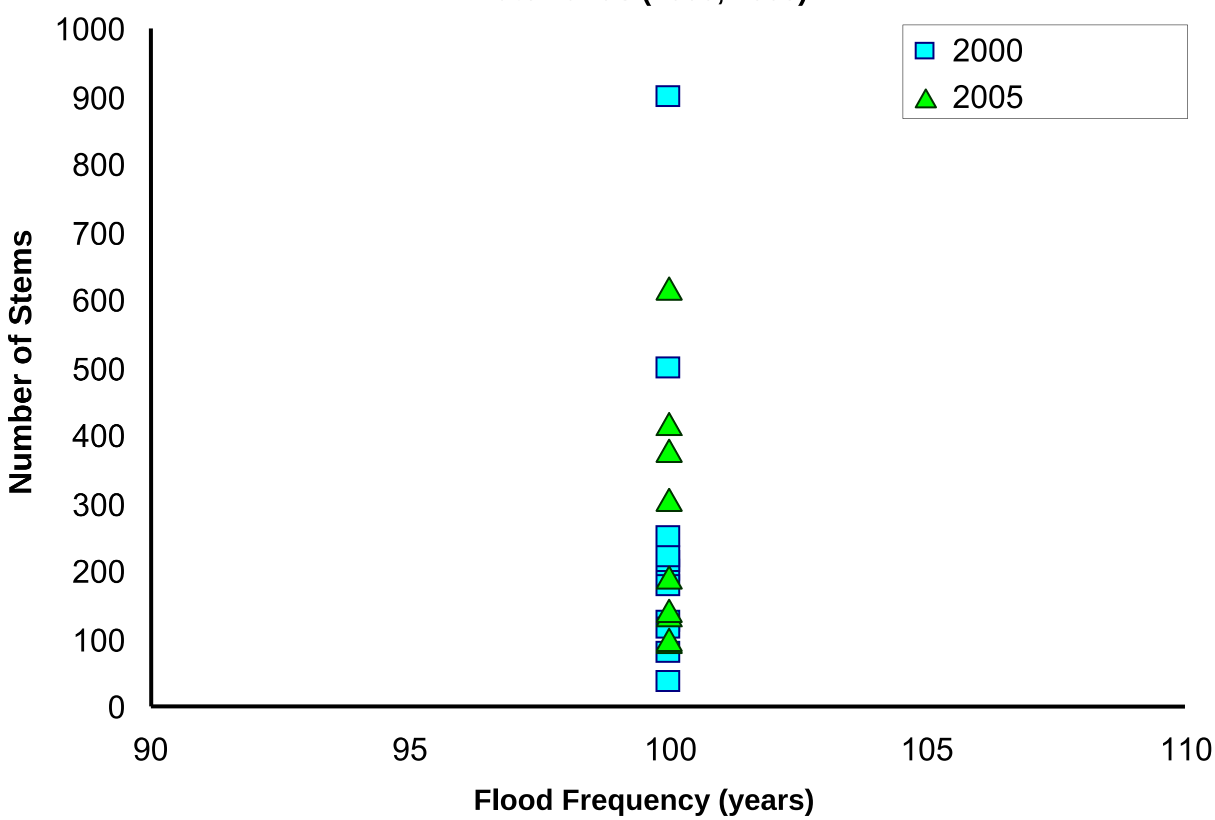


Figure 4-4. Relationship Between Number of Stems and Flood Frequency at Sites on Private Lands (2000, 2005)



4.3 BIOLOGICAL ENVIRONMENT

4.3.1 Associated Vegetation

The three most commonly observed overstory species associated with the pondberry colonies were sweetgum (*Liquidambar styraciflua*), overcup oak (*Quercus lyrata*), and pecan (*Carya illinoinensis*). The three most common understory species associated with the colonies were sweetgum, American elm (*Ulmus americana*), and red maple (*Acer rubrum* var. *drummondii*). The three most common shrub species were found to be sugarberry (*Celtis laevigata*), swamp dogwood (*Cornus foemina*) and red maple.

The three most common species found in the herbaceous layer in association with the pondberry colonies were vines: poison ivy (*Toxicodendron radicans*), greenbrier (*Smilax* spp.), and Virgina creeper (*Parthenocissus quinquefolia).* Appendix E presents the entire list of plant species identified near the pondberry colonies.

4.3.2 Herbaceous Cover

The percent of herbaceous cover observed at a colonies located in the DNF ranged from less than 20 to 100 (Table 4-2) and ranged from greater than 20 to nearly 100 at colonies located on private land (Table 4-3). For colonies in the DNF, the maximum and avearage number of stems observed at colonies within each herbaceous cover group was lowest at moderate values of herbaceous cover and tended to be greatest at the extreme values of herbaceous cover. There tends to be more colonies in the herbaceous cover groups with higher percentages of cover than in the groups with lower percentages of cover. These trends are not readily apparent in the data recorded from colonies on private land.

Table 4-2. Number of Colonies; and Minimum, Maximum, Average, and Standard Deviation of Number of Stems; Within Herbaceous Cover Groups in the DNF (2000, 2005)

Herbaceous Cover (percent)	Number of Stems (DNF)									
	2000					2005				
	n	min	max	avg	stdv	n	min	max	avg	stdv
0-20	5	5	3,791	1,183.60	1,705.10	5	6	1,274	410.80	569.69
21-40	9	2	485	125.67	192.05	8	8	308	83.88	119.18
41-60	6	8	72	34.33	22.84	6	13	565	153.83	206.79
61-80	8	2	1,800	269.00	622.77	11	10	558	114.82	164.50
81-100	22	6	398	110.55	109.76	16	2	1,280	135.38	321.04

Table 4-3. Number of Colonies; and Minimum, Maximum, Average, and Standard Deviation of Number of Stems; Within Herbaceous Cover Groups on Private Lands (2000, 2005)

Herbaceous Cover (percent)	Number of Stems (Private Lands)									
	2000					2005				
	n	min	max	avg	stdv	n	min	max	avg	stdv
21-40	5	115	900	329.00	321.92	1	617	617	617.00	na
41-60	3	79	177	127.00	49.03	4	140	16,638 (418)*	4,393.00 (311.33)*	8164.25 (149.86)*
61-80	3	37	500	262.33	231.74	4	99	305	182.50	90.01
81-100	0	na	na	na	na	1	94	94	94.00	na

* outlier removed; na = not applicable

The relationship between the average number of stems observed at a colony and percent herbaceous cover is illustrated graphically in Figure 4-5 for colonies in the DNF and in Figure 4-6 for colonies on private land. It appears from the graph that for colonies at which a greater average number of stems was observed, the associated percent herbaceous cover is either high or low. This same trend is not evident in the data collected from colonies on private land. It does appear that herbaceous cover increased between 2000 and 2005 at colonies located on private land.

Figure 4-5. Relationship Between Number of Stems and Herbaceous Cover at Sites in DNF (2000, 2005)

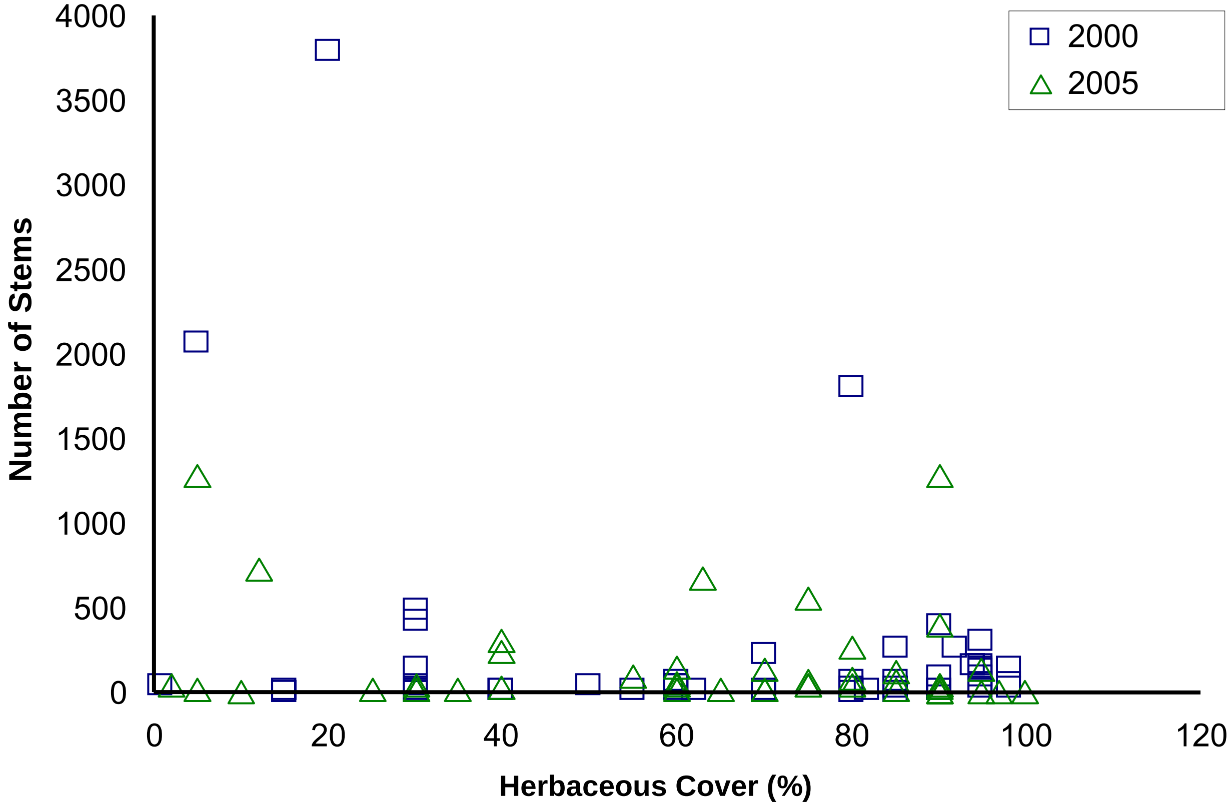
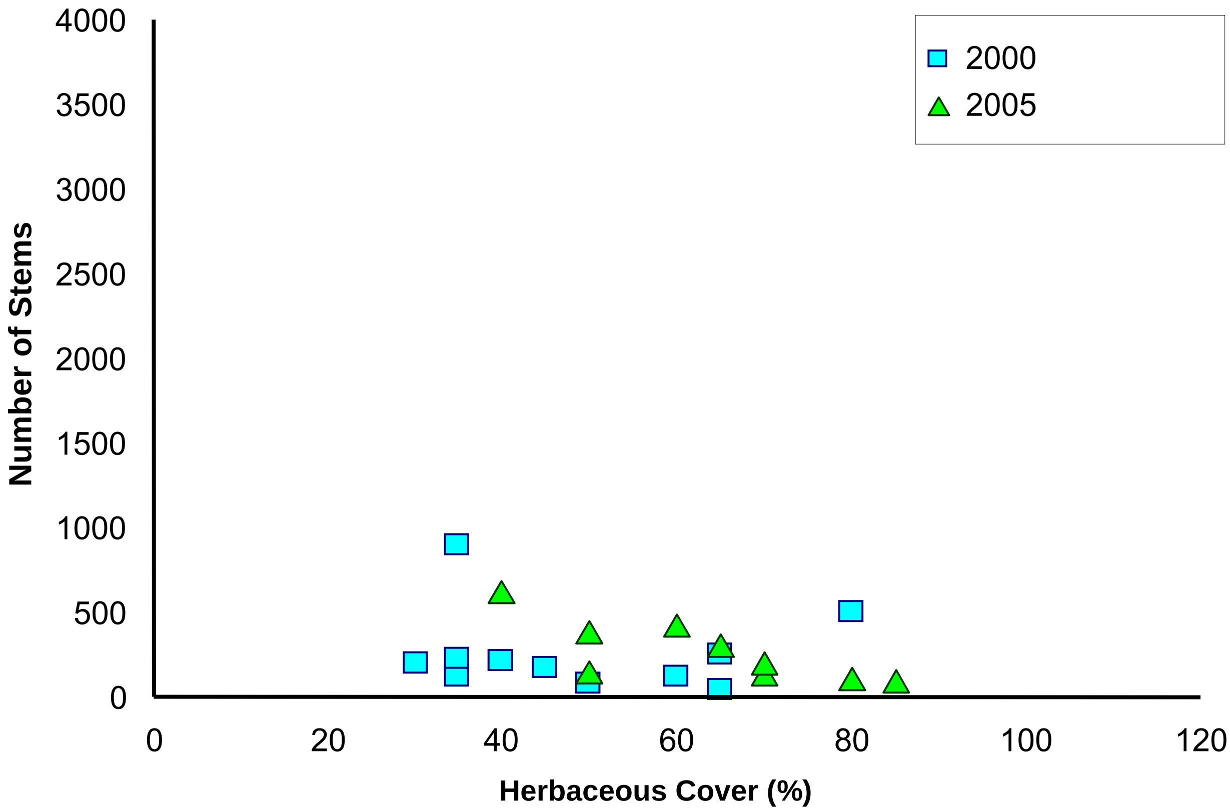


Figure 4-6. Relationship Between Number of Stems and Herbaceous Cover at Sites on Private Land (2000, 2005)



4.3.3 Canopy Cover

The percent of canopy cover at colonies in the DNF ranged between 70 and 100 in 2000 and between 50 and 100 in 2005 (Table 4-4). Although the maximum and average number of stems was lower at sites where canopy cover was greater than 90%, most colonies were in this percent canopy cover group in 2000. While most colonies were in the 80 - 89% and 90 – 100% canopy cover groups, the maximum and average number of stems recorded at these colonies were greater in 2005. The average number of stems observed at colonies in the 60 – 69% canopy cover group was also high in 2005.

Table 4-4. Number of Colonies; and Minimum, Maximum, Average, and Standard Deviation of Number of Stems; Within Canopy Cover Groups in the DNF (2000, 2005)

Canopy Cover (percent)	Number of Stems (DNF)									
	2000					2005				
	n	min	max	avg	stdv	n	min	max	avg	stdv
50-59	0	na	na	na	na	2	19	39	29.00	14.14
60-69	0	na	na	na	na	4	33	308	169.50	126.55
70-79	5	25	2,064	459.80	897.12	9	3	133	34.78	41.40
80-89	14	5	3,791	511.50	1,052.95	17	2	1,280	170.12	326.70
90-100	31	2	485	76.74	109.79	14	3	1,274	224.00	373.82

Similar to the range of observed percent canopy cover at each colony in the DNF, the range of percent canopy cover was more narrow in 2000 than in 2005 for colonies on private lands (Table 4-5). Colonies were nearly equally distributed among the canopy cover groups and there are no readily apparent trend in the maximum or average number of stems.

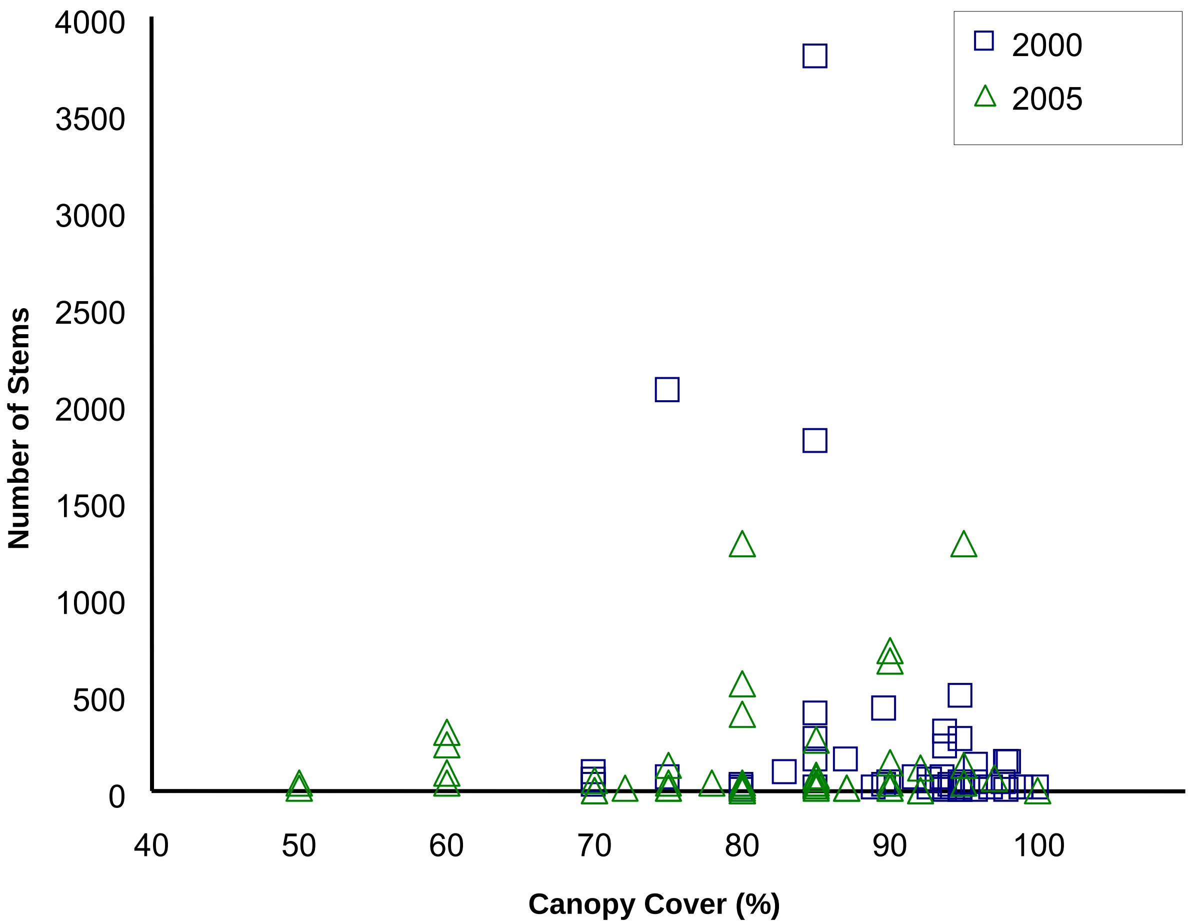
Table 4-5. Number of Colonies; and Minimum, Maximum, Average, and Standard Deviation of Number of Stems; Within Canopy Cover Groups at Sites on Private Lands (2000, 2005)

Canopy Cover (percent)	Number of Stems (Private)									
	2000					2005				
	n	min	max	avg	stdv	n	min	max	avg	stdv
50-59	0	na	na	na	na	3	99	16,638 (140)*	5,625.67 (119.5)*	9,536.98 (28.99)*
60-69	2	115	219	167.00	73.54	1	418	418	418.00	na
70-79	2	177	900	538.50	511.24	4	94	376	199.00	124.52
80-89	4	79	500	238.50	188.71	1	617	617	617.00	na
90-100	3	37	212	149.33	97.50	1	305	305	305.00	na

* outlier removed; na = not applicable

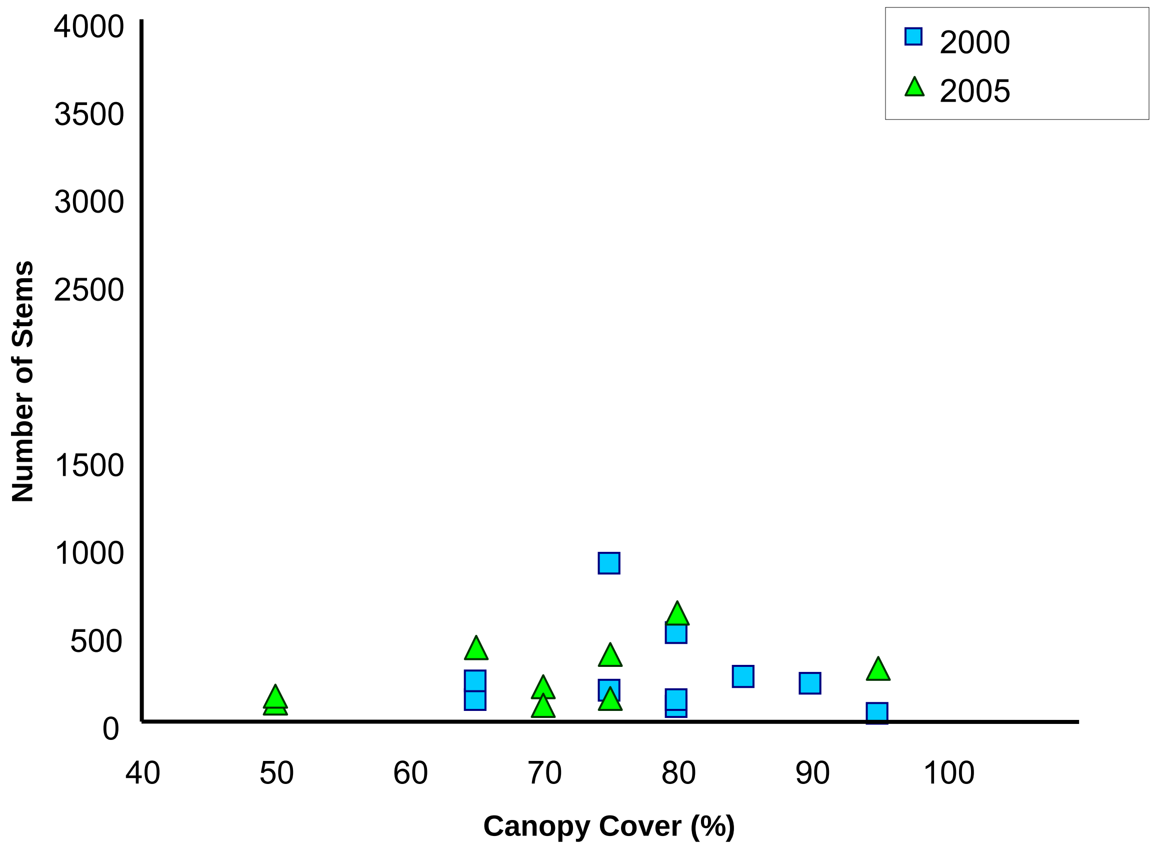
The relationship between the number of stems observed at a colony in the DNF and percent canopy cover is illustrated below in Figure 4-7. From this graph, it appears that the optimum canopy cover conditions occur between 80 and 90 percent. The number of stems appears to peak and this value, decreasing as percent canopy cover increases or decreases from this optimum value.

Figure 4-7. Relationship Between Number of Stems and Canopy Cover at Sites in DNF (2000, 2005)



The relationship between the number of stems observed at a colony on private lands and percent canopy cover is illustrated below in Figure 4-8. Although the variation in the number of stems observed at a colony is not as great as for those observed in the DNF, a slight peak can be observed at percent canopy cover values between 70 and 80 percent.

Figure 4-8. Relationship Between Number of Stems and Canopy Cover at Sites on Private Lands (2000, 2005)



4.3.4 Diameter Breast Height (dbh)

The dbh of trees at colonies in the DNF ranged between 10 and > 31 inches in 2000 and 2005 (Table 4-6). The distribution of the number of colonies in each dbh group is nearly normal.

Table 4-6. Number of Colonies; and Minimum, Maximum, Average, and Standard Deviation of Number of Stems; Within dbh Groups in the DNF (2000, 2005)

dbh (inches)	Number of Stems (DNF)									
	2000					2005				
	n	min	max	avg	stdv	n	min	max	avg	stdv
10-15	5	2	300	130.20	125.47	8	14	1,280	262.75	429.59
16-20	15	5	1,800	165.60	455.43	13	6	565	147.77	202.75
21-25	23	2	3,791	275.26	780.36	10	3	97	36.30	34.76
26-30	4	3	153	63.25	72.42	12	2	1,274	147.17	364.98
> 31	3	16	2,064	706.67	1,175.55	3	39	719	297.00	368.47

The dbh of trees at colonies on private lands ranged between 10 and 20 inches in 2000 and between 16 and 30 inches in 2005 (Table 4-7). Most colonies were within the lowest canopy cover group for each year and the maximum and average number of stems also appear to be greatest in this cover group.

Table 4-7. Number of Colonies; and Minimum, Maximum, Average, and Standard Deviation of Number of Stems; Within dbh Groups at Sites on Private Lands (2000, 2005)

dbh (inches)	Number of Stems (Private)									
	2000					2005				
	n	min	max	avg	stdv	n	min	max	avg	stdv
10-15	10	37	900	259.40	258.62	0	na	na	na	na
16-20	1	219	219	219.00	na	6	94	16,638 (418)*	2930.00 (188.40)*	6716.59 (134.14)*
21-25	0	na	na	na	na	3	135	617	352.33	244.46
26-30	0	na	na	na	na	1	376	376	376	na

* outlier removed; na = not applicable

The relationship between the number of stems at a colony and dbh at colony sites in the DNF appears to differ between 2000 and 2005 (Figure 4-9). In 2000, the dbh at colony sites where the number of stems is low ranges from less than 10 inches to nearly 50 inches. However, most colonies, including colonies with a greater number of stems, are equally distributed among sites where the dbh is between 15 and 28 inches. In 2005, the relationship between dbh and number of stems appears similar to the relationship between herbaceous cover and number of stems (see Figure 4-5). None of the colonies where the dbh is between 20 and 25 inches have a noticeably high number of stems. However, at colonies where the dbh is above or below this range, the number of stems appears to higher.

The relationship between the number of stems at a colony and dbh at colony sites on private lands appears to be similar in 2000 and 2005 (Figure 4-10). Although, the dbh is relatively higher in 2005 than in 2000, there appears to be a weak, positive linear relationship in both years. The number of stems appears to increase as dbh increases.

Figure 4-9. Relationship Between Number of Stems and dbh at Sites in DNF (2000, 2005)

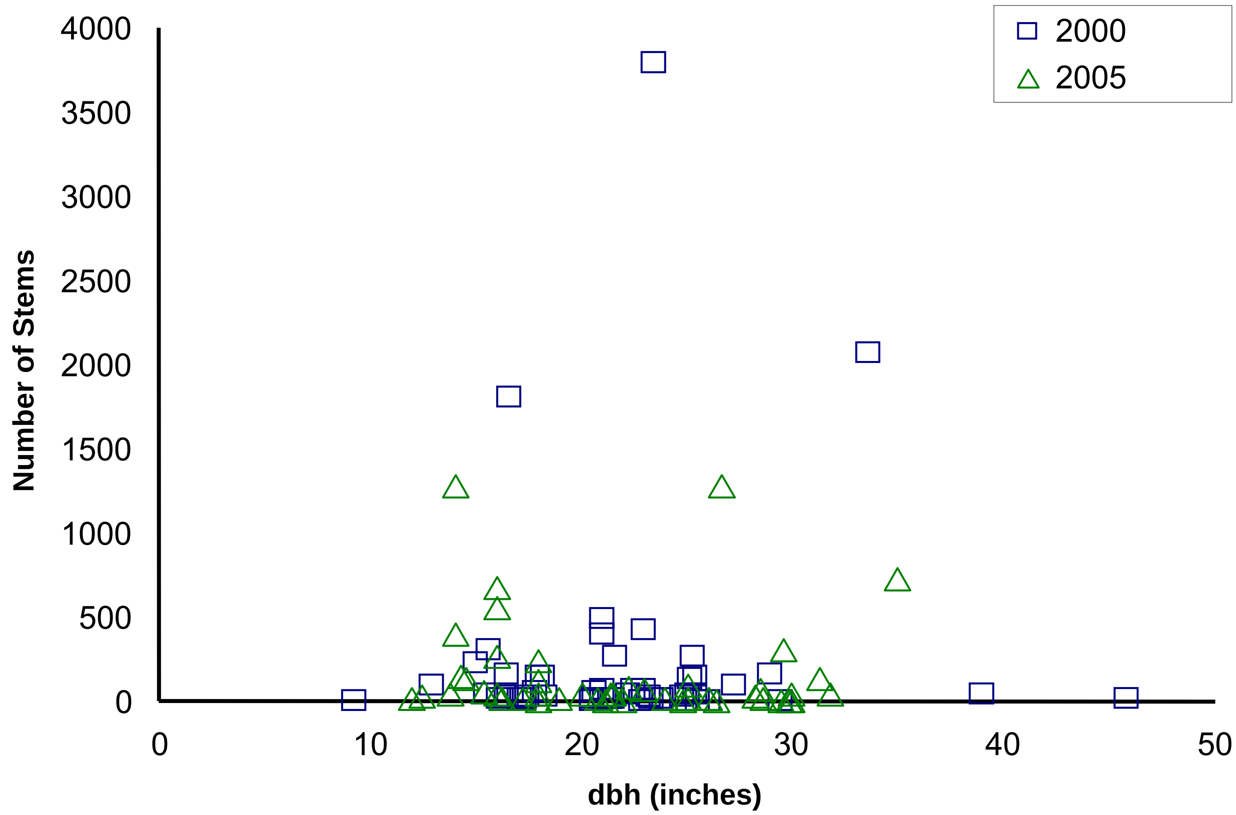
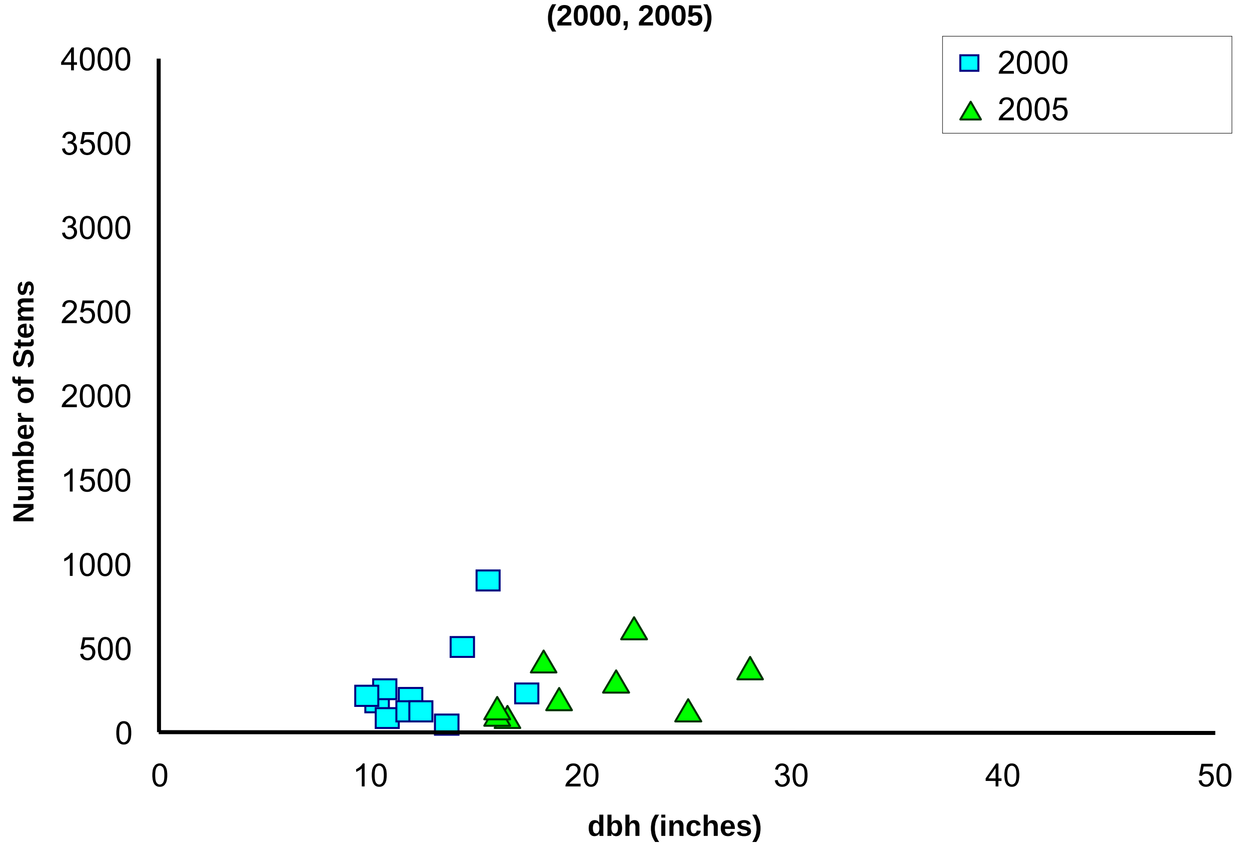


Figure 4-10. Relationship Between Number of Stems and dbh at Sites on Private Lands (2000, 2005)



4.3.5 Pondberry

A summary of colony size indicators as recorded in 2000 and 2005 is presented in Table 4-8. For colonies in the DNF, all but one of the descriptive statistics (minimum, maximum, and average) of stem diameter, stem height, and number of stems is lower in 2005 than in 2000. This is not true for colonies on private lands, where the maximum and average number of stems was greater in 2005. The number of colonies in which females were found also decreased. Of the 18 colonies found supporting females in 2000, only 3 of these were found to support fruiting females in 2005. However, four of the colonies that had no females identified in 2000 were found to support fruiting females in 2005.

Table 4-8. Minimum, Maximum, and Average Stem Diameter, Stem Height, and Number of Stems at Colonies in the DNF and on Private Lands (2000, 2005)

Variable	DNF							
	2000				2005			
	min	max	avg	stdv	min	max	avg	stdv
Number of Stems	2	3,791	239.76	646.65	2	1,280	147.28	291.19
Stem Diameter (inches)	0.038	0.875	0.309	0.168	0.059	0.375	0.170	0.084
Stem Height (inches)	10	42	20.14	7.24	10	31	17.00	6.06
Variable	**Private**							
	2000				2005			
	min	max	avg	stdv	min	max	avg	stdv
Number of Stems	37	900	242.00	239.00	94	16,638 (617)*	1,756.45 (268.30)*	4,938.26 (169.24)*
Stem Diameter (inches)	0.150	0.875	0.339	0.185	0.118	0.900	0.374	0.203
Stem Height (inches)	13	62	27.31	12.91	14	40	25.00	7.62

* outlier removed

A comparison of colony health, fungal damage, insect damage, and dieback as recorded in 2000 and 2005 is presented in Table 4-9. Most colonies were of good or excellent health in 2000 and of good health in 2005. For colonies on private land, 50% were of fair health and 42 percent were of good or excellent health in 2000 and 75% were of good health in 2005. When compared to 2000, the number of colonies where there was observed fungal damage was 80% less in 2005. Conversely, more colonies had insect damage, and nearly equivalent numbers of colonies showed sings of dieback in 2005.

Table 4-9. Comparison of Colony Health, Fungal Damage, Insect Damage, and Dieback (2000, 2005)

Year	Health (%)					Number of Colonies		
	NAE*	Poor	Fair	Good	Excellent	Fungal Damage	Insect Damage	Dieback
2000	0	2	13	45	40	27	42	52
2005	8	3	8	68	13	5	52	54

* NAE = no above ground evidence of pondberry

4.4 DATA ANALYSIS

4.4.1 Correlation Analysis

In general, there were few strong linear relationships and fewer statistically significant linear relationships between the number of stems at a colony and either physical or biological data (Appendix F). Most of the graphical illustrations of these relationships (Figures 4-3 through 4-10) also do not appear to be described by linear relationships. At colonies in the DNF, there is a statistically significant ($p = 0.05$), but weak, negative ($r = -0.278$) relationship between herbaceous cover and the number of stems at a colony in 2000. This relationship is seen again, but is much stronger ($r = -0.770$), for colonies on private land in 2005. Figure 4-6 supports this negative linear relationship between number of stems and herbaceous cover at colonies on private land in both 2000 and 2005. In 2005, the relationship between flood frequency and number of stems was statistically significant ($p = 0.04$), and moderately negative ($r = -0.308$) for sites in the DNF and was statistically significant ($p = 0.02$), but moderately positive ($r = 0.300$) when all colonies were analyzed together. Although the negative relationship is supported graphically (see Figure 4-3), the positive relationship appears to be affected more by relatively high values of flood frequency and number of stems at sites on private land, and is not supported graphically.

4.4.2 Analysis of Variance (ANOVA)

Only the average stem diameter and average stem height differed among flood frequency groups in 2005 (Appendix F). The average height and diameter of stems at colonies on private land (flood frequency > 100 years) was greater than at colonies on the DNF ($p = 0.0001$). There was no statistical difference among the average values of number of stems, number of clumps, density of stems, diameter of stems, or height of stems among flood frequency groups in 2000.

4.4.3 Paired t-test

There was no statistically significant difference between the number of stems at a colony in 2000 and the number of stems at the same colony in 2005 when colonies for which no above ground stems were evident were analyzed as having no stems ($p = 0.14$) or when these colonies were excluded from the analysis (0.23) (Appendix F).

5.0 CONCLUSIONS

After numerous field investigations, the USACE determined that a typical pondberry colony found within the Mississippi Delta generally occurs on slight ridges in a ridge and swale community prone to periodic flooding. The results of this study concur with the USACE 1991 and 2000 field investigations as well as previous studies (USDA 1958, 1959, 1962), in that the soils types in these areas are generally poorly drained clayey soils that occur in depressions. Furthermore, localized depressions, as defined previously, were again recorded at the majority (94%) of pondberry colonies in 2005.

In the DNF, the maximum and average number of stems was greatest in the 0 - 2 and 3 - 5 year flood frequency groups and the 3 - 5 year flood frequency group supported the greatest number of colonies (46% in 2000 and 50% in 2005). There was a statistically significant ($p = 0.04$) and moderately negative ($r = -0.308$) linear relationship between the number of stems and flood frequency at colonies in the DNF observed in 2005 and this relationship, as well as the relationship in 2000, is supported graphically. However, the maximum and average number of stems at colonies on private lands in Bolivar and Sunflower Counties, where the flood frequency is >100 years, was greater than the 6 – 10 year and the 11 – 20 year flood frequency groups in 2000. In 2005, the maximum and average number of stems at colonies in the >100 year flood frequency group was greater than those of all other flood frequency groups. Elevation and flood frequency alone might not accurately depict inundation frequency or duration at a specific pondberry colony location due to the nature of the local topography and soils.

Common associate overstory species were found to be similar to those found in the previous studies on pondberry. In 2000, sweetgum, willow oak and Nuttall oak were found most commonly in association with pondberry colonies. In 2005, sweetgum, overcup oak, and pecan were found to be the most common associate overstory species. Common associate shrub species were found to be sugarberry, swamp dogwood and red maple in 2005. It should be noted that the DNF is managed for oaks; thus, their importance as associate species may be exaggerated. No spicebush was found in areas where pondberry was present.

The number of stems observed at a colony was lowest at moderate values of herbaceous cover for colonies in the DNF in 2000 and 2005. However, more colonies were associated with high herbaceous cover than with low herbaceous cover. Herbaceous cover was greater than 80% at

44% of all surveyed colonies in 2000 and at 35% of all surveyed colonies in 2005. For colonies on private lands, the linear relationship between herbaceous cover and the number of stems was weak ($r = -0.060$) in 2000, but strongly negative ($r = -0.770$) and statistically significant ($p = 0.02$) in 2005. Similar to herbaceous cover, the number of stems at a colony tends to be lowest at moderate levels of canopy cover for colonies in the DNF during 2000. However, this relationship was not found in the 2005 data collected from DNF colonies or from data collected from colonies on private lands. The relationship between dbh and number of stems at colonies in the DNF was similar to the relationships observed between canopy cover and number of stems. For sites on private lands in Bolivar and Sunflower Counties, there was a moderately positive (2000 $r = 0.472$, 2005 $r = 0.452$) linear relationship between the number of stems and dbh that is supported graphically, but was not statistically significant (2000 $p = 0.14$, 2005 $p = 0.22$). These analyses might suggest that the number of stems found in a pondberry colony is affected by light and competition, but these relationships are not clear.

In this survey, pondberry colonies were found, on average, to have fewer, smaller, and shorter stems in 2005 than they did in 2000. This relationship does not include colony 52 at which an estimated 16,000 stems were observed in 2005. Furthermore, there was no statistical difference between the number of stems observed at each colony in 2000 and in 2005. Although the number of colonies of excellent health in 2000 was 27% greater than in 2005, 68% of colonies were of good health in 2005. The number of colonies in which females were found decreased by 44% from 2000 to 2005. However, it is difficult to identify gender of pondberry plants outside of the flowering season when female stems can only be identified by presence of fruit. Four of the colonies that reported no females in 2000, had fruiting females in 2005. Females could have not been identified as such if this was a poor fruiting season. Fungal damage was 80% less common in 2005 than in 2000. From these data it is difficult to make strong conclusion about the overall trend of colony health from 2000 to 2005.

There was no above ground evidence for 5 of the previously surveyed colonies in 2005. Two of these colonies in Bolivar and Sunflower Counties were inundated with water from nearby crop fields to the point of wilting in 2000. This suggests that colonies might be affected by repeated and prolonged inundation. Other possible explanations might be overspray of pesticides and runoff from nearby crop fields. The 3 colonies in the DNF for which no above ground evidence of pondberry was observed were reported to have low numbers of stems in 2000, but were in fair or good health.

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