Report on Post Hurricane Ian Tree Staking at the Lemon Creek Wildflower Preserve

Prepared by Dana Houkal for Lemon Bay Conservancy
July 16, 2023

1. Introduction

Hurricane Ian hit southwest Florida on September 28, 2022 as a Category 4 hurricane with the center passing approximately 8 miles southeast of the Lemon Creek Wildflower Preserve (Preserve)[1] which is owned and managed by the Lemon Bay Conservancy. Winds in excess of 100 miles per hour and rainfall in excess of 15 inches (recorded September 28-30, 2022) were reported near the Preserve.

A survey of the Preserve on October 18, 2022 (20 days post-Ian) indicated that many large and small trees were damaged by Hurricane Ian. The trunks of many large trees had snapped (windsnap), while many other large trees and small trees were uprooted and/or blown over (windthrow).

Revegetation plantings with native species occurred at the Preserve from September 2020 through January 2021, and in 2022. Damage to trees planted in 2022 was minimal with only a few trees showing windthrow. Apparently, the small size and flexibility of trees planted in 2022 enabled them to resist Ian's strong winds. However, trees planted from September 2020 through January 2021 were generally taller, had larger crowns, and had a significant incidence of windthrow.

Almost 3,000 native trees were planted in 2020/21. Although 15 species of trees were planted, the three most commonly planted species were south Florida slash pine (pine) (*Pinus elliotii* var. *densa*) (1327 planted), southern red cedar (cedar) (*Juniperus virginiana* var. *silicicola*) (342 planted), and live oak (oak) (*Quercus virginiana*) (180 planted). Considering the value of trees planted in 2020/21, which includes the initial plant material and planting costs as well the value of two years of growth in the field, it was decided that an attempt should be made to rescue as many of the windthrown trees as possible.

Shrubs planted in 2020/21 were also observed to have suffered significant windthrow from Hurricane Ian. Some of the shrub species planted in 2020/21 were difficult to distinguish from non-planted shrubs (natural regeneration) and their multi-stemmed form made the rescue of shrubs problematic. In addition, it was believed that the shrubs would naturally recover from

[1] NOAA National Centers for Environmental Information, Monthly National Climate Report for September 2022, published online October 2022, retrieved on January 25, 2023 from https://www.ncei.noaa.gov/access/monitoring/monthly-report/national/202209/supplemental/page-5

windthrow by sprouting from new shoots at the stem base (i.e., root collar). Grasses and forbs planted in 2020/21 did not suffer significant damage from Hurricane Ian.

The following sections describe the methods and materials that were used to rescue the windthrown trees planted in 2020/21 (Section 2), presents the results of rescue efforts (Section 3), and provides important conclusions of the rescue effort (Section 4).

2. Methods and Materials

2.1 Staking Procedures

A method for rescuing windthrown trees needed to be developed that would be effective, economical, and quickly/easily/safely conducted by volunteers at the Preserve.

A staking method was tested on October 20, 2023, on five windthrown cedar trees. This method consisted of hammering a wooden stake into the ground to serve as an anchor and using a rope to upright the tree and attach it to the stake (Figures 1, 2, and 3).

A series of knots collectively known as the trucker's knot was used to anchor the tree to the stake[2]. The staking process consisted of:

- First, a wooden stake was hammered into the ground using a 8-pound sledge hammer at 5 to 10 feet from the base of the tree on the side opposite the direction of windthrow. The distance of the stake from the base of tree depended upon tree height with greater distance required for taller trees. The stake was oriented at 20 to 40 degrees from vertical and angling away from the tree and with the wide side facing the tree. The stakes were generally hammered to a depth where only 3 to 6 inches remained above the ground. This procedure provided a strong anchor for the trees, particularly the taller trees with large crowns that could exert significant force on the stake under windy conditions.
- Second, an overhand loop was tied on the rope end to be attached to the stake. The loop was large enough to fit over the stake.
- Third, the rope was looped around the tree trunk at approximately 50 percent of the tree height (e.g., if the tree was 8 feet tall, the rope was attached to the trunk at approximately 4 feet above the ground). This method provided adequate leverage while not putting undo force on the smaller diameter stem higher in the tree.
- Fourth, an overhand loop was made on the segment of rope attached to the stake at a distance of approximately 2 feet from the base of the tree.
- Finally, the tree was brought up to a vertical position and the rope was passed through the overhand loop. The rope was tightened and locked off with a half-hitch with a loop.

[2] https://www.youtube.com/watch?v=ExZijLDEmbE see last knot on video.

The half-hitch with a loop allows the knot to be easily undone, which was important for eventual removal of the rope.

Staking began using 3/8-inch diameter braided polypropylene rope, but was switched to ¼-inch diameter braided polypropylene rope because it was more cost-effective and performed similarly. Likewise, staking began using 1"x2"x24" wooden stakes, but switched to 1"x2"x18" because they were more cost-effective and anchored the trees adequately.

The typical staking procedure consisted of two volunteers conducting tree staking two-days a week for 2 hours each day. One person hammered in the stake, while the second person tied the overhand loop on the end of the rope. That second person righted the tree while the first person affixed the rope to the stake and around the tree.

2.2 Staking Areas

Figure 4 shows the 16 native plant locations (labeled A thru P) that were planted in 2020/21. No trees were rescued in Area F because the few trees (18) that were planted there showed minimal windthrow. No trees were planted in Areas O and P. Therefore, staking occurred in 13 of 16 2020/21 planting areas.

2.3 Post-staking Survey

Following the cessation of staking, a survey was conducted in the thirteen 2020/21 planting areas to determine the number of staked trees and unstaked trees. The number of staked and unstaked trees were visually counted and noted while walking across the area. The accuracy of these counts was affected by the following factors:

- Staking ropes could be obscured by vegetation
- Occasionally, dark colored rope was used for staking which was difficult to see
- Natural regeneration of slash pine and Virginia live oak was at times difficult to distinguish from planted trees
- Unstaked trees were counted regardless of the degree of windthrow
- Unstaked trees were counted in several sub-areas where windthrown trees were inadvertently not staked, this could bias the calculation of percent of trees staked

Staked tree height was also measured during the post-staking survey to provide an estimate of the mean size of staked trees. Height was measured to the nearest foot on a maximum of 15 trees per species per planting area. In cases where more than 15 trees were staked for a species and area, the height of the first 15 trees encountered was measured. In cases were fewer than 15 trees of a species were staked, the height of all trees was measured. Tree height was measured from ground level to the top of the tallest live point using a graduated 8-foot polyvinyl chloride (PVC) pole to the nearest foot. If a tree was more than 8 feet tall, the total tree height was estimated by extending the measuring pole from the 8-foot point on the stem to the tallest live point and adding that height to the first 8-feet.

2.4 Staked Tree Survival

If left too long, the anchoring rope could damage the cambial layers of the tree trunk and completely or partially girdle the tree. However, removing the anchoring ropes from trees before the root system has re-established itself could result in further windthrow. A minimum of 6 months is typically required to insure newly planted and staked trees have strong enough root systems before anchoring ropes can be safely removed. Staked trees were periodically monitored to help determine the appropriate time to remove the ropes. Scheduling of rope removal varied by date of staking and species. Following rope removal, the trees were flagged with orange plastic tape so they could be monitored for an additional one year, if needed.

Many of the 2020/21 tree plantings that suffered windthrow also sustained significant root damage. In fact, the lateral root systems of some trees were so damaged that they appeared to have little or no anchoring roots whatsoever. The ultimate measure of success of the staking project is the survival of staked trees. Tree survival was initially assessed during removal of ropes/stakes which occurred between April 25 and June 20, 2023. The first significant 2023-season rainfall occurred at the Wildflower Preserve on June 17 when it is estimated that 2 to 3 inches of rain fell. The number of dead staked trees in each planting area was determined visually for each species and compared with the number of originally staked trees. A tree was classified as dead if all the foliage was missing or dead.

3. Results

3.1. Staking Activities

Tree staking began on October 21, 2022 (approximately 3-weeks post-Ian) and ended on January 24, 2023 (approximately 3 months after staking began). Trees were easily brought to a vertical position in October and November, 2022. However, by early December 2022, the roots of some pine[3] and cedar trees were regrowing which made it difficult to bring them to a vertical position. In fact, most pines staked in January 2023 could not be brought to a vertical position and were staked in a leaning position (Figure 5). Staking was terminated on January 24, 2023 because staking after that date would likely cause significant root damage and could negatively impact tree survival.

Trees varied in their degree of windthrow with some only slightly leaning and others completely blown over. Considering limitations of both manpower and materials, trees suffering minor windthrow were not staked and their survival was expected to be high. The decision of whether to stake a tree was made by volunteers in the field, but trees leaning less than approximately 20 degrees from vertical were typically not staked (Figure 6).

[3] In addition to south Florida slash pine, 114 longleaf pine (*Pinus palustris*) trees were planted in four planting areas in 2020/21. This included 17 trees in Area H, 17 trees in Area J, 35 trees in Area l and 45 trees in Area M. For purposes of staking, south Florida slash and longleaf pine were merged and identified as pine.

Pine, cedar, and red maple were observed to be vigorously growing in October 2022. They continued to grow through the end of staking period on January 24, 2023. In contrast, hackberry trees were found to be dormant in January 2023 having no or few browning leaves. Their lack of shoot growth during dormancy was likely associated with limited root growth which allowed them to be readily uprighted in January 2023. Oak trees did not show active shoot growth following Hurricane Ian through January 24, 2023, but were somewhat difficult to bring to an upright position in January 2023 suggesting some post-Ian root growth had occurred.

Several pine and cedar trees were left in an extreme windthrown position because their root systems were too severely damaged or because they were too strongly rooted to be brought to an upright position.

Unstaked windthrown trees began to demonstrate a geotropic[4] response in terminal shoot growth by early December 2022. The actively growing terminal shoots of windthrown pine and cedar began growing perpendicular to the ground in response to gravity (Figures 7 and 8). Once staked in an upright position, the shoots of these trees will respond by again curving to a position perpendicular to the ground. These trees may show a distinct stem curve until diameter growth is great enough to mask it. The fact that windthrown pine and cedar demonstrated a geotropic response in shoot growth supports the observation that they were actively growing during the 3-month staking period.

Windthrown cedar trees were observed to be dead in late November and early December, 2022 (Figure 9). Several dead cedars occurred in planting Areas A&B and J, while many dead cedars were observed in Area L. The cause of this mortality is unclear. In Areas A&B and J, several dead cedars were mixed in among live windthrown cedars and the surface soil in these areas were relatively sandy and appeared to be well drained. The cedars in Area L were planted as a visual barrier along the border with a condominium complex and many of these cedars were dead. The surface soil around the dead cedars in Area L had a relatively high organic matter content and was still saturated in early December 2022. Although cedar naturally grows on a wide range of soils, it is not commonly found on saturated soils[5]. Although windthrow could be responsible for the observed mortality in cedar, other causes such as water-logged soil may also be a cause.

Tree staking was typically conducted by a team of two Preserve volunteers for two hours on Tuesday and Thursday of each week (the typical schedule for volunteer activities). However, staking sometimes occurred on additional days and occasionally included 3 to 4 volunteers. Likewise, staking did not occur on every Tuesday and Thursday due to other needs at the Preserve. Tree staking was estimated to have been conducted on 28 days between October 21,

[4] Geotropism is the growth of plant parts with respect to the force of gravity. Plant shoots typically grow vertically which is negative geotropism.

[5] https://www.srs.fs.usda.gov/pubs/misc/ag_654/volume_1/juniperus/silicicola.htm

2022 and January 24, 2023. Assuming that staking was conducted by two volunteers for two hours each day, approximately 112 labor hours was spent staking trees.

Efforts were made to stake all windthrown trees planted in 2020/21 prior to the cessation of staking on January 24, 2023. However, a significant number of windthrown trees were not staked because:

- They were overlooked by the staking team.
- They were too strongly re-rooted to be staked.
- They could not be staked prior to the January 24, 2023 deadline.

Three 2020/21 planting areas were noted as having a significant number of unstaked windthrown trees, the west side of Area L, the northwest side of Area C, and the west side of Area E.

Table 1 shows tree staking dates for each of the 13 tree planting areas[6]. Table 2 shows tree staking data for each planting area organized by species[7]. In addition to the number of staked and unstaked trees in each planting area, Table 2 provides tree height data for the staked trees. Table 3 summarizes the tree staking activities. Figures 10, 11, and 12 show the mean height of pine, cedar and oak, respectively, across planting areas.

Table 3 shows that 654 trees were staked across the 13 planting areas. Approximately 15 additional trees were staked in other areas. Of the 654 trees staked on planting areas, 53 percent were pine, 27 percent were cedar, and 11 percent were oak. The remaining 9 percent of staked trees included red maple, hackberry, gumbo limbo, sea grape, red mulberry, and unidentified species.

Table 3 also shows the approximate number of unstaked trees in each area, so the percentage of staked trees could be estimated. Gumbo limbo had the highest percentage of staked trees (75 percent), while red maple had the lowest percentage of staked trees (25 percent). The staking percentage was significantly higher for cedar (64 percent), compared to pine (42 percent) and oak (44 percent). Cedar is an evergreen that has a dense crown extending from ground level to the shoot apex, which may make it more prone to windthrow.

Table 2 shows considerable variation in within-species staking percent across planting areas. For example, pine and oak had high staking percentages in Area A&B (60 and 48 percent respectively), but had significantly lower staking percentages in Area M (27 and 12 percent, respectively). In this case, the higher staking percentages in Area A&B may be due to greater

[6] Areas A and B were combined for reporting purposes because the border between Areas A and B was not discernable in the field. In addition, cedar trees planted along the north side of the creek separating Area G from Area I were included in Area G for purposes of this staking project.

[7] The accuracy of the staked and unstaked tree counts provided in Tables 2 and 3 have not been verified and should be considered as estimates.

exposure to Hurricane Ian's winds. Area A&B lies south of the Sandalwood housing development and Gasparilla Pines Blvd which provide little wind protection. On the other hand, Area M is buffered to some degree by approximately 0.3 mile of vegetated land to the north. Other factors may also contribute to differences in staking percent across planting areas (e.g., soil characteristics, depth to groundwater, variable sample sizes).

Overall, a total of 1,257 pines, oaks, and cedars were found as part of this study. They represent 66% of the 1,849 trees of these three species planted in the 2020/2021 restoration project. That raises questions about whether many of the other trees did not survive and whether some planting areas have higher survival rates than others. Future, detailed survey work by planting area would be required to more fully assess survival rates.

Figures 10, 11, and 12 show considerable variability in mean height of staked pine, cedar, and oak across planting areas. For example, the mean height of pine ranged from 5.9 feet in Areas J and K to 8.8 feet in Area G. Differences in mean height between planting areas are likely related to soil properties such as nutrient levels, soil moisture, depth to groundwater, and possibly planting date. The question arises as to whether tree height influenced the incidence of windthrow (i.e., were taller trees prone to greater windthrow then shorter trees). This question was assessed on pine by evaluating the relationship between mean height and windthrow percent across planting areas. Slash pine was selected for this analysis because it was present in all 13 planting areas and had a large number of staked trees in each planting area providing the most robust data set. Figure 13 is a scatter plot of mean tree height (x-axis) versus windthrow percent (y-axis) which includes a linear regression line and equation. Figure 13 clearly shows there is no relationship between these factors (i.e., the linear regression line (dashed line) has little slope and the coefficient of determination (r^2) is very small).

The estimated total cost for staking materials (i.e., stakes, rope, sledge hammer) was $1,245. Considering a total of 679 trees were staked (includes trees on planting areas and other areas), the material staking cost was approximately $1.83 per tree.

Assuming approximately 112 labor hours were spent staking 679 trees, the staking rate was approximately 6 trees per labor hour (or 12 trees per hour per 2-person team). This staking rate seems low considering that under ideal conditions (i.e., planting area close to work sheds, trees closely spaced, easy access to windthrown trees) it was observed that a 2-person team could stake 40-50 trees during a 2-hour period. Since the 2-hour volunteer window included an initial mobilization period of 5 to 10 minutes (e.g., organizing volunteers and gather staking materials) as well as walking to the staking site, actual time spent staking was undoubtedly less than 2-hours per day. This was particularly true for planting areas distant from the work sheds (i.e., departure point) which could involve up to a 30-minute round-trip transit time.

Tree staking involved several moderately hazardous practices (i.e., pounding stakes into the ground using a 8-pound sledgehammer, cutting rope with a knife or shears, and walking

through brushy conditions that pose a trip/fall potential). Gratefully, no significant accidents occurred during the tree staking project.

3.2. Rope Removal

Staked slash pine and eastern red cedar trees were evaluated to determine the appropriate timing of anchoring rope/stake removal. Starting in early April of 2023, staked trees were periodically evaluated to assess the adequacy of the root system to support the tree. The evaluation was primarily conducted in Areas I and N as these were the first areas to be staked. Initially, the stems of a number of upright unstaked trees in Areas I and N were manually pushed to get a sense of the force needed to move the base of a well-rooted tree. Then the rope was removed from several staked trees and force applied in the direction of windthrow to assess the force needed to move the base of the staked tree. This qualitative process was repeated on many trees over time to determine when it was safe to remove the anchoring ropes/stakes. This evaluation indicated that approximately 5-6 months are needed to ensure adequate root growth before anchoring ropes and stakes could be safely removal.

All staked gumbo limbo trees in Area I and several hackberry trees in Areas E and K did not have an adequate root system for tree support at the time of rope/stake removal. Continued staking of these trees is required. Both gumbo limbo and hackberry were not actively growing at the time of staking. Although both species showed some shoot growth at the time of rope/stake removal, growth was modest. It is assumed that this modest shoot growth is associated with modest root growth that resulted in an inadequate root system to allow rope/stake removal. We will continue to monitor these trees and remove the ropes/stakes when they demonstrate adequate rooting.

Rope/stake removal began on April 25, 2023 and ended June 20, 2023. Rope/stake removal began at the earliest staked area (Area I) and ended at the last staked area (Area C). Table 4 shows the dates when the planting areas were staked and de-staked.

A relatively small but significant number of staked trees were found to be unstaked at the time of rope/stake removal. The primary reason why trees became unstaked was that either the stake was pulled out of the ground or the rope slide off the stake. During staking the soil around several trees was found to be very loose which made it difficult to affix the stake in a secure manner. In addition, some stakes were simply not driven deep enough into the soil. In addition, the rooting of wild hogs in several areas caused stakes to become unsecured. Some unstaked trees had fallen over, but the majority were still upright suggesting that these trees became unstaked several months after being staked.

It was suggested that we periodically re-visit staked trees prior to de-staking to adjust the rope and/or restake trees that had become unstaked. Considering our man-power limitations, it was more prudent to stake windthrown trees rather than re-visiting already staked trees.

During de-staking, several red cedar and slash pine trees showed the stem tissue starting to grow over the rope (Figures 14 and 15). This is the result of active growth on the cambium around the point of constriction. In these cases, this damage is expected to be transitory and should not adversely affect the tree following rope removal. However, it does support the notion that removing the rope/stake from trees at 6 months post-staking is appropriate to avoid any significant tree damage.

At the time of de-staking, many of the wooden stakes had sustained significant attack by insects and fungi/bacteria. It was originally thought that the stakes would have to be removed by shovel to mitigate the trip/fall risk. However, the weakened stakes could easily be broken by simply stepping on them which obviated the need to dig them up.

Approximately 11 hours of labor were required to remove the ropes/stakes.

3.3. Survival Assessment

Survival of staked trees at the time of rope/stake removal (April 25 through June 20, 2023) was very high with only five dead trees observed (2 of 346 staked pines or 0.6% (Figure 16), 2 of 179 staked cedars or 1% (Figure 17), and 1 of 13 staked hackberry or 8% (Figure 18)). There was no observed mortality in the other staked species (i.e., red maple, mulberry, live oak, sea grape, gumbo limbo, and unidentified species).

A few staked pine trees had fallen completely over at the time of rope/stake removal and may eventually die. In these cases, either the stakes had been pulled out of the soil or the rope had come off the stakes shortly after staking which caused these trees to fall over.

The high survival rates of staked trees shows that staking has little negative affect on tree survival. In addition, slash pine, eastern red cedar, red maple, live oak, and mulberry showed active shoot growth at the time of staking which continued through rope/stake removal. This active shoot growth is likely associated with active root growth which allowed these species to re-establish a structurally strong root system able to support the stem and crown within a 5-6 month period.

Qualitative field observations also showed that many unstaked windthrown trees have a high rate of survival. However, there appeared to be higher mortality in unstaked windthrown trees compared to staked trees. Some windthrown trees were not staked because they suffered massive root damage and that damage may result in tree mortality.

4. Conclusions and Recommendations

The major conclusions and recommendations of this tree staking project are as follows:

- Approximately 679 trees were staked. Most of these trees were planted as container grown stock from September 2020 through January 2021 in 13 different planting areas. Although more than 8 different tree species were staked, the three most common ones

were south Florida slash pine (346 or 51 percent), southern red cedar (179 or 26 percent)), and live oak (72 or 10 percent). The mean height of these species was 7.0 feet (pine), 8.5 feet (cedar), and 9.6 feet (oak).

- Species varied in the percentage of trees that were windthrown and required staking from 25 percent for red maple to 75 percent for gumbo limbo. The percentage of staked trees was 42 percent for pine, 64 percent for cedar, and 44 percent for oak. The higher wind throw for cedar may be related to its relatively larger dense crown.
- The percentage of windthrown trees varied across planting areas. In the case of pine, the percentage of staked trees varied from 20 percent (Area D) to 67 percent (Area I). There was no significant relationship between planting area mean height and percentage of staked trees.
- The efficacy of tree staking was very high with an insignificant level of mortality of staked trees at the time of rope/stake removal at 6 months post-staking.
- The material cost for tree staking was $1.83/tree which seems justified considering the initial plant and planting costs and additional value of 2-3 years growth of trees in the field.
- Tree staking continued for too long a period. Staking started on 10/21/2022 and ended on 1/24/2023, almost 4 months after Hurricane Ian hit Florida on September 28, 2022. By early December 2022, it started to become difficult to move some windthrown trees to a vertical position because their root systems had begun to re-established themselves. By mid-January 2023, most windthrown trees could not be moved to a vertical position for staking. It is recommended that staking be completed within 2 to 3 months of windthrow.
- Rope/stake removal at 6 months post-staking is recommended for most species because the root systems have re-grown to a point where they can support the trees by that time. Although this recommendation is applicable to many species (i.e., pine, cedar, oak, maple, mulberry, and sea grape), it is not applicable to gumbo limbo and hackberry whose root systems had not re-established themselves sufficiently at 6 months.

Figures 1 and 2. This pine in Area D suffered severe windthrow from hurricane Ian and was rescued using the stake and rope method described in the text of this report (11/5/22).

Figure 3. This pine in Area D was successfully staked in a vertical position (11/5/22).

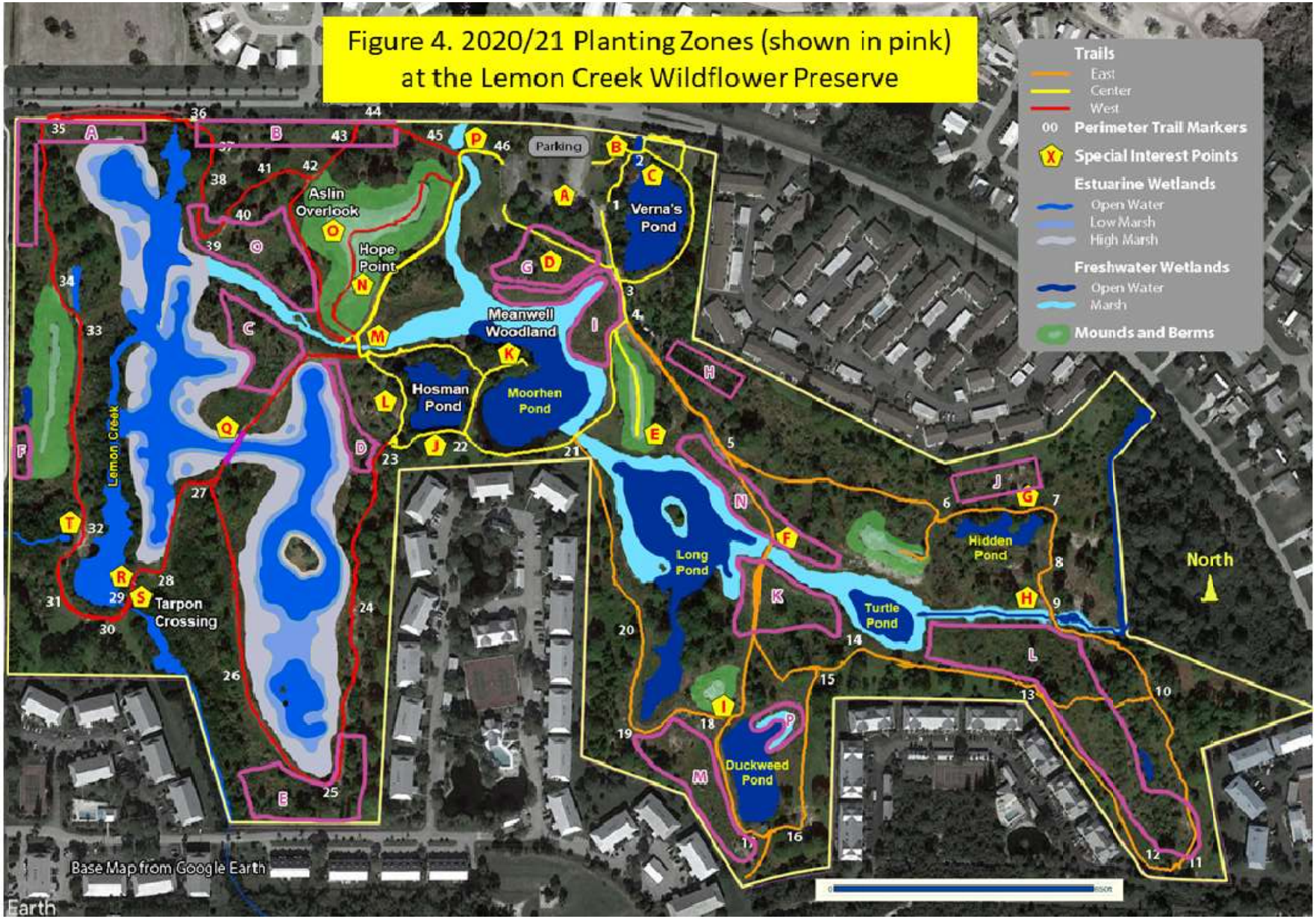
Figure 4. 2020/21 Planting Zones (shown in pink)
at the Lemon Creek Wildflower Preserve
Trails
East
Center
West
00 Perimeter Trail Markers
Special Interest Points
Estuarine Wetlands
Open Water
Low Marsh
High Marsh
Freshwater Wetlands
Open Water
Marsh
Mounds and Berms
Parking
Aslin Overlook
Hope Point
Verna's Pond
Meanwell Woodland
Hosman Pond
Moorhen Pond
Lemon Creek
Long Pond
Hidden Pond
Turtle Pond
Duckweed Pond
Tarpon Crossing
North
Base Map from Google Earth

Figure 5. This pine in Area C was staked in less than vertical position because the root system was too well developed and would be damaged if forced to vertical (1/24/2023).

Figure 6. This pine in Area C shows some windthrow, but it was not staked because it was decided the windthrow was insufficient to warrant staking (1/24/2023).

Figures 7 and 8. Windthrown pine showing a geotropic response in terminal shoot growth on December 4, 2022 in Area J and January 12, 2023 in Area M.

Figure 9. Dead windthrown cedar in Area J on December 4, 2022.

FIGURE 10. MEAN HEIGHT OF STAKED PINE BY AREA

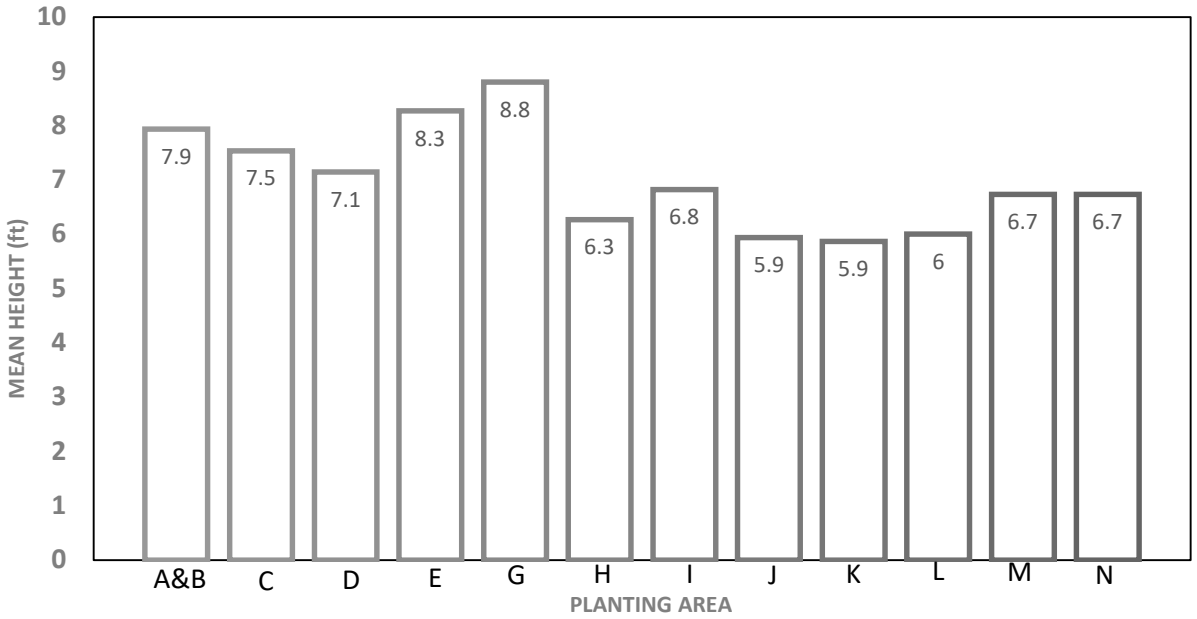

FIGURE 11. MEAN HEIGHT OF STAKED CEDAR BY AREA

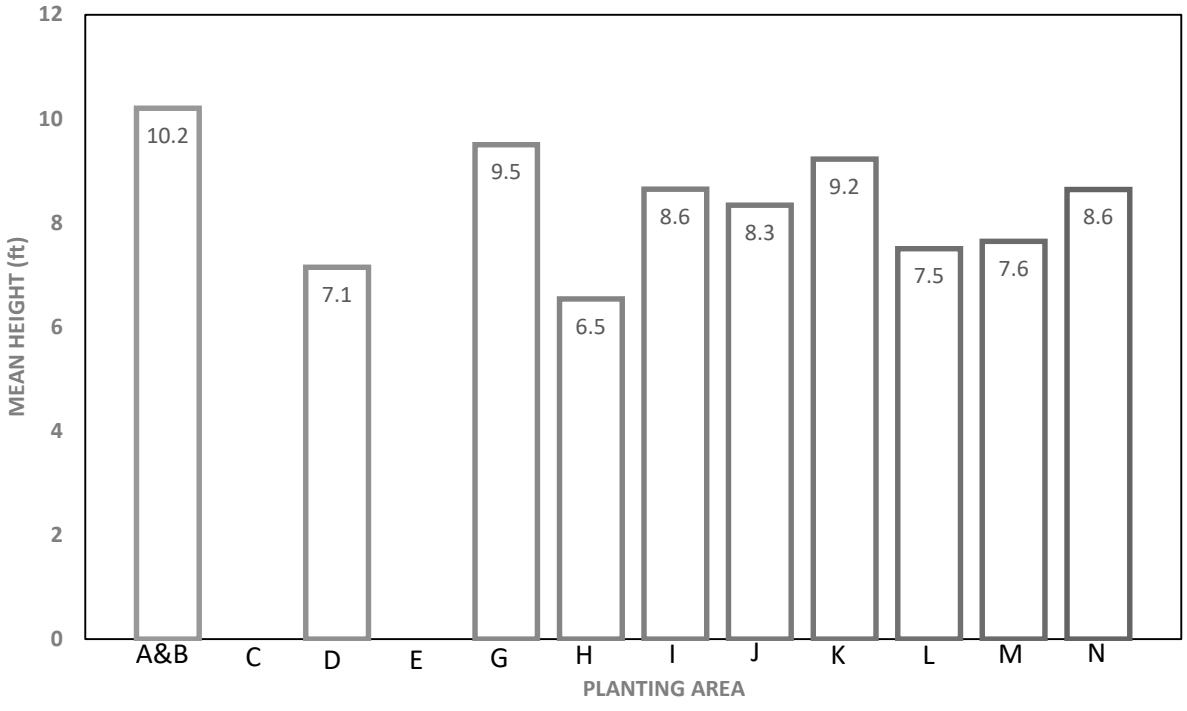

FIGURE 12. MEAN HEIGHT OF STAKED OAK BY AREA

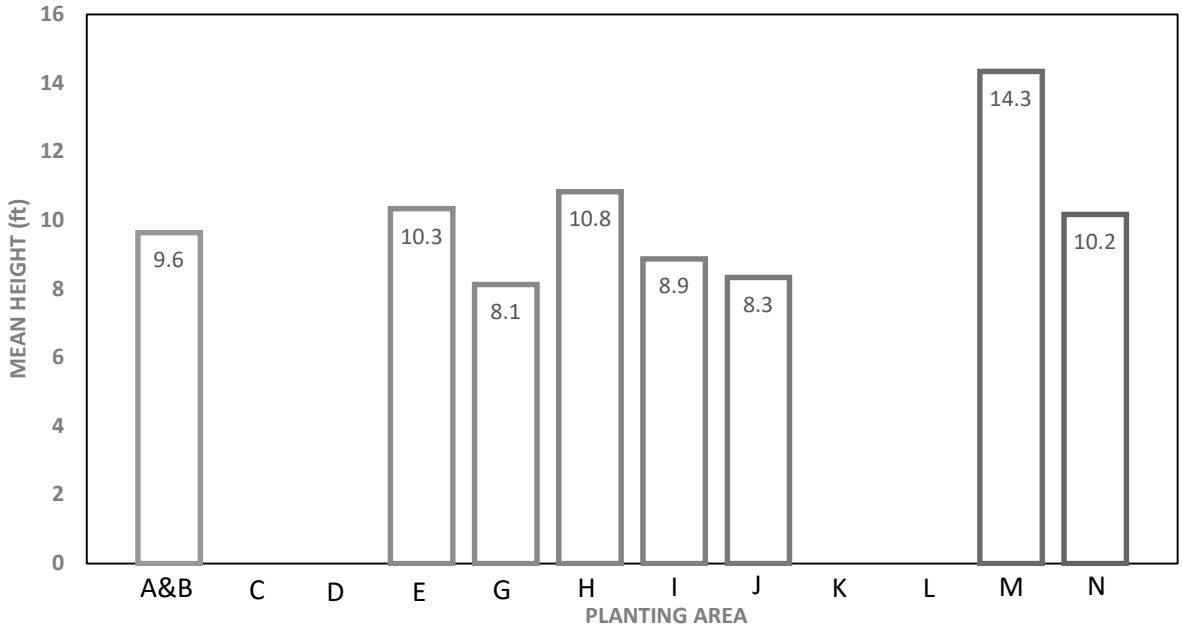

FIGURE 13. LINEAR REGRESSION OF MEAN HEIGHT AND WINDTHROW PERCENT IN PINE ACROSS PLANTING AREAS

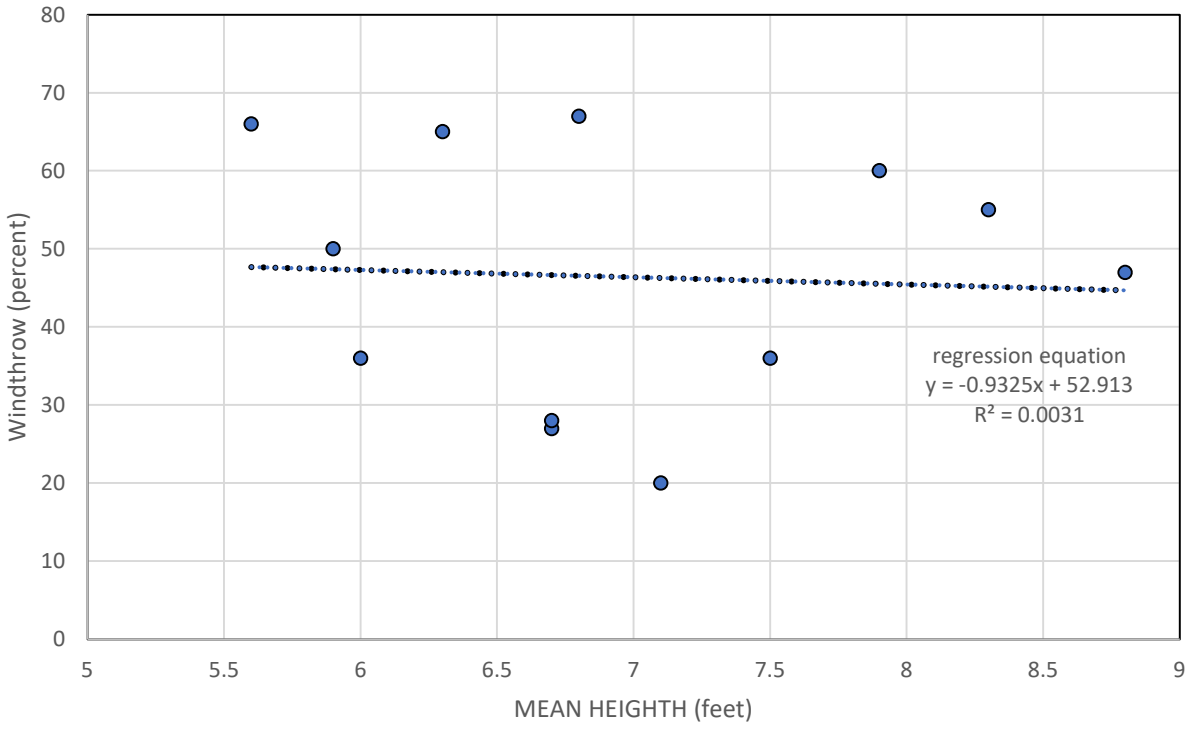

Figure 14. Pine in Area G with bark growing over rope (5/9/2023).

Figure 15. Cedar in Areas A&B with bark growing over rope (4/27/2023).

Figure 16. Dead staked pine Area J (5/16/2023). Figure 17. Dead staked cedar Area H (5/16/2023).

Figure 17. Dead staked hackberry Area K (5/11/2023).

TABLE 1. PLANTING AREA STAKING DATES

AREA (1)	YEAR PLANTED	DATES STAKED
A	2020	10/27&28/2022, 11/1/2022
B	2020	10/27&28/2022, 11/1/2022
C	2020	12/8&15/2022, 1/17&19&24/2023 (4)
D	2020	1/12/2023
E	2020	12/15/2022, 1/17&19&24/2023 (2)
F	2020	no staking (only 18 trees planted with limited windthrow)
G	2020	11/5&12/2022
H	2020	11/17/2022
I	2020	10/21/2022
J	2020	12/3/2022
K	2020	11/12/2022, 1/12/2023 (3)
L	2020	12/1&3/2022
M	2020	12/3&6/2022
N	2020	10/23&25/2022
O	2021	no staking (only shrubs and grasses planted)
P	2021	no staking (only shrubs and forbs planted)

Notes:

1) Areas A-G planted in September 2020, Areas H-N planted in December 2020, and Areas O and P planted in January 2021.

2) Many trees (~30) staked on 1/17&19&24/2023

3) Few trees staked on 1/12/2023 on east side of area

4) Many trees (~30) staked on 1/17&19&24/2023 on southeast side of area

TABLE 2. TREE STAKING DATA

AREA	SPECIES	No. STAKED	No. UNSTAKED	TOTAL No.	% STAKED	HEIGHT (FT)															STAKED TREE HEIGHT DATA			
						1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	No.	MIN	MAX	MEAN
A&B	PINE	29	19	48	60	8	14	7	6	7	8	7	8	8	7	9	9	7	6	8	15	6	14	7.9
	CEDAR	48	8	56	86	9	10	12	9	8	11	10	9	8	12	11	12	10	11	11	15	8	12	10.2
	OAK	14	15	29	48	13	13	9	10	9	10	8	8	8	9	9	--	--	--	--	11	8	13	9.6
	UNIDENTIFIED	1	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C	PINE	31	56	87	36	9	7	6	6	8	9	9	8	7	8	8	6	8	9	5	15	5	9	7.5
	CEDAR	0	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
	OAK	0	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	UNIDENTIFIED	4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
D	PINE	7	28	35	20	7	8	8	7	7	7	6	--	--	--	--	--	--	--	--	7	6	8	7.1
	CEDAR	35	3	38	92	9	9	10	10	11	6	8	8	7	9	8	8	10	7	9	15	6	11	8.6
	OAK	0	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	UNIDENTIFIED	3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
E	PINE	50	41	91	55	9	8	10	8	9	8	9	9	8	10	9	8	7	6	6	15	6	10	8.3
	CEDAR	0	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	OAK	3	2	5	60	13	9	9	--	--	--	--	--	--	--	--	--	--	--	--	3	9	13	10.3
	RED MAPLE	6	22	28	21	12	8	8	13	11	13	--	--	--	--	--	--	--	--	--	6	8	13	10.8
	HACKBERRY	5	10	15	33	11	9	15	10	11	--	--	--	--	--	--	--	--	--	--	5	9	15	11.2
	UNIDENTIFIED	5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

AREA	SPECIES	No. STAKED	No. UNSTAKED	TOTAL No.	% STAKED	HEIGHT (FT)															STAKED TREE HEIGHT DATA			
						1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	No.	MIN	MAX	MEAN
G	PINE	65	74	139	47	10	8	11	7	12	8	8	9	6	10	10	9	8	7	9	15	6	12	8.8
	CEDAR	6	3	9	67	11	12	9	8	9	8	--	--	--	--	--	--	--	--	--	6	8	12	9.5
	OAK	10	10	20	50	6	8	9	8	9	9	9	7	--	--	--	--	--	--	--	8	6	9	8.1
	SEA GRAPE	2	--	--	--	6	8	--	--	--	--	--	--	--	--	--	--	--	--	--	2	6	8	7.0
	RED MULBERRY	3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
H	PINE	20	11	31	65	10	6	6	7	7	3	7	6	6	7	7	6	6	4	6	15	3	10	6.3
	CEDAR	15	5	20	75	8	6	7	8	9	4	5	8	7	7	6	5	6	5	7	15	4	9	6.5
	OAK	6	2	8	75	11	10	12	13	9	10		--	--	--	--	--	--	--	--	6	9	13	10.8
	SEA GRAPE	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
I	PINE	14	7	21	67	6	8	7	6	8	7	5	6	7	8	7	--	--	--	--	11	5	8	6.8
	CEDAR	14	1	15	93	8	8	9	8	11	8	9	11	9	9	8	8	9	6		14	6	11	8.6
	OAK	7	9	16	44	8	7	9	8	10	10	9	10	--	--	--	--	--	--	--	8	7	10	8.9
	GUMBO LIMBO	6	2	8	75	11	15	14	8	7	10	--	--	--	--	--	--	--	--	--	6	7	15	10.8
J	PINE	27	27	54	50	5	6	6	8	6	5	7	4	6	5	4	7	8	6	6	15	4	8	5.9
	CEDAR	9	5	14	64	7	5	8	8	9	12	9	9	8	--	--	--	--	--	--	9	5	12	8.3
	OAK	6	7	13	46	7	7	8	10	9	9	--	--	--	--	--	--	--	--	--	6	7	10	8.3
	UNIDENTIFIED	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

AREA	SPECIES	No. STAKED	No. UNSTAKED	TOTAL No.	% STAKED	HEIGHT (FT)															STAKED TREE HEIGHT DATA			
						1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	No.	MIN	MAX	MEAN
K	PINE	21	11	32	66	6	7	5	6	6	6	6	6	7	5	5	5	6	6	6	15	5	7	5.9
	CEDAR	9	24	33	27	10	9	10	9	13	8	6	9	9	--	--	--	--	--	--	9	6	13	9.2
	OAK	0	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	RED MAPLE	8	13	21	38	14	12	12	11	10	13	15	13	--	--	--	--	--	--	--	8	10	15	12.5
	HACKBERRY	8	3	11	73	13	15	14	16	12	11	12	8	--	--	--	--	--	--	--	8	8	16	12.6
L	PINE	25	45	70	36	5	6	6	8	5	5	6	7	4	8	5	6	5	6	8	15	4	8	6
	CEDAR	2	16	18	11	7	8	--	--	--	--	--	--	--	--	--	--	--	--	--	2	7	8	7.5
	OAK	0	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	RED MAPLE	1	14	15	7	10	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
M	PINE	19	51	70	27	8	6	7	6	6	7	8	8	8	6	9	6	6	5	5	15	5	9	6.7
	CEDAR	14	9	23	61	7	5	6	7	10	8	7	10	7	7	7	6	10	10	--	14	5	10	7.6
	OAK	3	22	25	12	16	14	13	--	--	--	--	--	--	--	--	--	--	--	--	3	13	16	14.3
	RED MAPLE	3	6	9	33	8	11	10	--	--	--	--	--	--	--	--	--	--	--	--	3	8	11	9.7
N	PINE	19	50	69	28	8	6	7	6	6	7	8	8	8	6	9	6	6	5	5	15	5	9	6.7
	CEDAR	11	9	20	55	8	7	10	10	8	11	8	8	9	8	8	--	--	--	--	11	7	11	8.6
	OAK	6	12	18	33	10	10	11	9	11	10	--	--	--	--	--	--	--	--	--	6	9	11	10.2

Notes:

The number of unstaked trees was not counted for sea grape, red mulberry, and unidentified species because few trees were staked in few planting areas.

No. = number, % = percent, MIN = minimum, MAX = maximum

TABLE 3. SUMMARY OF TREE STAKING DATA

SPECIES	No. STAKED	No. UNSTAKED	TOTAL	% STAKED
PINE	346	470	816	42
CEDAR	179	99	278	64
OAK	72	91	163	44
RED MAPLE	18	55	73	25
HACKBERRY	13	13	26	50
GUMBO LIMBO	6	2	8	75
SEA GRAPE	3	--	--	--
RED MULBERRY	3	--	--	--
UNIDENTIFIED	14	--	--	--
GRAND TOTALS	654	730	1364	48

Notes:

The number of unstaked trees was not counted for sea grape, red mulberry, and unidentified species because few trees were staked in few planting areas.

No. = number, % = percent

TABLE 4. SUMMARY OF ROPE/STAKE REMOVAL

AREA	ACTIVITY DATE		COMMENTS
	STAKED	DE-STAKED	
A&B	10/27-28/2022, 11/1/2022	4/27/2023	1 dead cedar
C	12/8-15/2022, 1/17-24/2023	6/20/2023	1 dead pine
D	1/12/2023	6/20/2023	--
E	12/15/2022, 1/17/2023	6/8/2023	trees not flagged, left a few stacked hackberry staked
G	11/5-12/2022	5/9/2023	--
H	11/17/2022	5/16/2023	1 dead cedar
I	10/21/2022	4/25/2023	Left all staked gumbo limbo staked
J	12/3/2022	5/16/2023	1 dead pine
K	11/12/2022, 1/12/2023	5/11/2023	1 dead hackberry, left a few staked hackberry staked
L	12/1-3/2022	5/30/2023	--
M	12/3-6/2022	6/1/2023	--
N	10/23-25/22	4/25/2023	--