Final Report
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Project Title: Multistate Habitat and Population Restoration of Gopher Frogs in Alabama, Georgia, North Carolina, and South Carolina

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Project Goal: The goals of this project are to (1) improve the quality and quantity of suitable breeding sites for Gopher Frogs and other SGCN species in four participating states, and (2) restore populations of Gopher Frogs in GA and AL to increase the number of resilient populations on managed public lands.

Original Proposal Need

These state partners seek to expand and integrate conservation management projects for the Gopher Frog (*Rana [Lithobates] capito*) and other amphibian Species of Greatest Conservation Need (SGCN) across four of the five states that encompass the Gopher Frog species' range: Alabama (AL), Georgia (GA), North Carolina (NC), and South Carolina (SC) (Figure1). Specifically, this CSWG focuses predominantly on implementing and evaluating two actions – wetland restoration/construction in all four states and population augmentation/reintroductions in two states – to increase both the amount of suitable habitat and the number of secure, viable Gopher Frog populations on managed public lands. The research embedded within these management actions is intended to increase understanding and reduce uncertainty about the efficacy of proposed management actions, thereby improving ongoing and future management across the Gopher Frog range. The Gopher Frog is ranked as a "highest" Species of Greatest Conservation Need (SGCN) in all states within its range (AL 2015 SWAP, Table 1-4, p. 14-15; GA 2015 SWAP, Table 10, p. 144; NC SWAP 2015 p.38, Table 3-4; SC SWAP 2015 p. 2-6, Appendix 1) and is currently petitioned for listing under the Endangered Species Act (ESA). In SC, extant Gopher Frog populations are only known on the Savannah River Site and the Francis Marion National Forest. Since 1980, only three other Gopher Frog populations were documented on other SC public lands, but the species has not been detected on those sites since 2013.

Our focus on wetland restoration or construction and population augmentation and reintroduction through captive-rearing stems directly from each participating state's State Wildlife Action Plan (SWAP) and from actions identified during a "Gopher Frog Working Group" structured decision-making (SDM) workshop. The 2018 workshop included representatives of all five states (AL, FL, GA, NC, SC) that compose the Gopher Frog range and federal agencies including the United States Fish and Wildlife Service (USFWS). Workshop partners set range-wide conservation goals for the species that reflect state priorities and inform the USFWS on listing decisions.

The restoration or construction of isolated wetlands – particularly as breeding habitat for Gopher Frogs – is a priority conservation action identified by all participating states (AL 2015 SWAP, pps. 112, 115; GA 2015 SWAP, pps. 142, 162; NC 2015 SWAP, pp. 41, 45, 51; SC 2015 SWAP, pps. 3-15 and Supplemental Volume-Pond Breeding Amphibians Guild). Habitat restoration or creation could also benefit at least 76 SGCN that

utilize the same wetland environments as Gopher Frogs including the federally protected Frosted Flatwoods Salamander (*Ambystoma cingulatum*), and the Tiger Salamander (*Ambystoma tigrinum*).

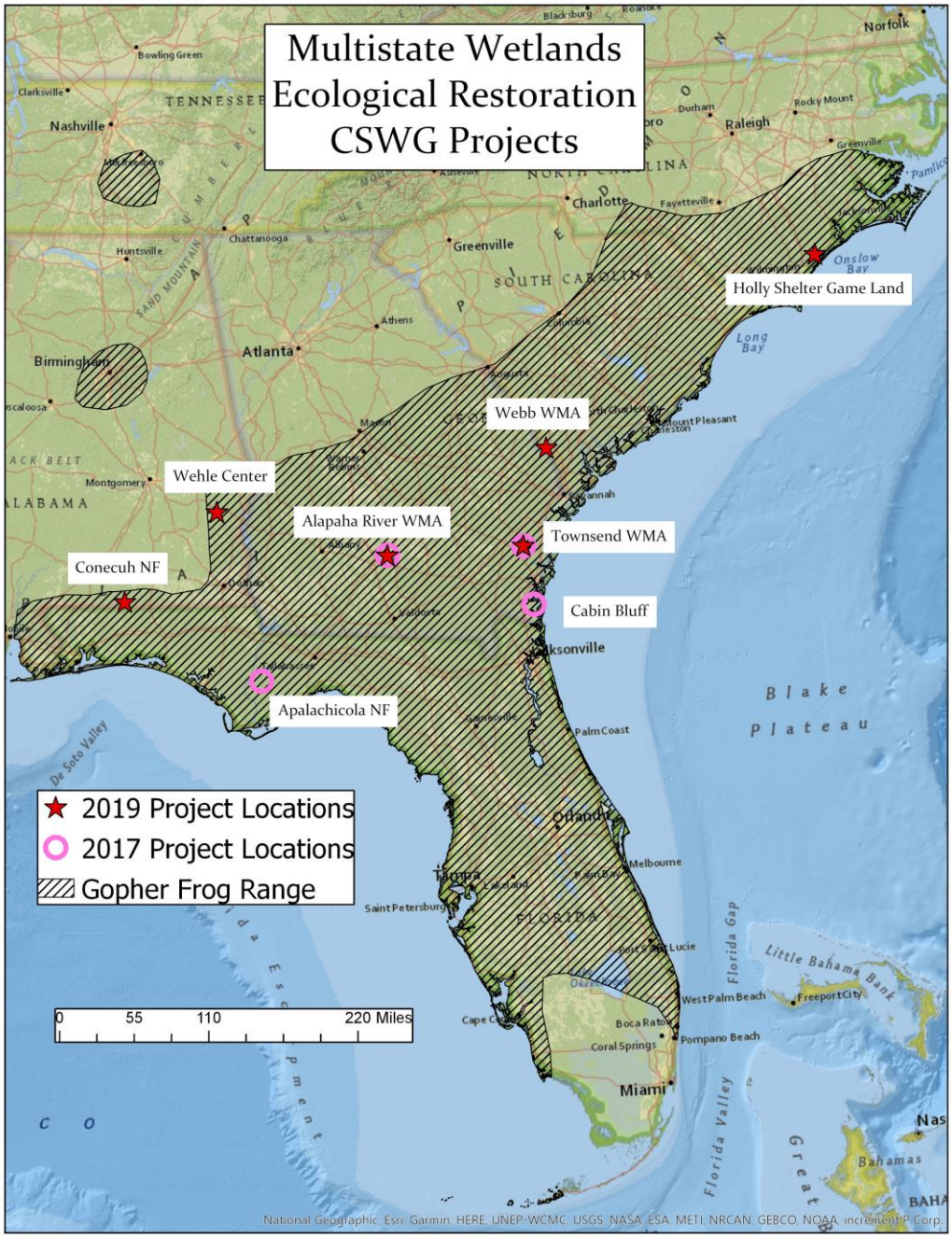


Figure 1. Map showing project study sites and complementary restoration and reintroduction projects for Gopher Frogs across the partner states.

Objectives

The goals of the project will be met by completing the following objectives by 2022:

1. Use mechanical or chemical vegetation removal, soil stabilization, and prescribed fire to restore 3 isolated wetlands in SC.
2. Monitor amphibian and plant species in restored, constructed, and reference wetlands to demonstrate an overall increase in Gopher Frog and other amphibian and plant SGCN in response to habitat restoration.

Approach

Wetland Restoration and Construction – South Carolina will restore three wetlands within the Webb Wildlife Center Wildlife Management Area (Webb WMA, Hampton County, SC; Figure 2) to increase breeding habitat

for Gopher Frogs and other amphibian SGCN including, potentially, Tiger Salamanders and federally-protected Flatwoods Salamanders (SC 2015 SWAP, pp. 3-15 and Supplemental Volume – Pond Breeding Amphibian Guild). Restoration methods may include light mechanical shrub and tree removal by chainsaws, handsaws, a mini skid steer, or a Brown tree cutter, girdling, or herbicide application with herbicides approved for use in aquatic habitats. These approaches are consistent with wetland restoration techniques used in FL and GA as part of their FY 2017 C-SWG and have been used in FL previously (Enge et al. 2014; Gorman et al. 2013). The specific approaches will be determined as appropriate and feasible and documented for comparison among all restored wetlands in all participating states and prior restoration efforts. There are no suitable "reference" wetlands on the Webb WMA, but SC has 8 years of pre-restoration amphibian monitoring at the focal wetlands for a robust, pre-post restoration evaluation.

Monitoring at all restoration and constructed sites will consist of standardized, before- and after-restoration surveys for vegetation and amphibians within all restored, constructed, and
– as appropriate – reference wetlands. SCDNR will contract their amphibian monitoring to Marshall University (Marshall). Amphibian surveys will be conducted using repeated call, egg mass, and dipnet surveys during the breeding season of the Gopher Frog (November – April) and any other amphibian SGCN in each respective state. Surveys will be standardized to a minimum of one 30-minute, double-observer sample per wetland per month allowing for dynamic, community occupancy analyses that account for imperfect detection (Zipkin et al. 2012). Vegetation monitoring will occur in restoration sites at least once prior to restoration and at least once one year after post-restoration. A transect running along the long axis of each wetland from the ecotone transition zone will be used to quantify the following measurements within nested quadrats located every 5 m along the transect: percent canopy cover, woody shrub cover, herbaceous groundcover, bare ground, litter, and woody debris. Canopy cover will be estimated with a spherical densitometer reading at each 5 m interval. Woody cover will be visually estimated within a 2 m x 2 m quadrat centered on each interval. Percent herbaceous groundcover, bare ground, litter, and percent woody debris will be visually estimated within a nested 1 m × 1 m quadrat also centered at each interval. A Daubenmire (1959) cover class scale will be used for visual cover estimates in order to minimize interobserver variability. In addition, basal area will be recorded at the transect midpoint using a 10 BAF wedge prism.

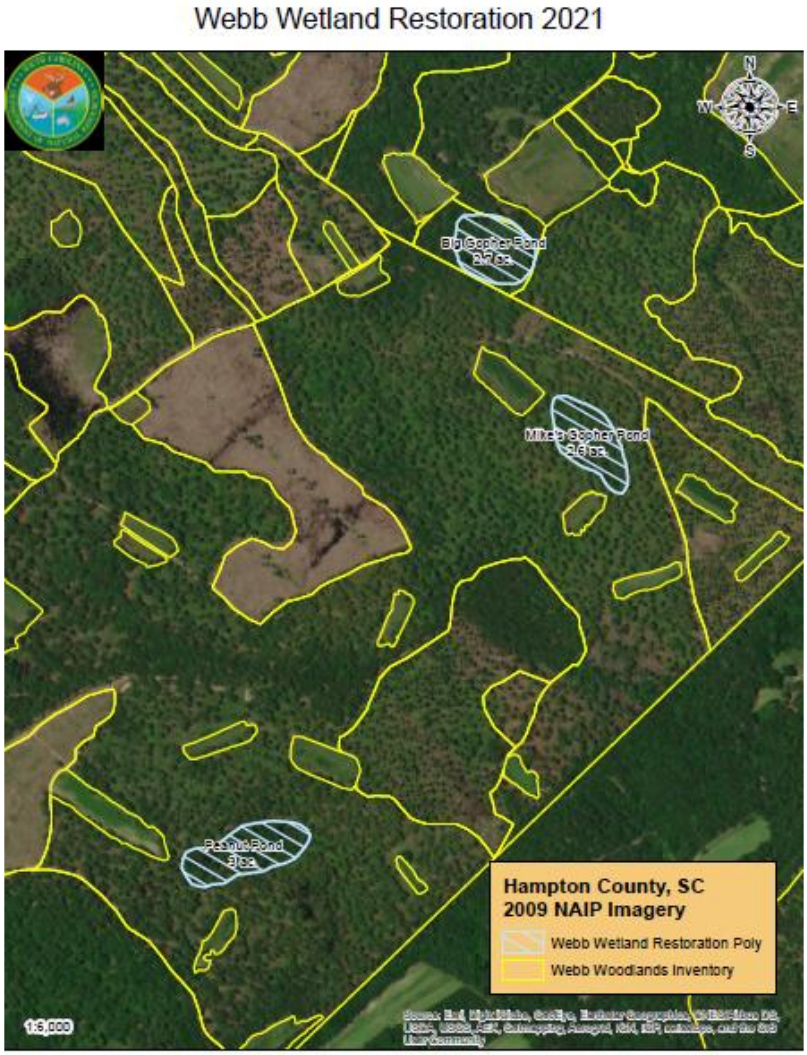


Figure 2. Three Wetlands Scheduled to be Restored at the Webb Wildlife Center, Hampton County, SC

Summary of Accomplishments

Accomplishments – Year 1:

- Received approval from the Army Corp to proceed with wetland restoration work on three identified wetlands
- Wetland boundaries flagged
- Flew drone over all wetlands to capture before aerial photos
- Established 9 photo stations total between three wetlands, to monitor changes over time
- Began reptile and amphibian surveys in and around isolated wetlands
- Completed pre-restoration vegetation surveys in 3 wetlands to be restored

Accomplishments – Year 2:

- Restoration work was packaged and put up for public notice/bid
- Three wetlands delineated and flagged for restoration work
- Primary restoration work on all three wetlands complete (8.3 acers total)
    - Mike's Gopher Pond (2.6 acres) – September 18, 2021
    - Big Gopher Pond (2.7 acres) – October 21-25, 2021
    - Peanut Pond (3 acres) – November 1-2, 2021
- Documented changes at 9 photo stations between three wetlands
- 288 headstarted Gopher Frog metamorphs were released
- Reptile and amphibian surveys in and around isolated wetlands

Accomplishments – Year 3:

- Documented changes at 9 photo stations between three wetlands
- Reptile and amphibian surveys in and around wetlands post restoration (see below)
- Vegetation Surveys in wetlands post restoration (See below)
- Mikes Gopher Pond and surrounding uplands burned July 26, 2022 when basin was mostly dry
- 17.6 acres treated with herbicide in the basin, ecotone and uplands around Big Gopher and Peanut pond on September 3-4, 2022

Significant Deviations: Due to an unforeseen opportunity, SCDNR in conjunction with Riverbanks Zoo was able to find, collect, headstart and release 288 newly metamorphed Gopher Frogs at the restored wetlands. No additional costs were associated with this effort. This addition to our objectives was approved by the Fish and Wildlife Service as it does not negatively impact the study design.

Accomplishment Details

Objective 1: Restore focus wetlands (Big Gopher Pond [BGP], Upper Peanut Pond [UP], and Mike's Gopher Pond [MGP]) on Webb Wildlife Management Area for Carolina gopher frog (*Lithobates capito capito*) reintroduction.

Accomplishments: Initial restoration of focus ponds was completed from mid-September to early November of 2021, and secondary restoration actions occurred in July/September of 2022.

MGP had a relatively low basal area before restoration (average 45 ft^2/acre [Appendix A]), so only a few large (DBH > 25") *P. elliottii/palustris* were removed from within the pond basin. No heavy machinery was used to fell and remove these trees within the pond basin; logs from these trees were removed and stumps were left in place. A hand crew manually cleared shrubby growth (*I. myrtifolia*) and saplings encroaching into the midstory (*D. virginiana* and *L. styraciflua*) and removed slash from the pond in September. Within three days of clearing, stumps were treated with herbicide, with minimal stump sprouts seen in the 2022 vegetation surveys. The management block around MGP was burned on July 26, 2022 with a backing fire that burned slowly through the plot. RCW trees were raked around to prevent damage to cavity trees for the active woodpecker cluster in the area, but no other changes were made around the basin during the burn. The water table was just below the surface at the lowest point of the basin, and most of the pond was dry during the burn. The exterior of the basin burned to mineral soil, but the interior of the basin did not burn due to the wet substrate and dense marsh fern (*T. palustris*). The remaining vegetation can be seen in the interior photos of Transects 4, 5, and 6 (Appendix B) as photos were taken post-burn.

BGP had an extremely dense basal area (average ~120 ft^2/acre) and a dense layer of duff from *Pinus* and *Taxodium* litter [Appendix A]. Heavy machinery was used in the pond basin to mechanically remove the mid-story and canopy. Only three pond cypress (*T. ascendens*) were left in the pond basin, and the average basal area was reduced to ~10 ft^2/acre. Larger logs were removed from the pond, including downed trees that were present pre-restoration. Fine woody debris and other, small-scale slash was left in the pond; this debris was up to 4" deep on some survey transects [Appendix A]. Vegetation surveys in 2022 saw a significant amount of stump sprouting from pond cypress and myrtle leaf holly.

The pond basin in UP was roughly 1/3 open and the rest of the pond was occupied by a dense stand of swamp tupelo (*N. biflora*) with an average basal area of ~55 ft^2/acre. Several large (DBH > 20") loblolly pines were also just inside the pond basin. Heavy machinery was brought into the basin during a seasonal drought to

remove dense shrubs (*I. myrtifolia*) and reduce the basal area. All mid-story and canopy trees were removed from the pond basin, including the large loblolly pines on the edge of the pond basin. Small tupelo stems (DBH < 10") were left in the pond, and fine woody debris was pushed to the side of the pond basin. Larger stems were removed. Two channels (soil compacted ~6") from machinery tracks went through the center of the pond, oriented North to South; soil compaction and increased water depth limited the establishment of herbaceous vegetation in this area. Several swamp tupelo and sweetgum stumps sprouts were seen in the 2022 vegetation surveys.

The pond basins, ecotones, and surrounding uplands (17.6 acres) in BGP and UP were treated with an herbicide on September 3rd and 4th of 2022. This treatment was done to limit the encroachment of woody plants and stump sprouts from stems cut during the mechanical clearing in the fall of 2021.

Objective 2: Conduct vegetation surveys in focus wetlands to quantify the effect of restoration actions on vegetative species richness and structure.

Accomplishments: All study wetlands were surveyed in July and August of 2021 before restoration efforts. Vegetation surveys were completed in July 2022, following initial restoration efforts (e.g. mechanical clearing) but before secondary restoration actions (e.g. herbicide treatments, burns). The survey findings are summarized below. Raw data is in Appendix A and transect photos showing change in structure are in Appendix B.

Mike's Gopher Pond

Vegetation surveys were done on July 16 – 18th, before applying fire to the pond. The basal area did not change from pre-restoration (45 ft^2/acre) despite the removal of two large (DBH > 20") pine trees from the basin's interior. This is likely due to slight changes in the surveyor's position that caused large pines on the basin's exterior to be included where they previously were not. Average canopy cover (CC) also remained constant, at 43%. A decrease in basal area and associated CC were not the main priority for restoring MGP, since there were already very few trees in the pond basin.

The removal of shrubs and midstory was the greatest concern for MGP as the dense hardwood stems caused a decrease in hydroperiod and shaded out herbaceous cover. Shrub-dominated areas along survey transects decreased by 36% post-restoration [prior to prescribed fire] to only 33.3% of surveyed areas. The composition of the remaining shrub-dominated zones also shifted; before restoration, these zones were composed mostly of sweetgum or American persimmon (*D. virginiana*) sprouts and included areas towards the interior of the pond. Following initial restoration efforts, shrub-dominated zones were concentrated on the exterior of transects (towards the basin edge) and were dominated by greenbrier (*Smilax* spp.). The greenbrier was completely burned back by the late summer burn but is likely to resprout from the root crowns. Stump sprouts were seen of or American persimmon in the pond but should be reduced with continuing efforts to treat stumps with herbicide.

Herbaceous plants and graminoids were the most dominant cover type, being the main vegetation type of 39.4% of surveyed transects. The primary species of herbaceous vegetation was marsh fern, though sedges and native bunch grasses were also present. Several patches of maidencane (*P. hemitomon*) sprouted in the pond post-restoration where they had not been previously, though these did not overlap with survey transects. The slight increase in herbaceous/graminoid-dominated areas and lack of increase in species is likely due to the presence of slash and the low water levels during the spring/summer of 2022. Sparsely vegetated areas more than doubled after hand-clearing, dominated by litter from cleared shrubs and surrounding pine trees. Pine litter on

the outer half of the basin was burned down to mineral soil and will hopefully allow grasses and sedges to establish. We suspect that the increase in hydroperiod and water depth will cause wetland herbaceous plants in the seedbank to re-establish in the pond as was seen in BGP and UP.

Big Gopher Pond

Post-restoration vegetation surveys for BGP were done in the week of July 18th, before the herbicide treatment of the pond basin and surrounding area. The average basal area in the basin decreased from approximately 130 ft^2/acre to 10 ft^2/acre. The post-restoration basal area is made up entirely of bald cypress; all other species noted in the basal area are outside of the pond [Appendix A]. The loss of basal area coincides with a significant decrease in canopy cover, from an average of 75% CC on survey transects to just over 10% CC.

Most vegetation zones on survey transects in pre-restoration vegetation were either classified as sparse or shrub (87.2%). Post-restoration, almost no areas were delineated as shrub-dominated as the under and midstory had been cleared [Appendix A]. Sparse vegetation was still the dominant classification following initial restoration actions, likely due to the thick layer of fine woody debris and slash distributed throughout the pond following logging. There was an increase in herbaceous vegetation in sparse plots, with each sparse zone having 5-15% of herbaceous/graminoid cover (except for Transect 3 which had a significant amount of litter/CWD). The amount of surveyed transects dominated by herbaceous and graminoid vegetation increased by over 50% to 20.1% of transects. Sedges made up most of the new herbaceous growth in the pond basin, the northeastern end of the pond [Transect 6] previously dominated by Cherokee sedge (*Carex cherokeensis*) became denser and now includes southern waxy sedge (*C. glaucescens*). Several other species of sedges were present throughout the pond and maidencane (*Panicum hemitomon*) grew along Transect 2 post-restoration.

The pond was partially inundated during both the pre- and post-restoration vegetation surveys, and there were obvious changes in the herbaceous community. Prior to logging, there was minimal species diversity due to the thick layer of pine duff, a closed canopy, and reduced water level. Post-restoration work in the pond found Virginia meadow beauty (*Rhexia virginiana*) on the pond margin and arrowhead (*Sagittaria* sp.) inflorescences were seen in the deep areas of the pond basin. Woody sprouts now include buttonbush (*Cephalanthus occidentalis*), in addition to stump sprouting pond cypress, myrtle leaf holly, and sweetgum. Wetland species diversity should increase as the pond's hydroperiod becomes long enough to displace non-wetland obligates (e.g. sweetgum). The level of slash left in the pond, especially the fine woody debris on the exterior of the pond basin, may pose an issue for further herbaceous diversity on the outer edges of the pond basin. Hopefully, future growing season burns can clear this to allow for graminoids to establish in the shallow areas of the basin.

Upper Peanut Pond

Post-restoration surveys took place on July 25th and 26th of 2022, before the chemical treatment of the basin/uplands. All stems were cleared in the basin, and the only stems within the basin seen in the 2022 vegetation surveys were stump-sprouting swamp tupelo, sweetgum, and persimmon. The average basal area in UP was reduced from approximately 55 ft^2/acre to <1 ft^2/acre and the average canopy cover (8%) was entirely from large *Pinus* and *Quercus* outside the pond basin.

Herbaceous vegetation was sparse in the thick litter on the basin edge and in the open area on the east end where the stand of swamp tupelo was previously. Vegetation was also limited where machinery had caused soil compaction and increased water depth. Herbaceous/graminoid vegetation was the dominant species on 53.7% of the survey transects, where it previously occupied 63% of survey transects. This decrease is likely due to the

presence of slash and the increase in the pond's depth. We suspect that aquatic plants will re-establish in the center of the pond basin in the next growing season. Several areas in the pond saw an increase in herbaceous/graminoid vegetation where it had not been previously, but there was also a significant decrease in vegetation around the pond border due to fine woody debris from restoration work. Sparsely vegetated areas along survey transects more than doubled, but shrub-dominated areas decreased significantly and were only present on the outermost section of transects.

Vegetation diversity increased after restoration, mirroring the pattern seen in Big Gopher Pond. Only Cherokee sedge was seen in abundance in pre-restoration surveys; after the pond had been cleared, a species of beak sedge (*Rhynchospora* sp.) and multiple species of flat sedges (*Cyperus* spp.) were also seen. Several species of wildflower are now present (*Sabatia* spp., *Rhexia virginica*, *Eupatorium album* complex) or more abundant (*Drosera brevifolia*, *Polygala lutea*, *Sarracenia minor* var. *minor*).

Objective 3: Survey the herpetofaunal to assess the impact of the restoration effort on anuran community assemblage.

Accomplishments: Ponds were minnow trapped at the end of July 2022 to assess the summer tadpole community. MGP was not able to be sampled at this point as the pond's water level was too low; Pinewoods Treefrogs (*D. femoralis*) tadpoles were observed in crawfish burrows where the water table was at the surface. Ten minnow traps (half of which were light-baited with glowsticks) in BGP caught approximately 200 Pinewoods Treefrog tadpoles at various stages of development. Freshwater brine shrimp, larval insects, and several predacious diving beetles were also caught. Adult Southern Cricket Frogs (*A. gryllus*) were observed throughout the pond and hundreds of Oak Toadlets *(A. quercicus*) were seen exiting the pond during minnow trapping. UP had a deeper water level than BGP, but only 30 Pinewoods Treefrog tadpoles were caught with the same sampling effort. Two Eastern Mud Turtles (*K. subrubrum*), two crawfish, and predacious diving beetles were also caught in traps. A neonate Cottonmouth (*A. piscivorous*) was also seen during post-restoration vegetation surveys.

Autonomous recording units (ARUs – Wildlife Acoustics Song Meter 2 and Song Meter 4) were deployed in study ponds as constantly as possible, with SD cards changed approximately biweekly. All nights (2100 – 0400) where daily precipitation exceeded .75" were manually analyzed for species presence. MGP had seven species noted both pre- and post-restoration, but the species assemblage did change. Pre-restoration the pond had *L. sphenocephalus*, which likely did not call post-restoration due to limited water levels. *P. nigrita* also did not call post-restoration, which could be due to the early calling season of this species falling very close to the disturbance from the initial restoration activities. *H. squirella* and *G. carolinensis* were detected post-restoration, both of which are associated with disturbance and a more open canopy. BGP species diversity increased from 7 to 13 species, with three more species of treefrogs (*H. chrysoscelis, cinereus,* and *squirella*) detected. The open canopy species of Southern Cricket Frogs (*A. gryllus*), Oak Toads (*A. quercicus*), and Eastern Narrowmouth Toads (*G. carolinensis*) were also detected – all chorusing. UP increased from 10 to 13 species, also with an increase in *Hyla* and the Eastern Narrowmouth Toad. The number of analyzed sampling dates and complete species lists is given in Appendix C.

Estimated Federal Expenditure: (See 425)

Recommendation: All objectives have been completed. Close the grant.

Appendix A

Mike's Gopher Pond

Table 1. The basal area, canopy cover, and litter depth at the midpoint and interior point of all six vegetation transects in Mike's Gopher Pond. Dominant tree species are also noted in the basal area. Transects were surveyed pre-restoration (1A) and post-restoration (1B). "In." indicates that the litter at the survey point was inundated.

Table 1A.

Transect (length)		Litter Depth	Basal Area (ft^2/ac)	CC - N	CC - S	CC - E	CC - W	CC – Avg (%)
1 (112 ft)	Interior	1.25" In.	50	44	23	51	37	38.75
	Midpoint	1.5"	80	55	17	62	37	42.75
2 (95.5 ft)	Interior	.5" In.	40 (P. palustris)	19	37	33	46	33.75
	Midpoint	.25"	60 (P. palustris)	35	31	23	28	31.75
3 (100.75 ft)	Interior	.5" In.	30	18	30	11	16	18.75
	Midpoint	.5"	30	22	37	45	27	31.25
4 (71.5 ft)	Interior	.5" In.	30 (P. Palustris - RCW)	10	26	24	33	23.25
	Midpoint	1" In.	40 (P. Palustris - RCW)	17	52	23	44	34
5 (91.5 ft)	Interior	.75" In.	20	12	34	36	31	28.25
	Midpoint	.5" In.	30	20	48	28	84	45
6 (83.25 ft)	Interior	.5"	60	49	92	86	75	75.5
	Midpoint	.75"	70	41	73	96	51	65.25

Table 1B.

Transect (length)		Litter Depth	Basal Area (ft^2/ac)	CC - N	CC - S	CC - E	CC - W	CC – Avg (%)
1 (112 ft)	Interior	.5"	40 (P. elliottii)	25	42	58	58	45.75
	Midpoint	.5"	80 (P. elliottii and taeda)	63	38	71	46	54.50
2 (95.5 ft)	Interior	.75" In.	40 (P. elliottii and palustris)	50	54	46	38	47
	Midpoint	.5"	60 (P. elliottii and palustris)	83	58	54	13	52
3 (100.75 ft)	Interior	.5"	40 (P. palustris)	50	13	72	42	44.25
	Midpoint	.25"	30 (P. elliottii and palustris)	50	21	58	42	42.75
4 (71.5 ft)	Interior	.25"	30 (P. palustris)	38	27	42	29	34
	Midpoint	1.25"	40 (P. palustris)	13	29	21	67	32.50
5 (91.5 ft)	Interior	.5"	10 (P. elliottii)	25	21	38	42	31.50
	Midpoint	1"	30 (P. elliottii, taeda)	29	50	21	67	41.75
6 (83.25 ft)	Interior	.25"	40 (P. elliottii)	54	25	58	63	50
	Midpoint	1"	90 (P. elliottii, palustris)	33	92	17	46	47

Tables 2 & 3. Tables representing each transect (a – f) in Mike's Gopher Pond with vegetation zones delineated and dominant species for each vegetation zone noted. Tables are approximately scaled to reflect the size of vegetation zones. Tables 2(a – f) show pre-treatment vegetation zones as compared to post-treatment [Table 3(a – f)].

Table 2a. Transect 1

Herbaceous *0 – 49.5'*	85% Forb (T. palustris) 5% shrub 5% graminoid 5% open
Shrub *49.5' - 68'*	70% Shrub (L. styraciflua) 15% sparse 5% graminoid 5% herb 5% woody debris
Sparse *68 – 82.5'*	30% Litter 30% water 20% shrub 20% graminoid
Shrub *82.5 - 112'*	35% Shrub (L. styraciflua, Smilax sp.) 50% litter 10% graminoid 5% woody debris

Table 2b. Transect 2

Shrub *0 – 26.25'*	20% Shrub (L. styraciflua, D. virginiana) 50% water 5% herb 5% graminoid
Sparse *26.5 - 40.25'*	65% Litter 20% graminoid (clump-forming grasses) 15% water
Shrub *40.25 - 95.5'*	60% Shrub (L. styraciflua, I. glabra) 35% litter 5% graminoid

Table 3a. Transect 1

Herbaceous *0-17'*	35% Forb (T. palustris) 40% sparse/litter 15% shrub (Smilax sp.) 10% graminoid (P. hemitomon)
Sparse *17-31.5'*	75% Litter 10% shrub (Smilax sp.) 10% graminoid (P. hemitomon) 5% forb
Shrub *31.5-72.5'*	40% Shrub (Smilax sp.) 45% litter 5% CWD 5% graminoid 5% forb
Sparse *72.5-112'*	75% Litter 15% shrub (Smilax sp.) 10% graminoid (bunch grass)

Table 3b. Transect 2

Sparse *0-36'*	80% Litter 20% shrub (Smilax sp.) 5% graminoid (Carex)
Graminoid *36-50.5'*	40% Graminoid (Carex) 50% litter 15% shrub (Smilax sp.)
Shrub *50.5-95.5'*	75% Shrub (Smilax sp., I. glabra) 25% litter

Table 2c. Transcect 4

Herbaceous *0 – 10'*	60% Herb (T. palustris) 20% shrub (D. virginiana) 10% water 5% graminoid 5% shrub (Smilax sp.)
Graminoid *10 – 38.75'*	25% Graminoid 60% water 10% fern 5% shrub (Smilax)
Herbaceous *38.75 - 61'*	40% Herb (T. palustris) 30% water 15% graminoid 10% litter (thatch) 5% shrub (D.)
Shrub *61' - 100.75'*	45% Shrub (L. styraciflua, Clethra, I. glabra) 30% litter 15% herb (Ludwigia pilosa) 10% graminoid

Table 2d. Transect 4

Herbaceous *0 – 32.25'*	60% Herb (T. palustris) 20% shrub (Smilax sp., C. occidentalis) 20% water
Graminoid *32.25 - 55.5'*	30% Graminoid 20% litter 30% shrub (D. virginiana) 15% water 5% herb
Shrub *55.5 - 71'*	50% Shrub (D. virginiana, Smilax sp.) 20% graminoid 30% litter

Table 3c. Transect 3

Graminoid *0 – 22'*	35% Graminoid (grass, Carex) 45% litter 15% shrub (Smilax sp.) 5% forbs
Herbaceous *22 - 36'*	40% Forb (T. palustris) 50% litter 5% grass 5% shrub
Graminoid *36 – 50'*	55% Graminoid (grass, Carex) 30% litter 10% shrub 5% shrub
Shrub *50 – 74'*	45% Shrub (C. tomentosa) 40% litter 10% forb 5% graminoid
Herbaceous *74 - 100.75*	30% Forb (Eupatorium sp.) 25% shrub (C. tomentosa, I. glabra) 25% litter 20% graminoid (bunch grass)

Table 3d. Transect 4

Herbaceous *0 - 34'*	65% Forb (T. palustris) 20% litter 10% graminoid 5% shrub (D. virginiana sprouts)
Shrub *34 - 43.5'*	30% Shrub (D. virginiana) 45% litter 15% graminoid (Carex sp.) 10% forb
Sparse *43.5 - 55.5'*	80% Litter 10% forb 5% graminoid 5% shrub
Shrub *55.5 - 71'*	50% Shrub (Smilax sp., D. virginiana) 40% litter 5% graminoid 5% forb

Table 2e. Transect 5

Shrub *0 – 16'*	35% Shrub (Smilax sp., D. virginiana) 30% herb (T. palustris) 20% water 10% graminoid 5% woody debris
Herbaceous *16 – 50'*	70% Herb (T. palustris) 15% water 10% shrub (D. virginiana) 5% graminoid
Shrub *50 – 91.5'*	60% Shrub (Smilax sp., C. occidentalis, D. virginiana) 25% litter 10% herb 5% water

Table 2f. Transect 6

Sparse *0 – 12.5'*	50% Water 35% shrub (L. styraciflua, Smilax sp.) 15% herb
Shrub *12.5 - 43.75'*	45% Shrub (L. styraciflua, Smilax sp.) 35% fern (T. palustris) 20% water
Sparse *43.75 - 59'*	60% Water 25% shrub (L. styraciflua, Smilax sp.) 10% herb 5% litter
Shrub *59 – 73.5'*	35% Shrub (Smilax sp.) 40% water 15% litter 10% graminoid
Sparse *73.5 - 83.25'*	40% Water 40% litter 15% shrub (Smilax sp.) 5% graminoid

Table 3e. Transect 5

Sparse *0 - 7'*	85% Litter (incl. stumps) 10% forb 5% shrub
Herbaceous *7 - 42'*	50% Forb (T. palustris) 30% litter 20% shrub
Shrub *42 - 91.5*	80% Shrub (Smilax sp., D. virginiana) 15% litter 5% forb

Table 3f. Transect 6

Sparse *0 - 15.5'*	80% Litter (incl. stumps) 15% forb (T. palustris) 5% shrub
Herbaceous *15.5 - 41'*	30% Shrub (Smilax sp., stump sprouting L. styraciflua) 50% litter 20% forb (T. palustris)
Sparse *41 - 67.5*	80% Litter 15% shrub (Smilax sp.) 5% forb 5% graminoid
Graminoid *67.5 - 83.25*	45% Graminoid (bunch grass) 30% litter 25% shrub (Smilax sp.)

Big Gopher Pond

Table 4. The basal area, canopy cover, and litter depth at the midpoint and interior point of all six vegetation transects in Big Gopher Pond. Dominant tree species are also noted in the basal area. Transects were surveyed pre-restoration (4A) and post-restoration (4B). "In." indicates that the litter at the survey point was inundated.

Table 4A.

Transect (length)		Litter Depth	Basal Area (ft^2/ac)	CC - N	CC - S	CC - E	CC - W	CC – Avg (%)
1 (104.5 ft)	Interior	.75"	190 (T. ascendens, P. taeda)	49	88	52	60	62.25
	Midpoint	1.5"	90 (Pinus spp. saplings)	87	91	77	97	88
2 (110.5 ft)	Interior	3"	110 (L. styraciflua)	84	98	95	81	89.5
	Midpoint	2"	170 (P. taeda saplings)	67	82	72	78	74.74
3 (96.5 ft)	Interior	3"	130 (N. biflora, T. ascendens)	73	79	85	91	82
	Midpoint	4"	120 (Pinus spp.)	89	64	87	68	77
4 (112 ft)	Interior	.5"	110 (T. ascendens)	48	51	71	33	50.75
	Midpoint	.5"	100 (T. ascendens)	30	62	64	77	58.25
5 (102.5 ft)	Interior	1.5"	100 (P. elliottii, T. ascendens)	68	81	75	90	78.5
	Midpoint	.33"	120 (P. elliottii, T. ascendens)	89	77	68	92	81.5
6 (107.5 ft)	Interior	.75"	180 (T. ascendens)	85	82	68	90	81.25
	Midpoint	2"	100 (Pinus spp.)	43	31	59	48	45.25

Table 4B.

Transect (length)		Litter Depth	Basal Area (ft^2/ac)	CC - N	CC - S	CC - E	CC - W	CC – Avg (%)
1 (104.5 ft)	Interior	1" In.	0	8	4	0	0	3
	Midpoint	.5" In.	0	29	0	4	4	9.25
2 (110.5 ft)	Interior	2.5"	10 (T. ascendens)	4	8	4	0	4
	Midpoint	.5"	30 (P. taeda, N. biflora)	50	0	29	0	19.75
3 (96.5 ft)	Interior	1" In.	0	4	21	8	4	9.25
	Midpoint	4" [FWD - logging]	10 (P. palustris)	0	58	4	13	18.75
4 (112 ft)	Interior	.25"	0	0	67	4	29	25
	Midpoint	2" In.	10 (T. ascendens)	0	25	4	29	14.5
5 (102.5 ft)	Interior	1.5" In.	10 (T. ascendens)	4	17	0	25	11.5
	Midpoint	1.25" In.	10 (T. ascendens)	0	8	8	54	17.5
6 (107.5 ft)	Interior	2.5" In.	0	25	4	0	8	9.25
	Midpoint	2"	30 (T. ascendens)	29	4	0	13	11.5

Tables 5 & 6. Tables representing each transect (a – f) in Big Gopher Pond with vegetation zones delineated and dominant species for each vegetation zone noted. Tables are approximately scaled to reflect the size of vegetation zones. Tables 5(a – f) show pre-treatment vegetation zones as compared to post-treatment [Table 6(a – f)].

Transect 5a. Transect 1

Sparse *0 – 53.5′*	75% Litter 10% shrub (L. styraciflua) 10% CWD 5% graminoid
Sparse (Old logging road) *53.5 - 64.5′*	85% Litter 10% shrub (Smilax sp.) 5% graminoid
Shrub *64.5 - 104.5′*	20% Shrub (Smilax sp., Quercus sp.) 70% litter 5% graminoid 5% CWD

Table 6a. Transect 1

Sparse *0 - 45.5′*	75% Water 15% litter 10% graminoid (Carex)
Graminoid *45.5 - 104.5′*	25% Graminoid (Carex) 65% litter 5% CWD 5% water

Table 5b. Transect 2

Shrub *0 - 6.5′*	40% Shrub (Smilax sp., D. virginiana) 40% litter 20% herb (T. palustris)
Sparse *6.5 - 110.5′*	50% Litter 30% CWD 10% shrub (Smilax sp.) 5% herb 5% graminoid

Table 6b. Transect 2

Sparse *0 - 110.5′*	80% Litter 15% graminoid (P. hemitomon) 5% water

Table 5c. Transect 3

Sparse	80% Litter

Table 6c. Transect 3

Herbaceous	30% Forb (T. palustris) 40% litter

0 - 34.5′	15% shrub (I. myrtifolia) 5% CWD
Shrub *34.5 - 52.5′*	25% Shrub (Pinus, I. myrtifolia) 75% litter
Sparse *52.5 - 83.5*	85% Litter 10% CWD 5% shrub (Smilax)
Shrub *83.5 - 96.5′*	40% Shrub (Clethra sp., Vaccinium sp.) 60% litter

Table 5d. Transect 4

Herbaceous *0 – 8′*	65% Herb (T. palustris) 5% shrub 10% water 20% litter
Sparse *8 – 58.5′*	90% Litter 5% CWD 5% shrub
Graminoid *58.5 - 75.5′*	30% Graminoid (C. cherokeensis) 40% litter 25% shrub 5% water
Shrub *75.5 - 94′*	55% Shrub (Pinus sp., I. myrtifolia) 45% litter
Sparse *94 – 112′*	50% CWD (several large down pines) 40% litter 5% water 5% shrub

0 - 13′	30% water
Sparse *13 - 96.5′*	75% Litter 10% shrub 10% water 5% CWD

Table 6d. Transect 4

Sparse *0 - 28′*	80% Water 10% graminoid 5% shrub (stump sprouts) 5% litter
Graminoid *28- 47′*	25% Graminoid (C. glaucescens) 60% water 10% CWD 5% litter
Sparse *47 - 88.5′*	90% Litter 5% graminoid 5% CWD
Shrub *88.5 - 112′*	60% Shrub (C. tomentosa, Gaylussacia sp.) 35% litter 5% forb

Table 5e. Transect 5

Herbaceous *0 – 13′*	20% Herb (T. palustris) 60% water 20% litter
Sparse *13 – 102.5′*	45% Litter 30% water 15% shrub (I. myrtifolia, D. virginiana) 5% CWD 5% Sphagnum

Table 5f. Transect 6

Sparse *0 – 52′*	50% Litter 20% CWD 15% shrub (I. myrtifolia) 15% water
Graminoid *64.5 - 107.5′*	35% Graminoid (C. cherokeensis) 30% water 20% litter (thatch) 15% CWD

Table 6e. Transect 5

Sparse *0 - 29.5′*	70% Water 20% litter 5% shrub (I. myrtifolia stump sprouts) 5% forb
Herbaceous *29.5- 38′*	20% Forb (T. palustris) 60% litter 10% shrub 10% water
Sparse *38 - 102.5′*	70% Litter 10% water 10% CWD 5% graminoid 5% shrub

Table 6f. Transect 6

Sparse *0 - 79.5′*	55% Water 20% litter 10% CWD 10% shrub (L. styraciflua sprouts) 5% graminoid
Graminoid *79.5 - 107.5′*	55% Graminoid (C. glaucescens & cherokeensis) 45% water

Table 7. The basal area, canopy cover, and litter depth at the midpoint and interior point of all six vegetation transects in Upper Peanut Pond. Dominant tree species are also noted in the basal area. Transects were surveyed pre-restoration (7A) and post-restoration (7B). “In.” indicates that the litter at the survey point was inundated.

Table 7A.

Transect (length)		Litter Depth	Basal Area (ft^2/ac)	CC - N	CC - S	CC - E	CC - W	CC – Avg (%)
1 (69.5 ft)	Interior	.25"	40	42	46	70	77	58.75
	Midpoint	.75"	50 (P. taeda)	70	17	49	38	43.5
2 (94 ft)	Interior	2.5"	100 (N. biflora)	58	83	61	74	69
	Midpoint	1"	60 (P. taeda, N. biflora)	46	62	27	49	46
3 (79 ft)	Interior	.5"	30 (P. taeda, P. serotina)	14	57	60	61	48
	Midpoint	1.25"	70	17	59	54	46	44
4 (74 ft)	Interior	1"	70 (N. biflora, L. styraciflua)	76	72	53	77	69.5
	Midpoint	.25"	30	69	33	66	66	58.5
5 (88.5 ft)	Interior	1"	80	44	51	31	72	49.5
	Midpoint	1.5"	80 (N. biflora, L. styraciflua)	64	55	52	83	63.5
6 (74.5 ft)	Interior	2"	10	24	41	15	18	24.5
	Midpoint	.5"	30	62	7	27	18	28.5

Table 7B.

Transect (length)		Litter Depth	Basal Area (ft^2/ac)	CC - N	CC - S	CC - E	CC - W	CC – Avg (%)
1 (69.5 ft)	Interior	.5" In.	0	21	0	0	8	7.25
	Midpoint	1.25"	0	63	0	0	4	16.75
2 (94 ft)	Interior	.25" In.	0	21	4	0	0	6.25
	Midpoint	0	0	46	8	13	0	16.75
3 (79 ft)	Interior	.5" In.	0	4	4	13	0	5.25
	Midpoint	3"	0	0	21	8	0	7.25
4 (74 ft)	Interior	4" In. (slash)	0	0	8	0	0	2
	Midpoint	.25"	0	0	29	0	0	7.25
5 (88.5 ft)	Interior	.5" In.	0	4	13	0	4	5.25
	Midpoint	.25"	0	0	21	0	0	5.25
6 (74.5 ft)	Interior	.25"	0	0	8	0	0	2
	Midpoint	1"	10 (P. taeda)	54	4	0	0	14.5

Tables 8 & 9. Tables representing each transect (a – f) in Upper Peanut Pond with vegetation zones delineated and dominant species for each vegetation zone noted. Tables are approximately scaled to reflect the size of vegetation zones. Tables 8(a – f) show pre-treatment vegetation zones as compared to post-treatment [Table 9(a – f)].

Table 8a. Transect 1

Herbaceous *0 – 44'*	30% Herb (T. palustris) 20% graminoid 20% water 15% shrub (I. myrtifolia) 10% litter
Sparse *44 – 61.5'*	80% Litter 10% graminoid 5% CWD 5% shrub
Graminoid *61.5 - 69.5'*	20% Graminoid 80% litter

Table 9a. Transect 1

Herbaceous *0 – 40.5'*	40% Forb (T. palustris, Rhexia sp., Sabatia sp.) 30% graminoid (P. hemitomon) 20% water 10% litter
Graminoid *40.5 - 69.5'*	25% Graminoid (grasses) 70% litter 5% forb

Table 8b. Transect 2

Graminoid *0 – 36'*	25% Graminoid (C. cherokeensis) 40% water 20% litter 10% shrub 5% herb
Herbaceous *36 – 87'*	30% Herb (T. palustris) 35% water 15% litter 10% graminoid 10% shrub 5% CWD
Sparse *87- 94'*	75% Litter 10% graminoid 10% shrub 5% herb

Table 9b. Transect 2

Sparse *0 – 19'*	95% Water 5% graminoid (C. cherokeensis)
Graminoid *19 - 51'*	35% Graminoid (P. hemitomon) 35% water 20% litter 10% forb (T. palustris)
Sparse *51 - 83'*	80% Litter 10% graminoid 10% CWD
Shrub *83 - 94'*	60% Shrub (C. tomentosa) 30% litter 5% forb 5% grass

Table 8c. Transect 3

Herbaceous *0 – 38.5′*	70% Herb (T. palustris) 15% water 10% sedge 5% litter
Sparse *38.5 - 73′*	40% Water 20% litter 15% shrub 15% graminoid 10% CWD
Shrub *73 – 79′*	60% Shrub (Ericaceous) 20% litter 10% graminoid 10% herb

Table 8d. Transect 4

Graminoid *0 – 9.75′*	20% Graminoid (Carex) 65% water 10% herb (P. palustris) 5% litter
Herbaceous *9.75 – 43.5′*	40% Herb (T. palustris) 40% water 10% graminoid 10% litter
Shrub *43.5 – 74′*	45% Shrub (Celthra) 35% litter 10% herb 5% graminoid 5% water

Table 9c. Transect 3

Herbaceous *0 – 17.5′*	55% Forb (T. palustris) 25% water 10% graminoid 5% shrub 5% litter
Sparse *17.5 - 67′*	60% Litter 20% graminoid (bunch grass) 10% CWD 10% forb
Herbaceous *67 - 79′*	60% Forb (Pteridium sp.) 35% litter 5% shrub

Table 9d. Transect 4

Sparse *0 – 13.5′*	70% water 10% graminoid (C. cherokeensis 10% forb (T. palustris) 10% litter
Herbaceous *13.5 - 50′*	40% Forb (T. palustris, Eupatorium sp.) 45% litter 15% graminoid
Sparse *50 - 74′*	60% Litter 15% graminoid 10% shrub (Gaylussacia) 10% CWD 5% forb

Table 8e. Transcript 5

Sparse *0 – 11′*	85% Water 10% graminoid 5% herbaceous
Herbaceous *11 – 51′*	35% Herb (T. palustris) 40% water 20% graminoid (P. hemitomon) 5% litter
Sparse *51 – 65′*	55% Water 20% CWD 15% litter 10% graminoid
Shrub *65 – 88.5′*	40% Shrub (Clethra sp.) 30% graminoid 30% litter

Table 8f. Transcript 6

Herbaceous *0 – 15.5′*	55% Herb (T. palustris) 20% graminoid (P. hemitomon) 25% water
Shrub *15 – 23′*	35% Shrub (D. virginiana) 15% herb (T. palustris) 10% graminoid (P. hemitomon) 10% litter 30% water
Graminoid *23 – 48.5′*	25% Graminoid (P. hemitomon) 30% litter 30% litter 10% herb 5% shrub
Shrub *48.5 – 74.5′*	60% Shrub (Clethra, Vaccinium) 10% graminoid 5% herb 25% litter

Table 9e. Transcript 5

Sparse *0 – 12′*	75% Litter 20% water 5% graminoid
Herbaceous *12 - 33.5′*	50% Forb (T. palustris) 40% litter 10% graminoid
Graminoid *33.5 - 75′*	20% Graminoid 60% litter 10% forb 5% CWD 5% shrub
Shrub *75 - 88.5′*	50% Shrub (L. mariana) 40% litter 5% forb 5% graminoid

Table 9f. Transcript 6

Herbaceous *0 – 27′*	65% Forb (T. palustris) 10% shrub (D. virginiana) 10% litter 10% water 5% graminoid
Sparse *27 - 61′*	70% Litter 10% forb 10% graminoid 5% shrub 5% CWD
Shrub *61 - 74.5′*	50% Shrub (Vaccinium spp.) 45% litter 5% graminoid

Appendix B

Photos taken on vegetation transects before restoration efforts (July/August 2021) and after initial restoration efforts (July 2022). Photos were taken from the midpoint of transects, facing towards the center of the pond [interior] and the outside of the pond [exterior]. In the pre-treatment photos the person is holding a meter stick vertically 1.5 meters from the midpoint, in the post-treatment photos they are 5 meters away. *

*The GADNR vegetation protocol calls for the person for reference to be 5 meters from the midpoint. Pre-restoration vegetation was often too dense for a person to be visible at 5 meters, so the protocol was modified in the field.

Mike's Gopher Pond

Pre-Treatment *Post-Treatment*

Transect 1

Interior

Exterior

Interior

Exterior

Transect 2

Interior

Exterior

Interior

Exterior

Transect 3

Interior

Exterior

Interior

Exterior

Transect 4

Interior

Exterior

Interior

Exterior

Transect 5

Interior

Exterior

Interior

Exterior

Transect 6

Interior

Exterior

Interior

Exterior

Big Gopher Pond

Pre-Treatment *Post-Treatment*

Transect 1

Interior Exterior Interior Exterior




Transect 2

Interior Exterior Interior Exterior




Transect 3

Interior Exterior Interior Exterior




Transect 4

Interior

Exterior

Interior

Exterior

Transect 5

Interior

Exterior

Interior

Exterior

Transect 6

Interior

Exterior

Interior

Exterior

Upper Peanut Pond

Pre-Treatment *Post-Treatment*

Transect 1

Interior

Exterior

Interior

Exterior

Transect 2

Interior

Exterior

Interior

Exterior

Transect 3

Interior

Exterior

Interior

Exterior

Transect 4

Interior

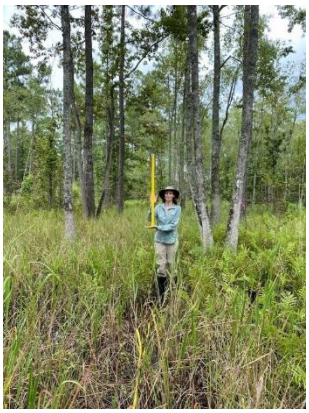
Exterior

Interior

Exterior

Transect 5

Interior



Exterior

Interior

Exterior

Transect 6

Interior

Exterior

Interior

Exterior

Appendix C

Calling anurans were detected using ARUs in each gopher frog pond. Song Meter SM2s and SM4s (Wildlife Acoustics, Maynard MA) placed in the pond were programmed to record the first five minutes of each hour. Recordings were taken from 2100 – 0400 on nights with ≥ .75" daily precipitation and were manually screened for calling species. Ponds were sampled from January 2021 to February 2023. Differences in sampling efforts are due to either battery faults or the removal of ARUs for management activities in each pond.

	Pre-Treatment	Post-Treatment
Mike's Gopher Pond	18 Sampling Nights – 7 species - *A. quercicus* - *H. femoralis* - *L. sphenocephalus* - *P. crucifer* - *P. nigrita* - *P. ocularis* - *P. ornata*	18 Sampling Nights – 7 species - *A. quercicus* - *G. carolinensis* - *H. femoralis* - *H. squirella* - *P. crucifer* - *P. ocularis* - *P. ornata*
Big Gopher Pond	14 Sampling Nights – 7 species - *H. femoralis* - *L. clamitans* - *L. sphenocephalus* - *P. crucifer* - *P. nigrita* - *P. ocularis* - *P. ornata*	15 Sampling Nights – 13 species - *A. gryllus* - *A. quercicus* - *G. carolinensis* - *H. chrysoscelis* - *H. cinereus* - *H. femoralis* - *H. squirella* - *L. clamitans* - *L. sphenocephalus* - *P. crucifer* - *P. nigrita* - *P. ocularis* - *P. ornata*
Upper Peanut Pond	17 Sampling Nights – 10 species - *A. gryllus* - *A. quercicus* - *H. femoralis* - *H. squirella* - *L. catesbianus* - *L. sphenocephalus* - *P. crucifer* - *P. nigrita* - *P. ocularis* - *P. ornata*	20 Sampling Nights – 13 species - *A. gryllus* - *A. quercicus* - *G. carolinensis* - *H. cinerea* - *H. chrysoscelis* - *H. femoralis* - *H. squirella* - *L. clamitans* - *L. sphenocephalus* - *P. crucifer* - *P. nigrita* - *P. ocularis* - *P. ornata*

Reference Photo Stations for three wetlands on the Webb Wildlife Center

Big Gopher Pond 1:

Big Gopher 2:

Big Gopher 3:

Big Gopher 4:

Big Gopher 5:

Big Gopher AFTER:

Mikes Gopher 1:

Mikes Gopher 2:

Mike’s Gopher AFTER:

Peanut 1:

Peanut 2:

Peanut Pond AFTER: