Lake Norman Vegetation Survey Report

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Introduction

Lake Norman, North Carolina's largest reservoir, is located on the main stem of the Catawba River in the Piedmont region of the state. The reservoir was impounded in 1963 by the Duke Power Company (now Duke Energy) and provides 36,472 acres (14,760 ha) of surface area for both recreational boating and sporting activities. Although the primary function for Lake Norman is to provide hydroelectric power and support energy production at Duke Energy facilities, the reservoir's highly developed shorelines also provide great economic value to the area.

Lake Norman supports a diverse aquatic plant community, which is comprised of populations of both native, beneficial species and noxious, undesirable species. Current management programs are directed at two noxious species, hydrilla (*Hydrilla verticillata*) and lyngbya (*Microseira wollei*). Hydrilla is a non-native, invasive submersed aquatic plant. In North Carolina, initial infestations were confined to small ponds and lakes; however, by 1988 it had spread into Lake Gaston, a major Piedmont reservoir located on the border of North Carolina and Virginia. Hydrilla continued to spread and was identified in the large lakes on the Catawba River system in the early 2000's. The establishment and distribution of hydrilla threatens the societal and ecological functions of freshwater systems in the United States due to its aggressive growth and reproductive capabilities. Because of this, hydrilla has been Federally-listed as a noxious weed and is further classified as a Class A noxious weed in North Carolina.

Lyngbya is a free-suspension filamentous cyanobacterium. This species has become increasingly problematic for southeastern reservoirs over the past decade and was first documented at Lake Norman in 2020. Lyngbya has the ability to produce robust filamentous mats, both along the benthos and at the water's surface, which negatively impacts the surrounding aquatic ecosystem, as well as the recreational utility of the system.

Management response to the first detection of hydrilla at Lake Norman in 2000 was immediate. To control biomass and reduce future growth potential, hydrilla was targeted by chemical control measures and treated annually with herbicides from 2000 to 2004. However, hydrilla produces subsurface tubers which can remain dormant for up to seven years before sprouting (Nawrocki et al. 2016). To address this future growth potential, approximately 6,120 triploid grass carp were stocked into Lake Norman in 2004 and annual supplemental stockings (at various stocking rates) continued until 2012 when it was deemed that the tuber bank was depleted. These management efforts were successful in eradicating all 444 standing acres (180 ha) of hydrilla by 2004 and suppressing future hydrilla growth for several years. In 2018, an estimated 640 acres of hydrilla were again recorded in Lake Norman (NCSU 2018). Much of the growth was documented within the southern portion of the lake in the Ramsey Creek arm. In

response to this hydrilla recurrence, annual grass carp stockings have occurred in Lake Norman since 2018 for hydrilla control in quantities of 10,200 (2018), 12,330 (2019), and 750 (2020-2024) total fish per stocking (B. Hartis, personal communication). In 2024, 60 acres of hydrilla were also chemically treated with fluridone in the upper reaches of Lake Norman, in a cove just above Buffalo Shoals Road (NCDEQ 2024).

Management of lyngbya was initiated in 2024 due to the increasing infestation. A pilot program targeting 10 acres with chelated copper based algaecide was facilitated by the Lake Norman Marine Commission. Lyngbya viability has shown a short-term decrease, but long-term impacts are still to be determined. However, lyngbya management at low density and infestation levels has proven beneficial for algaecide treatment programs (Bishop and Rogers 2012).

Another aquatic plant population that is receiving increased attention from homeowners at Lake Norman is eelgrass (Eryn Molloy; personal communication). Eelgrass is a native and beneficial species that provides a host of ecosystem services including habitat for aquatic organisms, sediment stabilization, and water quality improvement. However, eelgrass can form dense beds that may impede recreational activities such as swimming and boating. Previous genetic testing of the Lake Norman eelgrass population determined that the species present is *Vallisneria neotropicalis*, a native species to the Southeastern United States (NCSU 2023). Non-native and hybrid eelgrass taxa have become established in several US waterbodies and are difficult to identify based on morphological features alone (Beets et al. 2024), and as such, continued monitoring and genetic testing is needed in Lake Norman. Additional samples of the Lake Norman eelgrass population were collected during the 2024 survey and will be sent to Montana State University for genetic analysis confirmation. Currently, there are no large scale management efforts directed at this species but homeowners can receive permitting for small scale applications.

Annual whole-lake shoreline surveys at Lake Norman by North Carolina State University researchers were initiated in 2018. Survey results can be used to monitor the management programs for hydrilla and lyngbya at Lake Norman as well as to track changes within the native aquatic plant community. In partnership with this survey, homeowners can report aquatic plant related issues through Duke Energy's Aquatic Plant Management Program's Aquatic Plant Reporting Tool (Eryn Molloy; personal communication).

Methods

Macrophyte Survey

Hurricane Helene directly impacted the system on September 26th and 27th, 2024 resulting in historical amounts of water being pushed through the system. Therefore, the annual survey of

Lake Norman was completed during two separate sampling events occurring pre- and post-hurricane in mid-September and mid-October 2024 (Figure 1). During both survey timeframes, the lake elevation remained around 97 feet. This elevation was not far off from the target elevation of 98 ft (based on full pool of 100 ft). A sub-sample of sites completed pre-hurricane were resampled post-hurricane to determine the compatibility of the two survey dates. The sub-sample of sites displayed similar characteristics within the aquatic plant community and therefore were the datasets were combined for final analysis.

To quantify submersed plant abundance and locations, a point intercept method was utilized to determine species presence or absence and to provide a basis for comparison in determining future hydrilla spread or reductions. A total of 929 points were sampled south of the Hwy 150 bridges at approximately 1,600 ft (500 m) intervals around the shoreline by North Carolina State University (NCSU) personnel both pre- and post-hurricane (Figure 2). These GPS points have been surveyed consistently since NCSU efforts began in 2018. An additional 950 points were sampled by the Duke Energy Aquatic Plant Management group north of the Hwy 150 bridges pre-hurricane. In total, 1,879 points were surveyed in 2024. The sites surveyed by the Duke Energy Aquatic Plant Management group were randomly selected along the lake's shoreline and are not consistent between survey years. Because of this, reported trend over time analyses only includes NCSU data.

The sample method included visual observation of the survey area and 2 rake tosses at each point to identify any submersed species present. Rake tosses were collected in water from 4 to 12 ft (1.2 to 3.6 m) deep. Plant abundance was assessed at each point with a 0 to 4 rating scale, (0 = no plants present on the rake; 1 = plants present at low densities < 25% cover (*trace*); 2 = plants present at moderate densities 25-50% cover (*sparse*); 3 = plants present a moderate to high densities 50-75% cover (*moderate*); 4 = plants present at extremely high densities 75-100% cover (*dense*)).

Within the NCSU survey area, hydroacoustic (sonar) data were collected at and between survey points with Lowrance™ fish finding units in areas where target submersed plant species were present (hydrilla and eelgrass). The collected sonar data were uploaded to BioBase™, a cloud-based computing platform, and the standing biovolume (proportion of submersed plant height by water depth) of the targeted species was quantified.

Post-Processing

Collected data from NCSU and the Duke Energy Aquatic Plant Management teams were compiled and summarized in Microsoft Excel and then imported into ArcPro (v. 3.2.1) for visualization of species extent and distribution. Additionally, an estimated acreage extent was determined for hydrilla, eelgrass, and lyngbya through the combination of point-intercept results and biovolume measurements. Due to limitations of this technology, it is not possible

to get accurate estimates of biovolume in areas where water depth is less than approx. 2.5 feet or where plant abundance is very low. As such, sonar data was not applied during post-processing in the selected areas where accurate data could not be captured. Further, because lyngbya is a free-floating cyanobacteria, sonar data cannot accurately quantify its presence. Therefore, sonar data was not utilized in the acreage estimation for lyngbya, and instead, only point-intercept distribution was applied.

Data were compared to previous survey efforts to determine changes in the aquatic plant community at Lake Norman over time. Resultant figures, tables, and maps are included in Appendix I.

Results and Discussion

Overall Vegetation

Aquatic vegetation was present in Lake Norman at 469 of the 929 (50%) surveyed points by NCSU and 294 of the 950 (31%) points surveyed by the Duke Energy Aquatic Plant Management group during the 2024 survey. When combined, 763 of 1879 survey points (41%) contained aquatic vegetation at Lake Norman in 2024 and included submersed, floating-leaved, emergent, and algal species (Table 1; Figures 3 – 5). When compared to previous survey years, most species recorded at Lake Norman in 2024 are those that have been consistently documented at NCSU survey sites, with the exception of brittle naiad (*Najas minor*) and primrose (*Ludwigia sp.)*, which had not been documented by NCSU in the past (Table 2), but have been found north of the Highway 150 bridge at Duke Energy Aquatic Plant Management group's survey sites (NCSU 2023). In general, other species presence and distribution in 2024 has increased or remained stable when compared to previous survey years. An exception is macroalgae (*Chara sp*.) which has decreased in presence from a peak of 43% of surveyed sites in 2022 to 19% of surveyed sites in 2024 (Table 2, Figure 4). A few other species, including hydrilla and lyngbya, have increased in presence when compared to 2023 levels, but overall distribution in Lake Norman remains low.

The most common species present at Lake Norman in 2024 was spikerush (*Eleocharis baldwinii*), found at 537 (29%) total survey points (Table 1, Figure 6). At most sites where found, spikerush was noted in trace abundance (Table 1; Figure 3). Most dense spikerush growth occurred in the northern section of Lake Norman in 2024 (Figure 6). Spikerush has consistently been one of the most common species at Lake Norman at NCSU survey sites since 2018 (Table 2).

Other submersed species present included hydrilla (Figure 7), eelgrass (*Vallisneria neotropicalis;* Figures 8 - 9), native naiad species (*Najas flexilis and N. guadalupensis;* Figure 10), brittle naiad (*N. minor*; Figure 11), and native pondweed species (*Potamogeton spp.;*

Figure 12). Documented algal species were macroalgae (*Chara spp*.; Figure 13), Lyngbya (*Microseria wollei;* Figure 14), and filamentous algae (*Spirogyra spp.,* Figure 15). Floating or emergent species included water primrose (*Ludwigia spp.;* Figure 16) as well as common duckweed (*Lemna minor)*, American water willow (*Justicia americana)*, Spatterdock (*Nuphar advena)*, and American lotus (*Nelumbo lutea)* (Figure 17).

Most of the submersed aquatic macrophyte species were present at less than 5% of surveyed sites, with the exception of pondweed and eelgrass that were present at 17% and 8% of surveyed sites, respectively (Table 1). These findings are not unusual for Piedmont reservoir systems and native SAV are likely impacted by the active grass carp population at the lake.

Hydrilla

Hydrilla was present at 25 total survey points at Lake Norman during the 2024 survey (Table 1, Figure 7). Of these, 7 occurred below the Highway 150 bridge at the sites surveyed by NCSU, an increase from 3 sites documented in 2023 (Table 2). Hydrilla was most frequently present in trace abundance (68% of points), followed by sparse at 16% of points, and moderate or dense abundance at 8% each (Figure 3). The only areas where moderate or dense growth occurred was in the upper end of the lake, above Buffalo Shoals Road (Figure 7). In 2023, hydrilla in this region was even more widespread, but active management that occurred during the 2024 growing season likely suppressed growth (DEQ 2024). Established hydrilla growth was also noted just south of the Highway 150 Bridge in a creek arm located to the west of the Lake Norman Marina. Documented hydrilla at all other survey sites south of the Highway 150 Bridge where recorded as trace abundance, and as such, only floating fragments or small plant stems were present in these areas. Based on our data, we estimate that 43 acres of Lake Norman's shoreline supported hydrilla growth in 2024. With these results, we conclude that the hydrilla population remains at low levels throughout Lake Norman and continued grass carp stockings are effectively suppressing the total standing acreage (Figure 18).

Vallisneria

The eelgrass population continues to increase in distribution and abundance at Lake Norman (2021: 2 Points, 2022: 16 points, 2023: 39 points, 2024: 58 points) (Table 2; Figure 4). During the 2024 survey, eelgrass was noted to be dense at many sites in the Ramsey Creek arm (Figures 8 and 9), but was more sparsely growing at surveyed areas north of the Ramsey Creek section. We estimate that there are 94 acres of eelgrass in Lake Norman in 2024.

Lyngbya

A total of 16 surveyed points contained lyngbya, a benthic filamentous algae that is capable of growing to nuisance levels in North Carolina's reservoirs, during the 2024 survey. Lyngbya was

noted to be in trace abundance at 81% of the sites in which it was present (Table 1). Among the NCSU survey sites, lyngbya was present at 14 points, an increase from 7 points in 2023 (Table 2). The northernmost population of hydrilla was found near Lake Norman State Park, and the densest growth was found in Lake Norman's Ramsey Creek Arm (Figure 14). The extent of lyngbya is estimated to cover 28 acres in Lake Norman in 2024.

Brittle Naiad

Brittle naiad was found in trace abundance at a single survey point below the Highway 150 Bridge in 2024. While this species has never been documented in this region of the lake, it has been present in the upper reaches during previous survey years (NCSU 2023). Brittle naiad is a non-native species and listed on North Carolina's Noxious Weed List. Brittle naiad has been documented in other reservoirs in the Piedmont region, including Philpott Reservoir and Lake Gaston, but has generally not exhibited growth levels that would be considered a nuisance. Nonetheless, continued monitoring of this population will be important to determine potential impacts of the Lake Norman system.

Conclusion and Management Implications

- Hydrilla at Lake Norman continued to be present in low abundance during the 2024 survey. Our results suggest that current management activities, including grass carp stockings and chemical controls, are effective at suppressing hydrilla growth within the system. Future management practices should consider targeting established hydrilla in the northern reaches of the lake, including the coves above Buffalo Shoals Road and west of the Lake Norman Marina. It is probable that hydrilla in these areas have produced vegetative propagules that can remain dormant in the system for at least 7 years. Continued monitoring and management will be important for long-term population suppression.
- Spikerush and macroalgae (*Chara* sp.) remain the dominant SAV species in Lake Norman as of 2024 and other native SAV species were found as generally sparse populations. Overall native SAV occurrence has increased or remained stable compared to previous years.
- Lyngbya has displayed a steady increase within survey points when compared to previous survey years at Lake Norman. While lyngbya density and distribution remains generally low throughout the system, sudden and rapid expansion of this species has been documented in other North Carolina piedmont reservoirs. A lyngbya management project was initiated at Lake Norman in 2024 and long-term impacts of this program remain unclear. Because of the morphology of this filamentous cyanobacteria, control is difficult to achieve within a single treatment season and will

most likely be reflected after multiple consecutive treatment years.

- The eelgrass population continues to increase in distribution and abundance at Lake Norman. Eelgrass at Lake Norman has been confirmed to be native *V. neotropicalis* through genetic analysis. Continued monitoring and sample collection will be valuable for future management decisions. The native and non-native/hybrid eelgrass species have cryptic morphological traits, making identification with the human eye difficult. Field notes on growth rates, average leaf width and length, male and/or female flower traits, and root characteristics also aid in the initial characterization of species within the *Vallisneria* genus.
- The online Aquatic Plant Reporting Form for Lake Norman launched by the Duke Energy Aquatic Plant Management group in 2024 collected nearly 100 instances of aquatic plant presence from homeowners at Lake Norman between January and October 2024. In general, the reports correlate well to survey results for major species in the Lake Norman system, including Chara, eelgrass, and lyngbya (Figures 19 – 21). This tool can continue to provide support for managers through directed documentation of potential plant populations that are of concern to stakeholders at Lake Norman, especially at sites where annual sampling has not historically occurred.
- Annual monitoring of SAV in Lake Norman should continue to track the presence and abundance of native and non-native aquatic plant species.

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Appendix I: Tables and Figures

Table 1: Species abundance and growth densities for aquatic plants recorded during the 2024 Lake Norman survey by both NCSU and Duke Energy Aquatic Plant Management survey units.

	Common Name	Scientific Name	Total		Trace		Sparse		Moderate		Dense	
			#	% (of Total)	#	%	#	%	#	%	#	%
Submersed	Eelgrass	*Vallisneria neotropicalis*	58	3%	33	57%	13	22%	6	10%	6	10%
	Spikerush	*Eleocharis baldwinii*	537	29%	330	61%	146	27%	40	7%	21	4%
	Southern Naiad	*Najas guadalupensis*	17	1%	15	88%	2	12%	0	0%	0	0%
	Slender Naiad	*Najas flexilis*	19	1%	6	32%	8	42%	3	16%	2	11%
	Brittle Naiad	*Najas minor*	1	<1%	1	100%	0	0%	0	0%	0	0%
	Hydrilla	*Hydrilla verticillata*	25	1%	17	68%	4	16%	2	8%	2	8%
	Pondweeds	*Potamogeton spp.*	132	7%	119	90%	12	9%	1	1%	0	0%
Algae	Filamentous Algae	*Spirogyra spp.*	7	<1%	7	100%	0	0%	1	14%	1	14%
	Lyngbya	*Microseria wollei*	16	1%	13	81%	1	6%	1	6%	1	6%
	Macroalgae	*Chara spp.*	211	11%	141	67%	38	18%	24	11%	8	4%
Floating / Emergent	Duckweed	*Lemna minor*	2	<1%	2	100%	0	0%	0	0%	0	0%
	Water Willow	*Justicia americana*	4	<1%	2	50%	1	25%	1	25%	0	0%
	Spatterdock	*Nuphar advena*	4	<1%	2	50%	0	0%	0	0%	2	50%
	American Lotus	*Nelumbo lutea*	6	<1%	0	0%	4	67%	0	0%	2	33%
	Primrose Species	*Ludwigia spp.*	10	1%	2	20%	0	0%	4	40%	4	40%
		Total Vegetated Points	763	41%	384	50%	122	16%	19	2%	11	1%
		Total Surveyed Points	1879									

Table 2: Change in aquatic plant species presence and abundance at Lake Norman between 2018 and 2024 at NCSU survey sites. Values represent the percent change in abundance from those reported the previous year.

		2018		2019		2020		2021		2022		2023		2024	
Common Name	**Type**	#	% Change	#	% Change	#	% Change	#	% Change	#	% Change	#	% Change	#	% Change
Chara/Nitella	Submersed	134	-	203	51%	225	11%	316	40%	396	25%	289	-27%	179	-38%
Spikerush	Submersed	65	-	38	-42%	90	137%	98	9%	110	12%	259	135%	276	7%
Eelgrass	Submersed	2	-	2	0%	1	-50%	2	100%	16	700%	39	144%	58	49%
Hydrilla	Submersed	126	-	2	-98%	2	0%	0	-100%	0	-	3	>100%	7	133%
Pondweed	Submersed	38	-	0	-100%	2	>100%	0	-100%	29	>100%	36	24%	132	267%
Brittle Naiad	Submersed	0		0	-	0		0	-	0	-	0	-	1	>100%
Naiad	Submersed	25	-	7	-72%	0	-100%	1	>100%	0	-100%	49	>100%	34	-31%
Dwarf Milfoil	Submersed	1	-	0	-100%	0	-	0	-	0	-	0	-	0	-
Water-willow	Emergent	3	-	0	-100%	1	>100%	2	100%	0	-100%	0	-	0	-
Ludwigia	Emergent	0	-	0	-	0	-	0	-	0	-	0	-	2	>100%
Lyngbya	Algae	0	-	0	-	2	>100%	3	50%	0	-100%	7	>100%	14	100%
Filamentous Algae	Algae	6	-	0	-100%	5	>100%	0	-100%	0	-	9	>100%	7	-22%
Total Surveyed Points		**907**	**-**	**891**	**-1.8%**	**945**	**6.1%**	**947**	**0.2%**	**927**	**-2.1%**	**938**	**1.2%**	**929**	**-1.0%**
Total Vegetated Points		400		252		328		422		551		691		469	

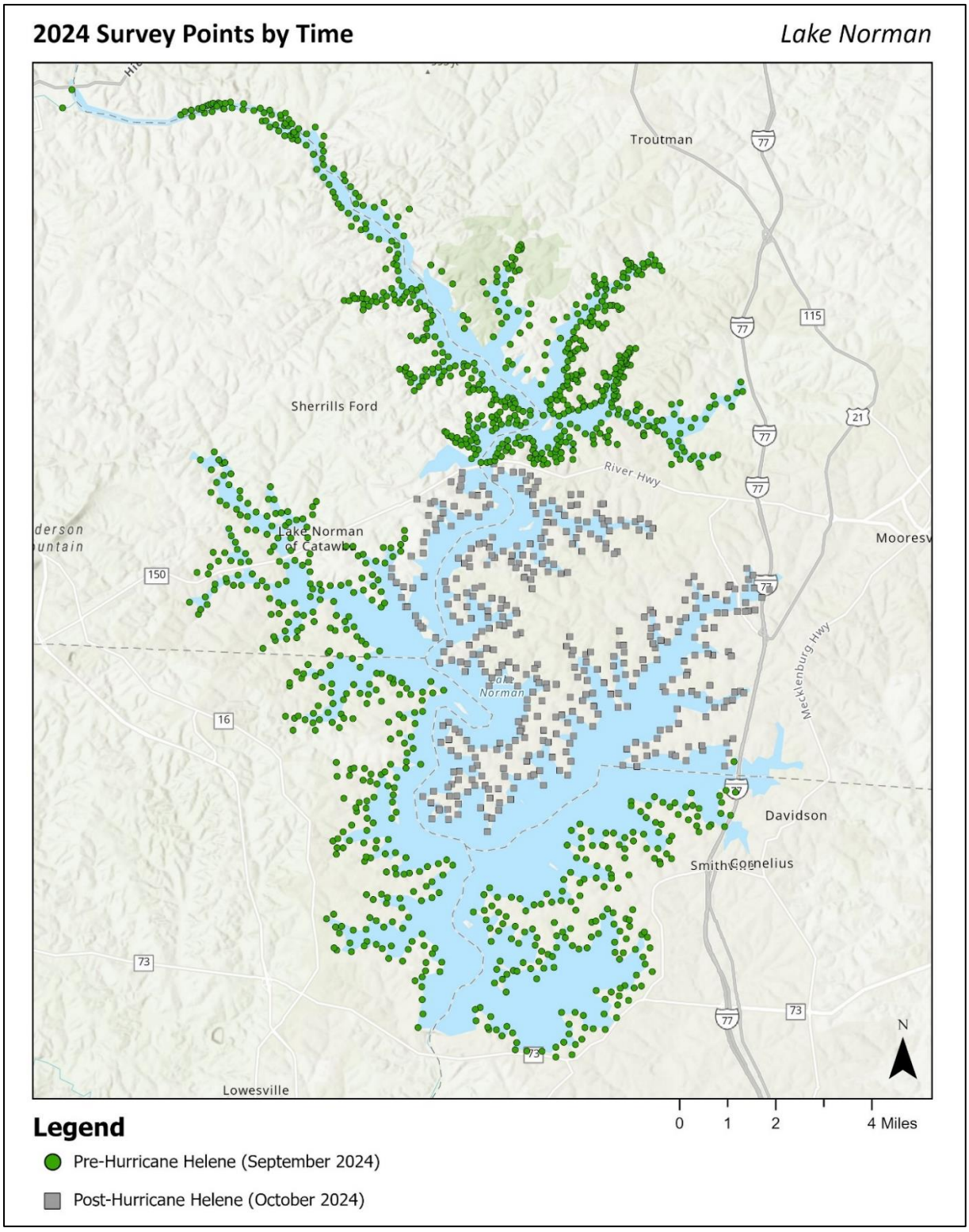

Figure 1: Sampling timing of surveyed points during the 2024 aquatic vegetation survey. Green dots represent sites that were sample pre-Hurricane Helene and grey squares represent sites surveyed post-Hurricane Helene.

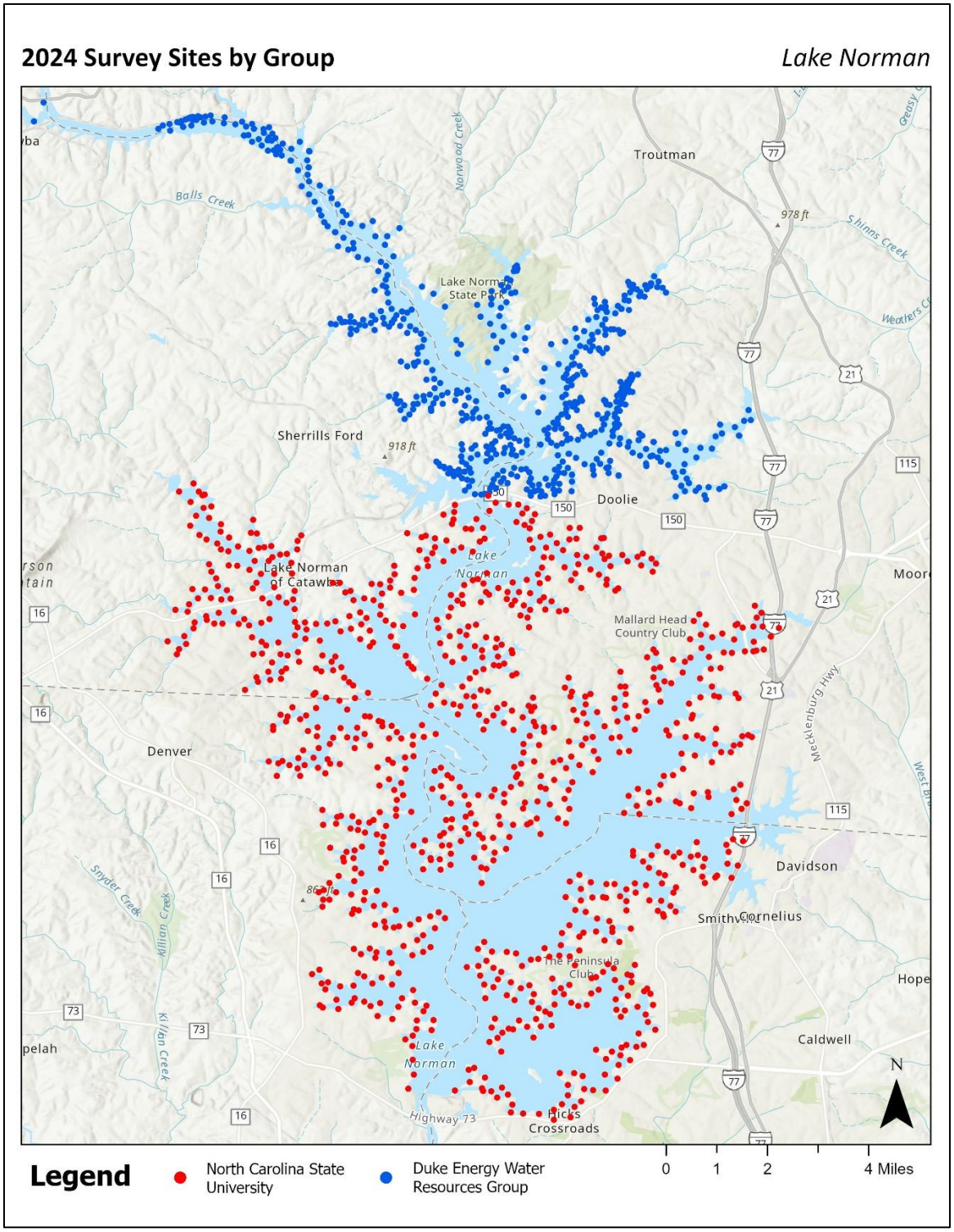

Figure 2: Sampled points at Lake Norman during the 2024 survey effort. Red points represent sites surveyed by North Carolina State University Aquatic Plant Management group and blue points represent sites surveyed by the Duke Energy Aquatic Plant Management group.

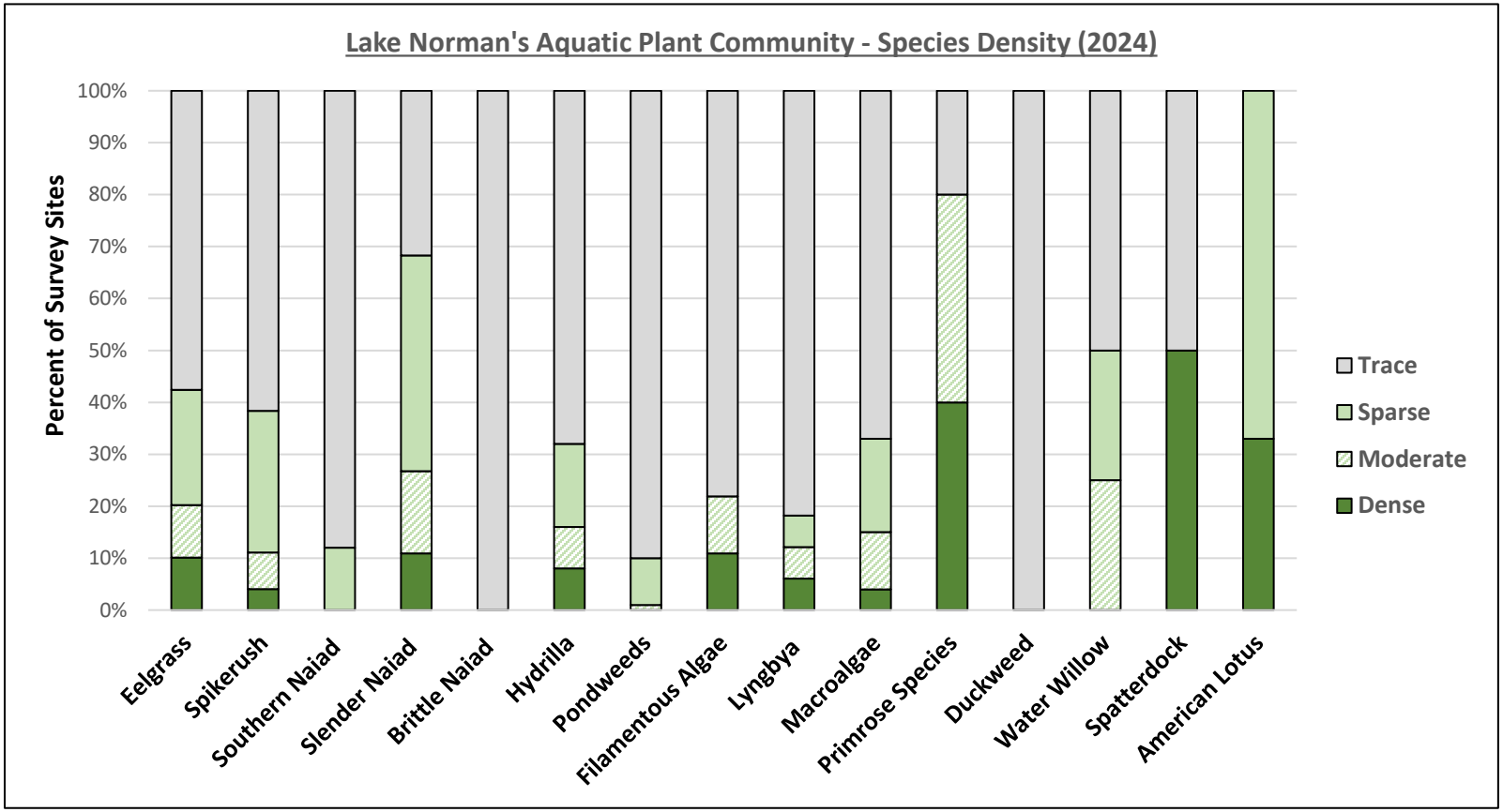

Figure 3. Growth levels displayed by aquatic plant species were ranked as trace, sparse, moderate, or dense at NCSU survey sites during the 2024 vegetation survey. The varying levels of growth displayed by individual species are shown as a percent of all survey sites in which that particular species was present.

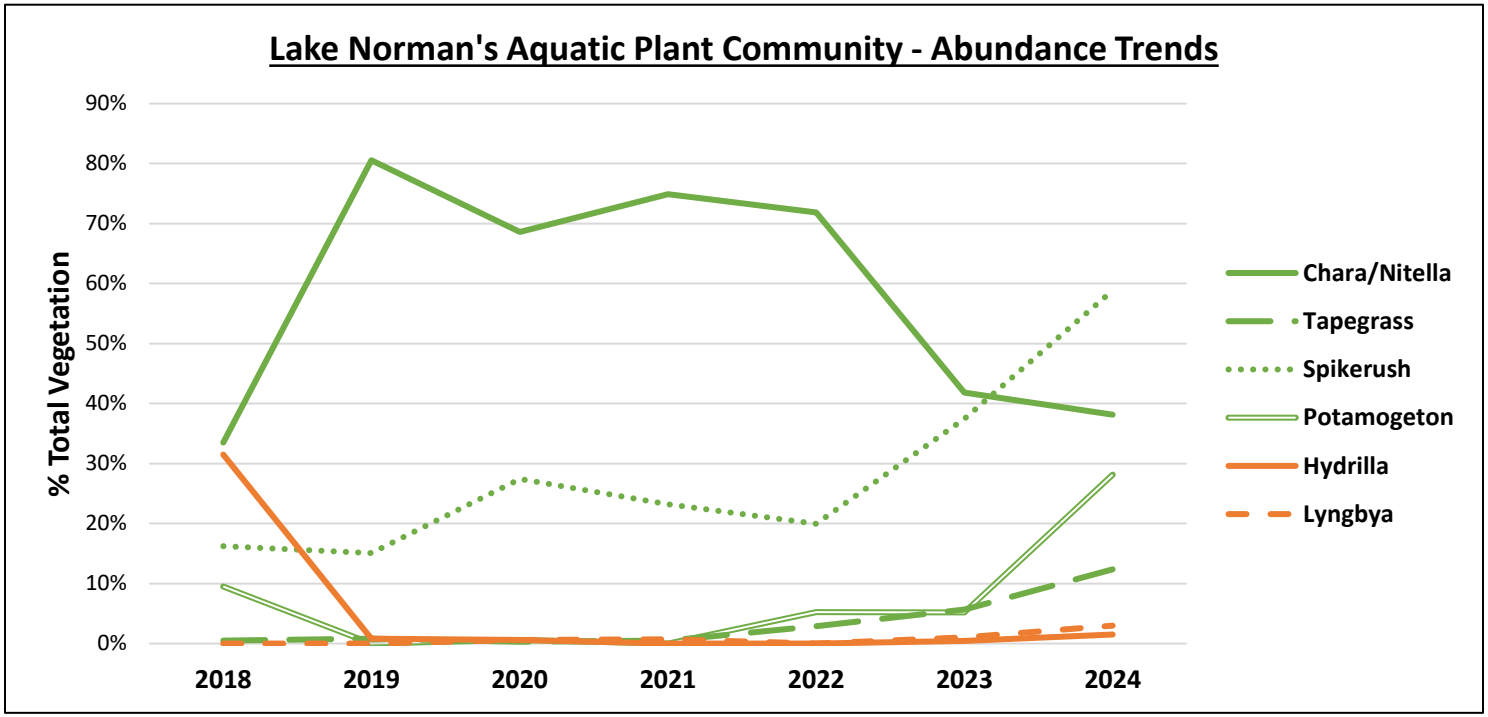

Figure 4: Trends in the relative abundance of aquatic plant species surveyed in Lake Norman from 2018 to 2024 according to NCSU survey data. Relative abundance was calculated as the number of sites in which a specific species was present vs. the total number of vegetated sites surveyed. Native, beneficial species are indicated by the green lines while invasive, noxious species are indicated by orange lines.

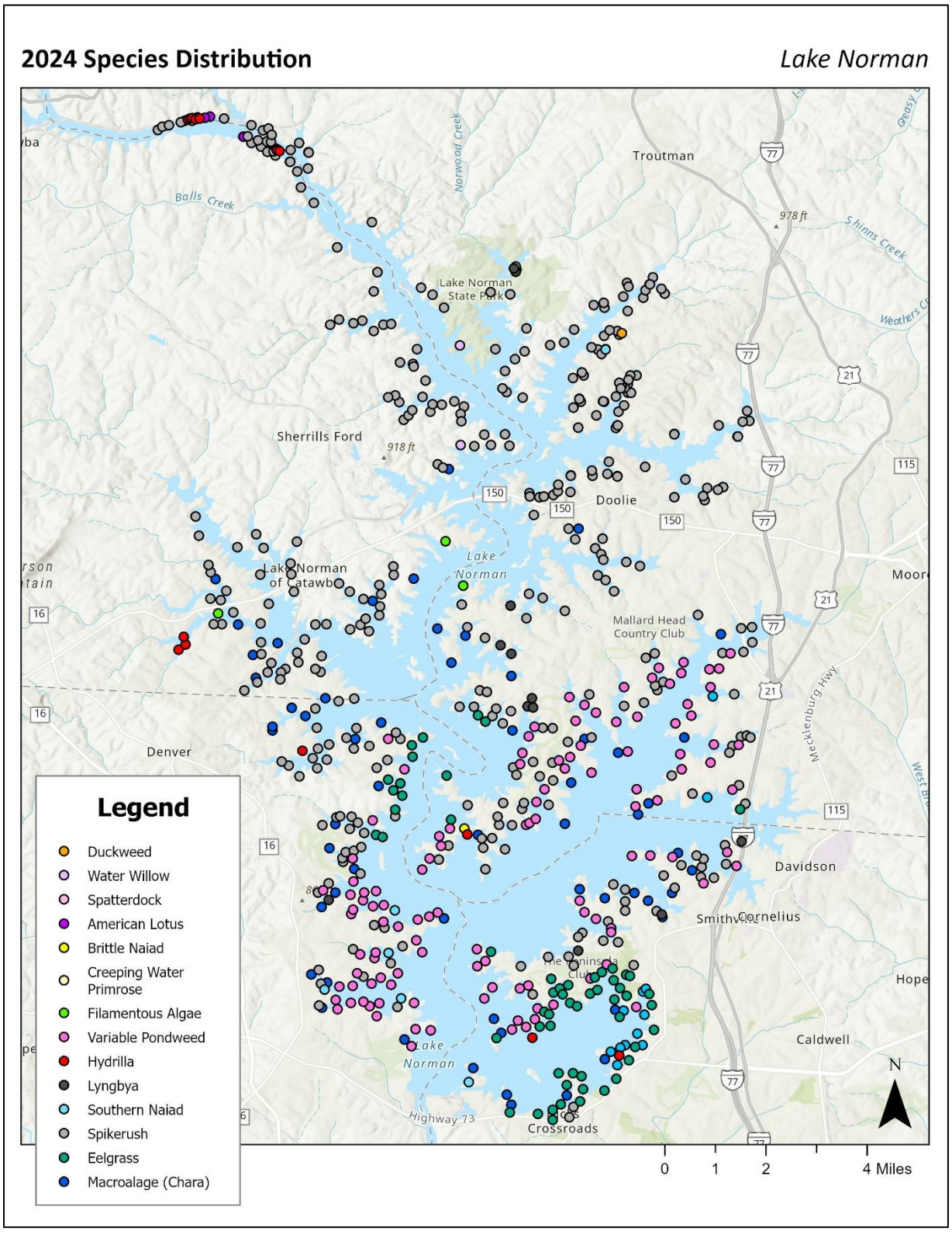

Figure 5: Distribution of all species documented during the 2024 Lake Norman aquatic vegetation survey.

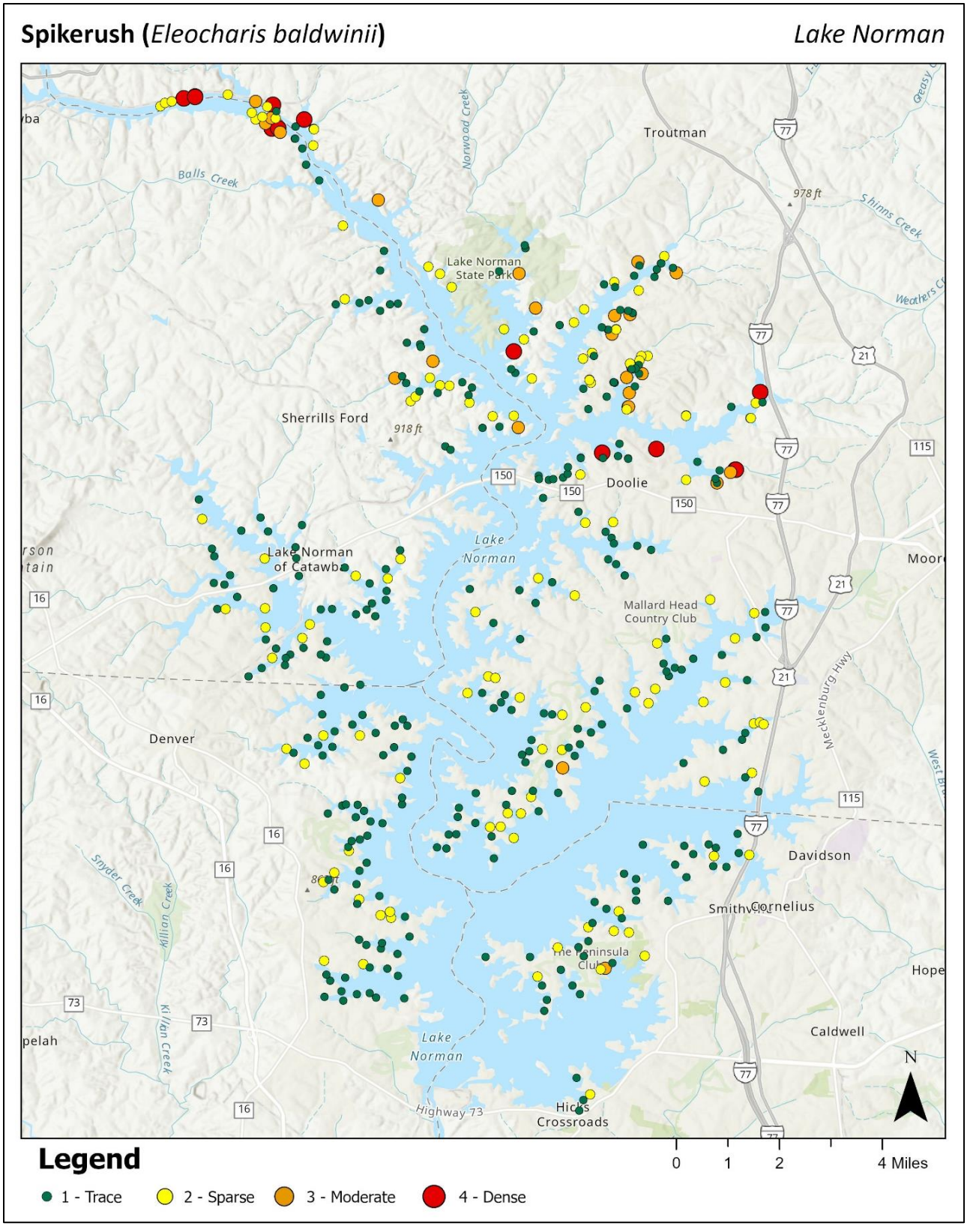

Figure 6: Spikerush sites and abundance ratings documented during the 2024 Lake Norman survey.

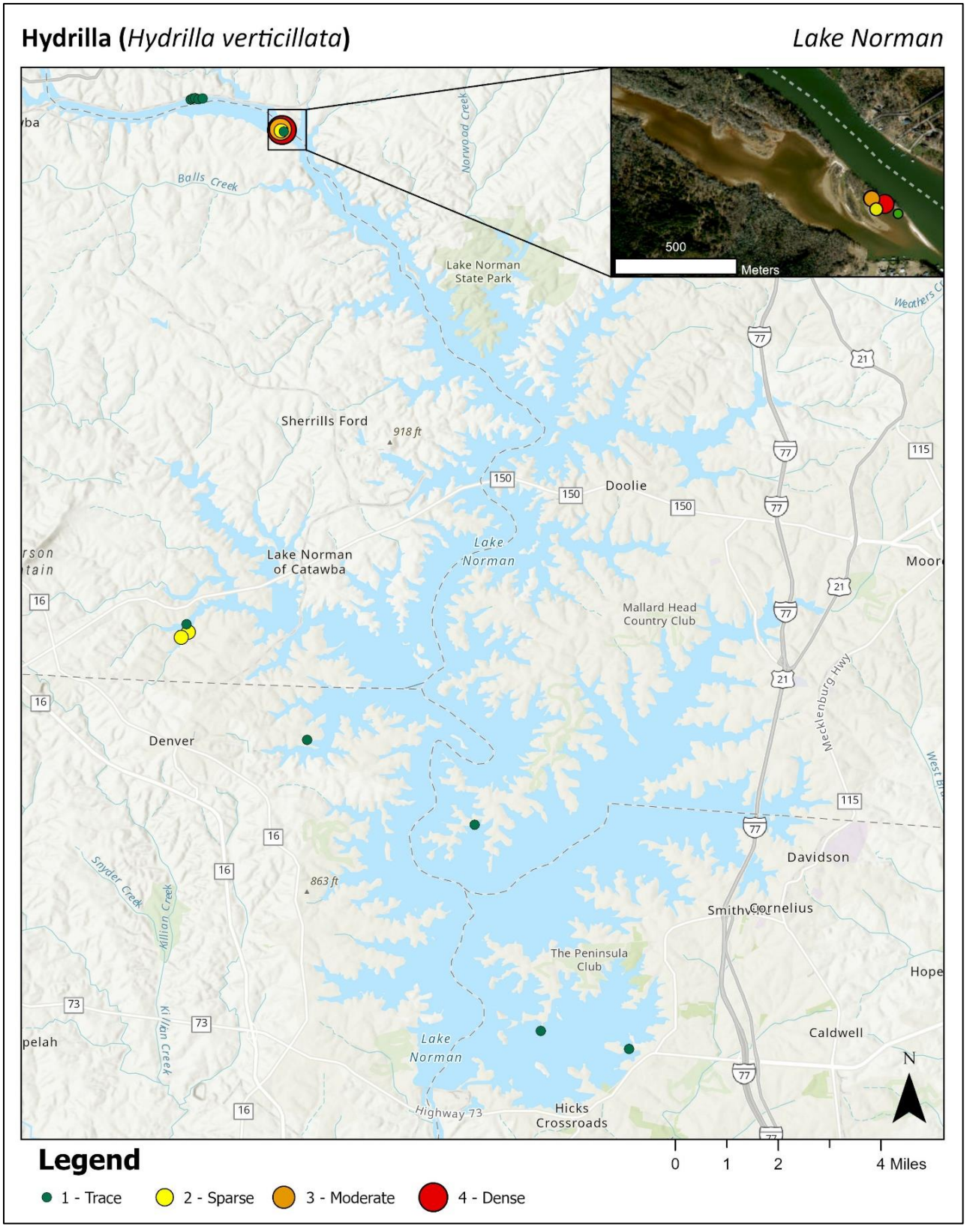

Figure 7: Hydrilla sites and abundance ratings documented during the 2024 Lake Norman survey

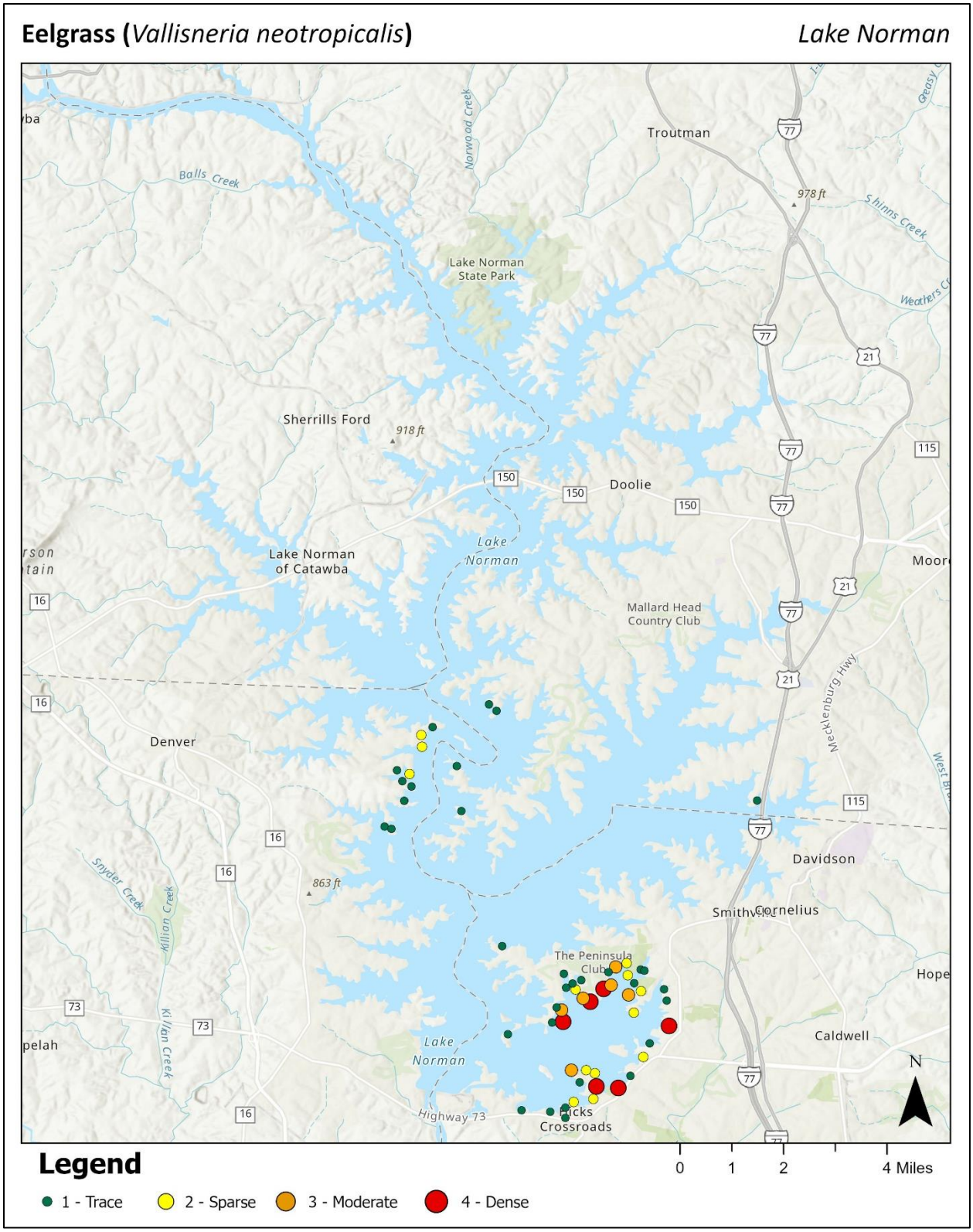

Figure 8: Eelgrass sites and abundance ratings documented during the 2024 Lake Norman survey.

Figure 9: Examples of eelgrass growth in Lake Norman during the 2024 survey.

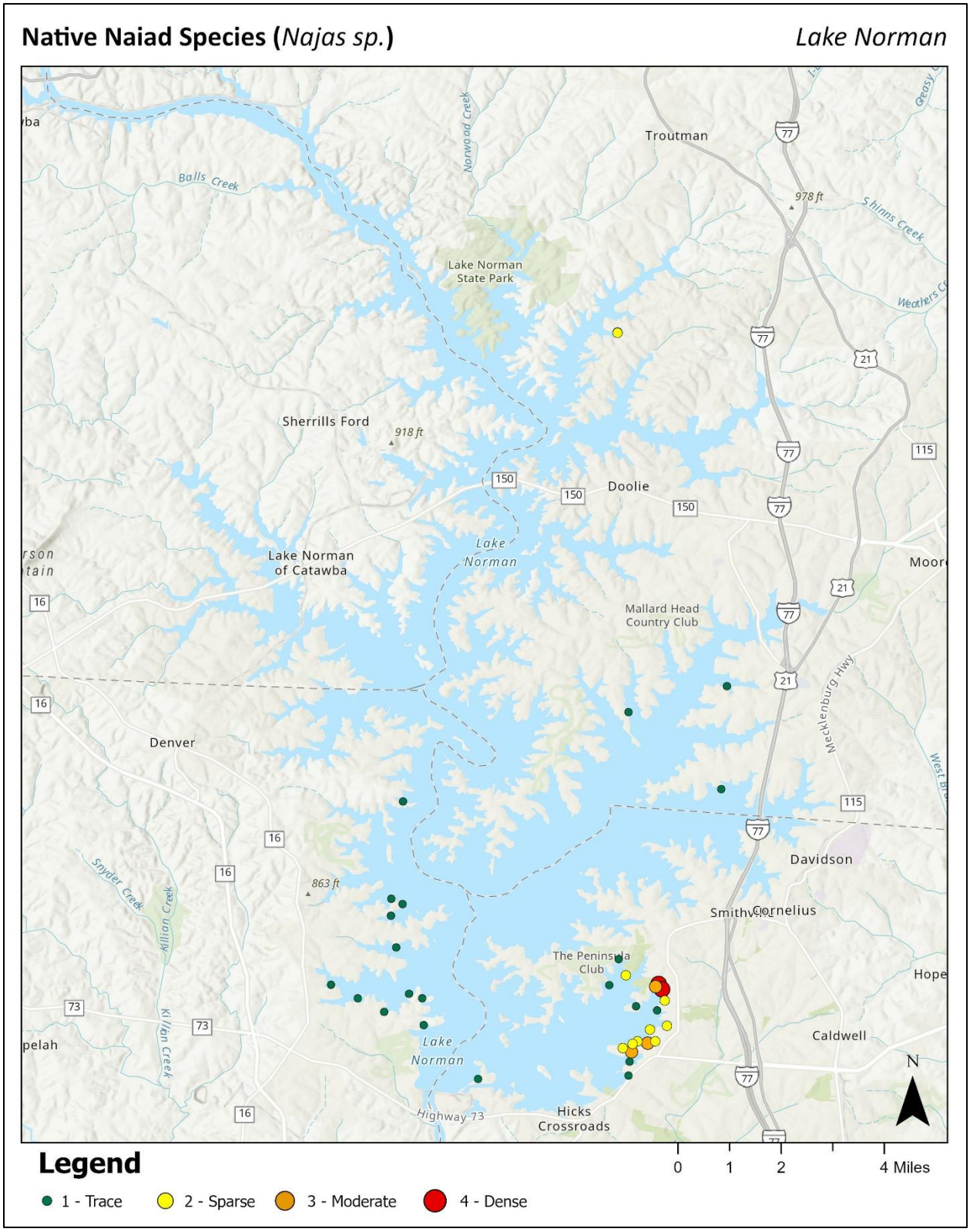

Figure 10: Native naiad species (*Najas guadalupensis* and *N. flexilis*) sites and abundance ratings documented during the 2024 Lake Norman survey.

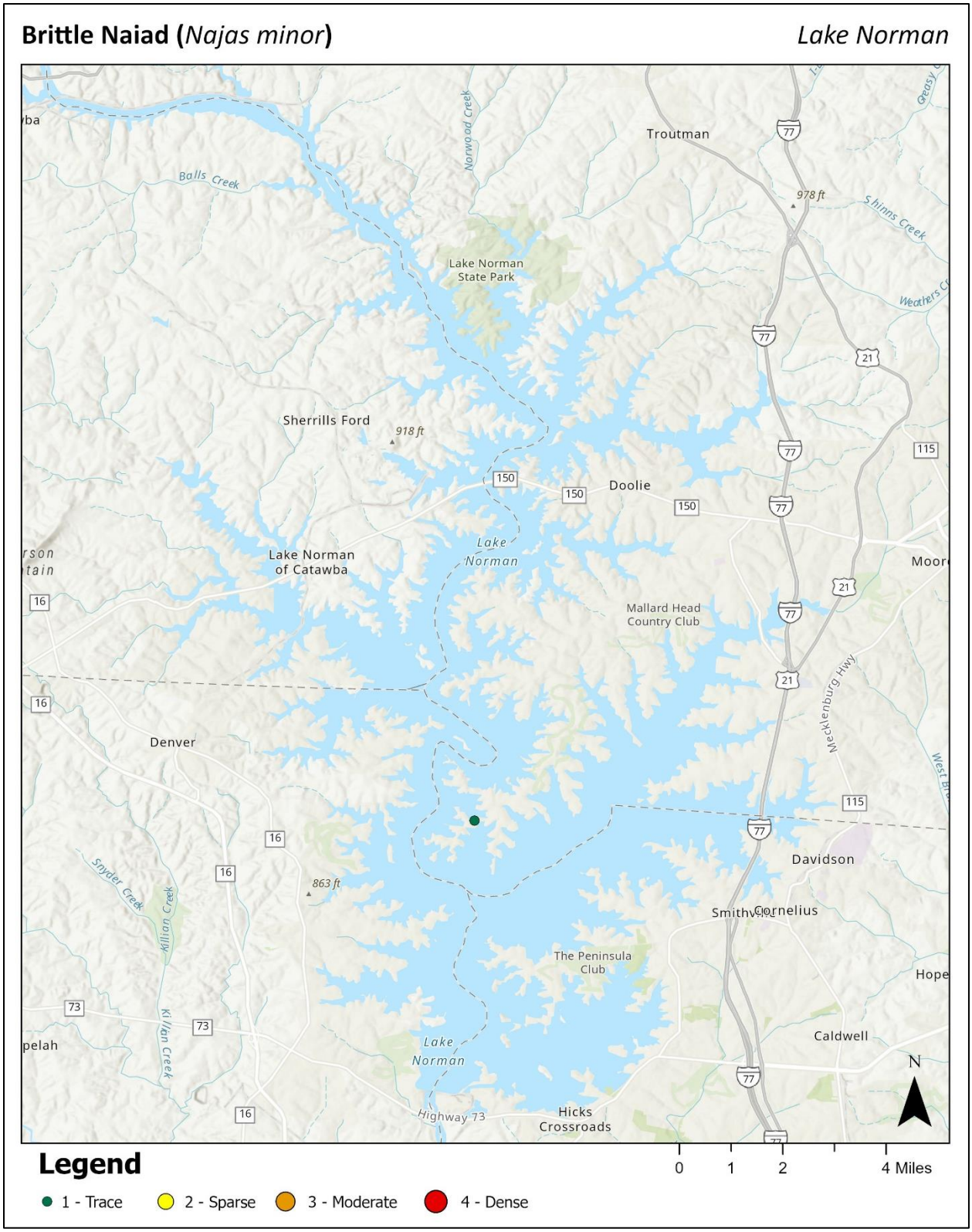

Figure 11: Brittle naiad sites and abundance ratings documented during the 2024 Lake Norman survey.

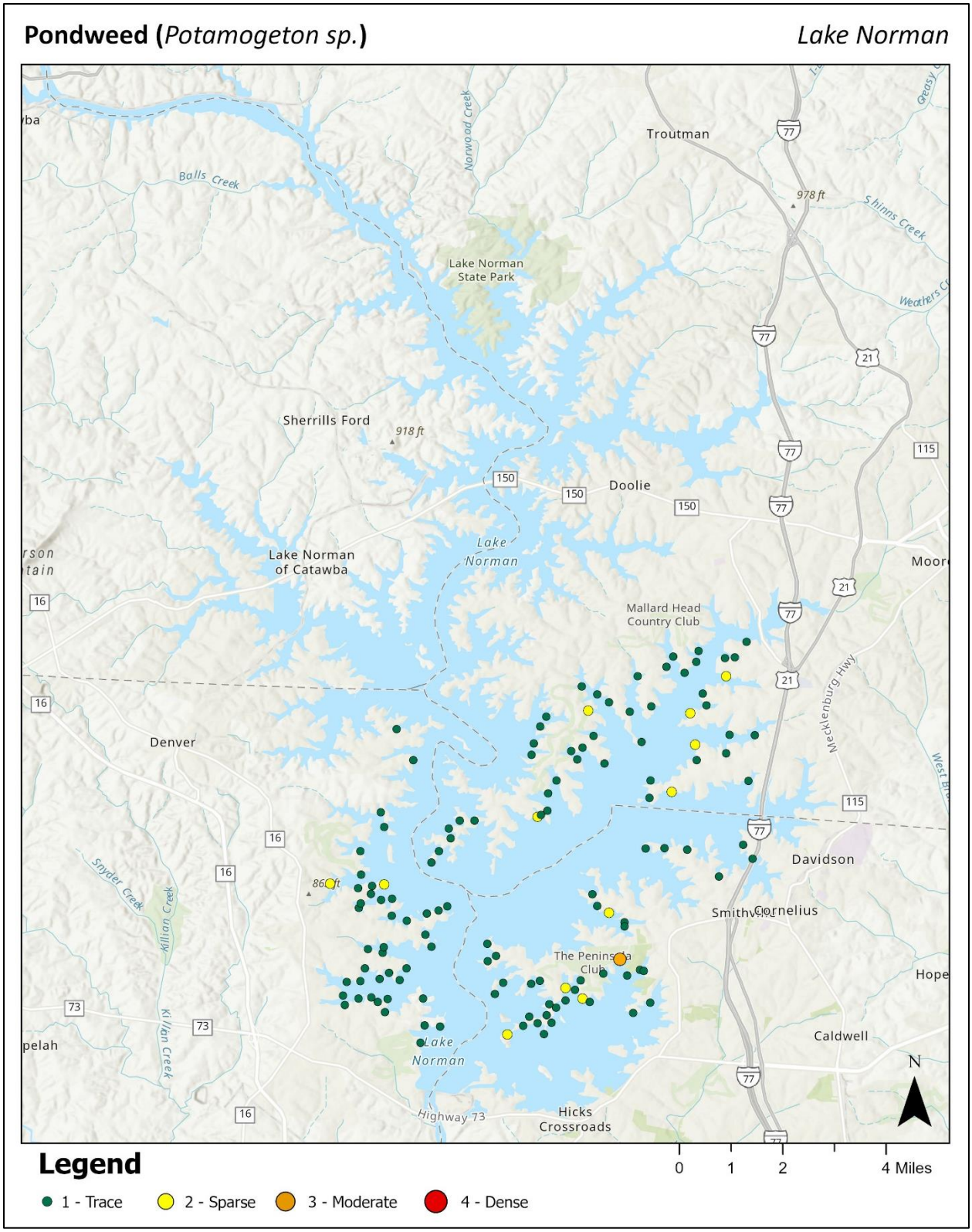

Figure 12: Pondweed sites and abundance ratings documented during the 2024 Lake Norman survey.

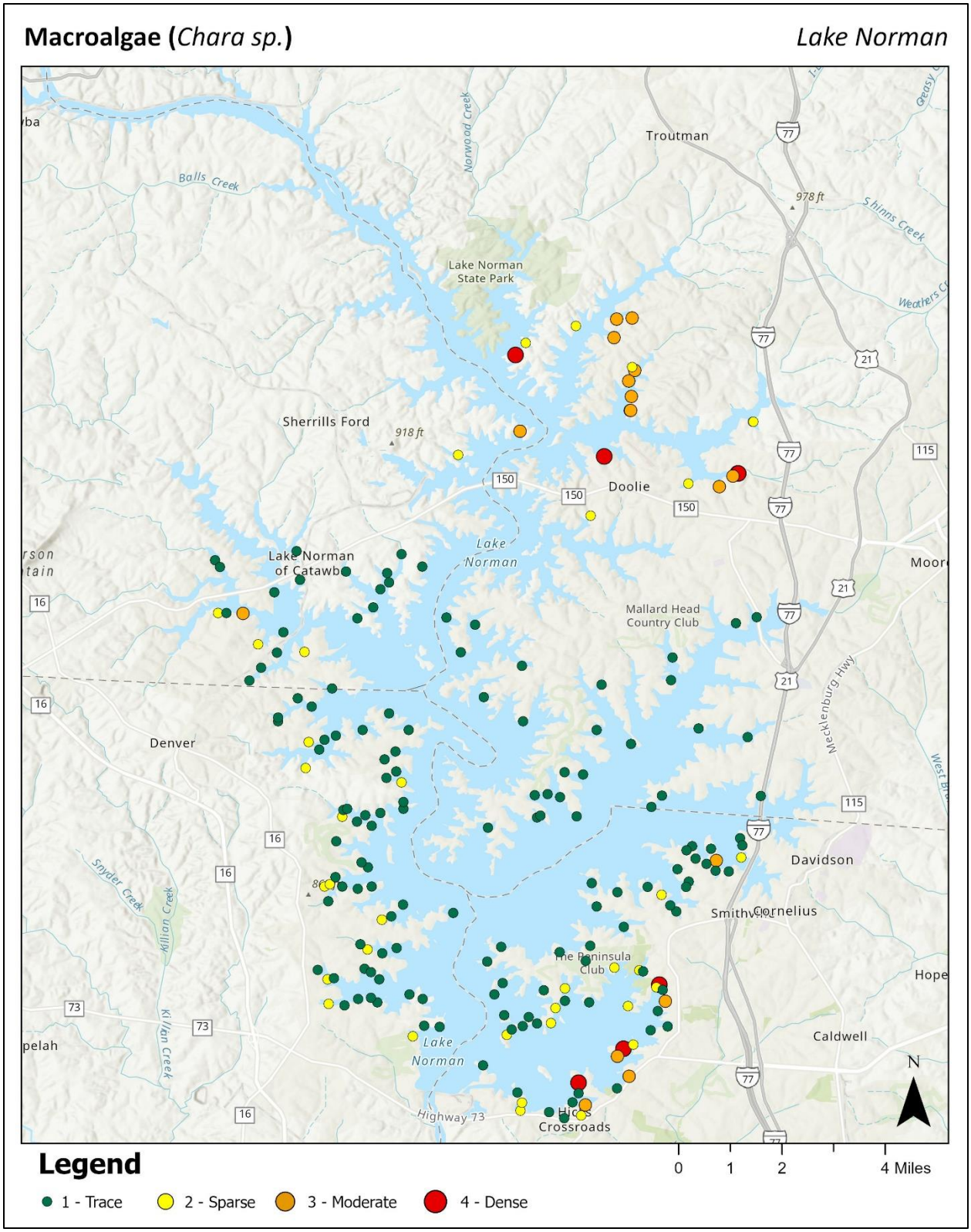

Figure 13: Macroalgae (*Chara*) sites and abundance ratings documented during the 2024 Lake Norman survey.

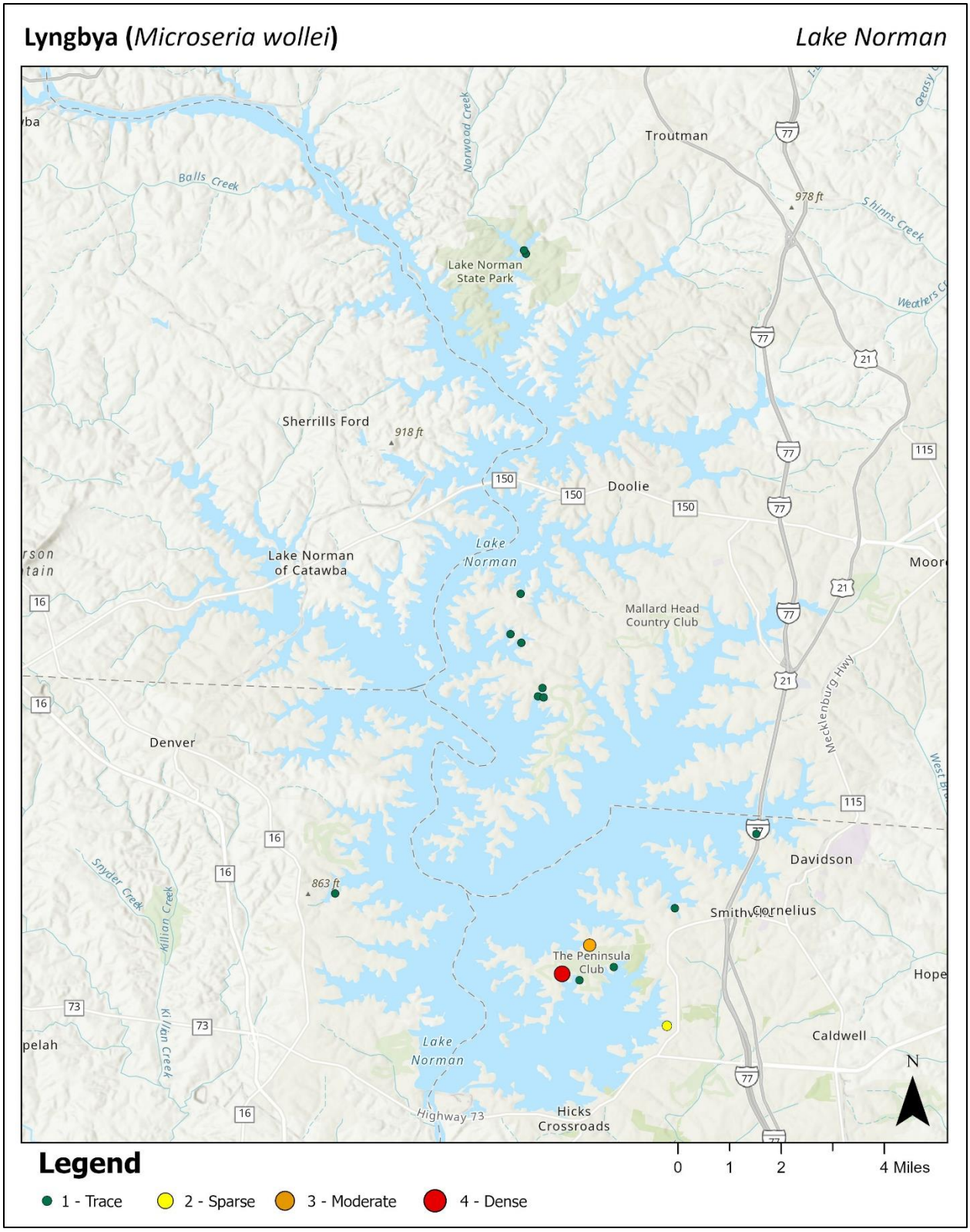

Figure 14: Lyngbya sites and abundance ratings documented during the 2024 Lake Norman survey.

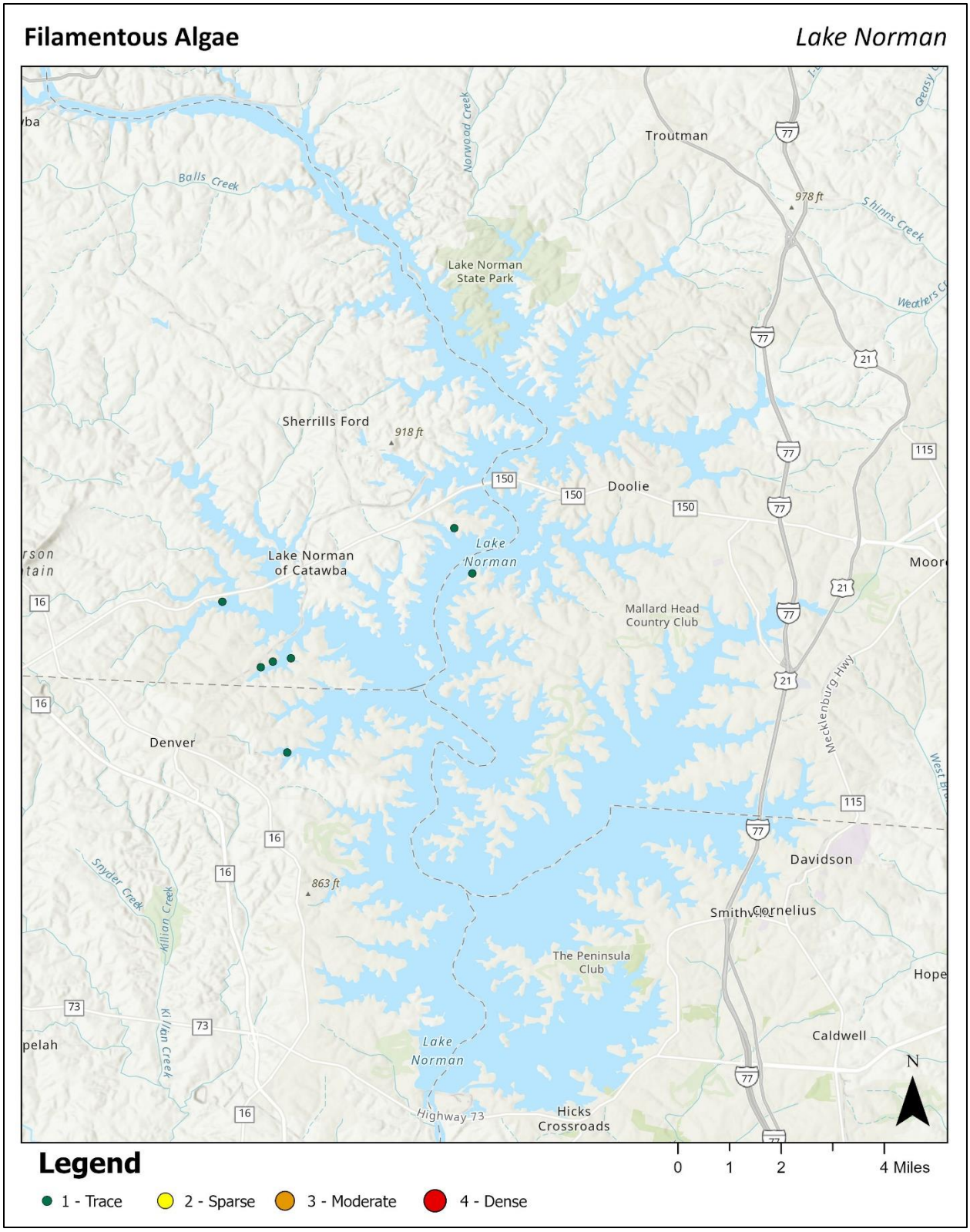

Figure 15: Filamentous algae sites and abundance ratings documented during the 2024 Lake Norman survey.

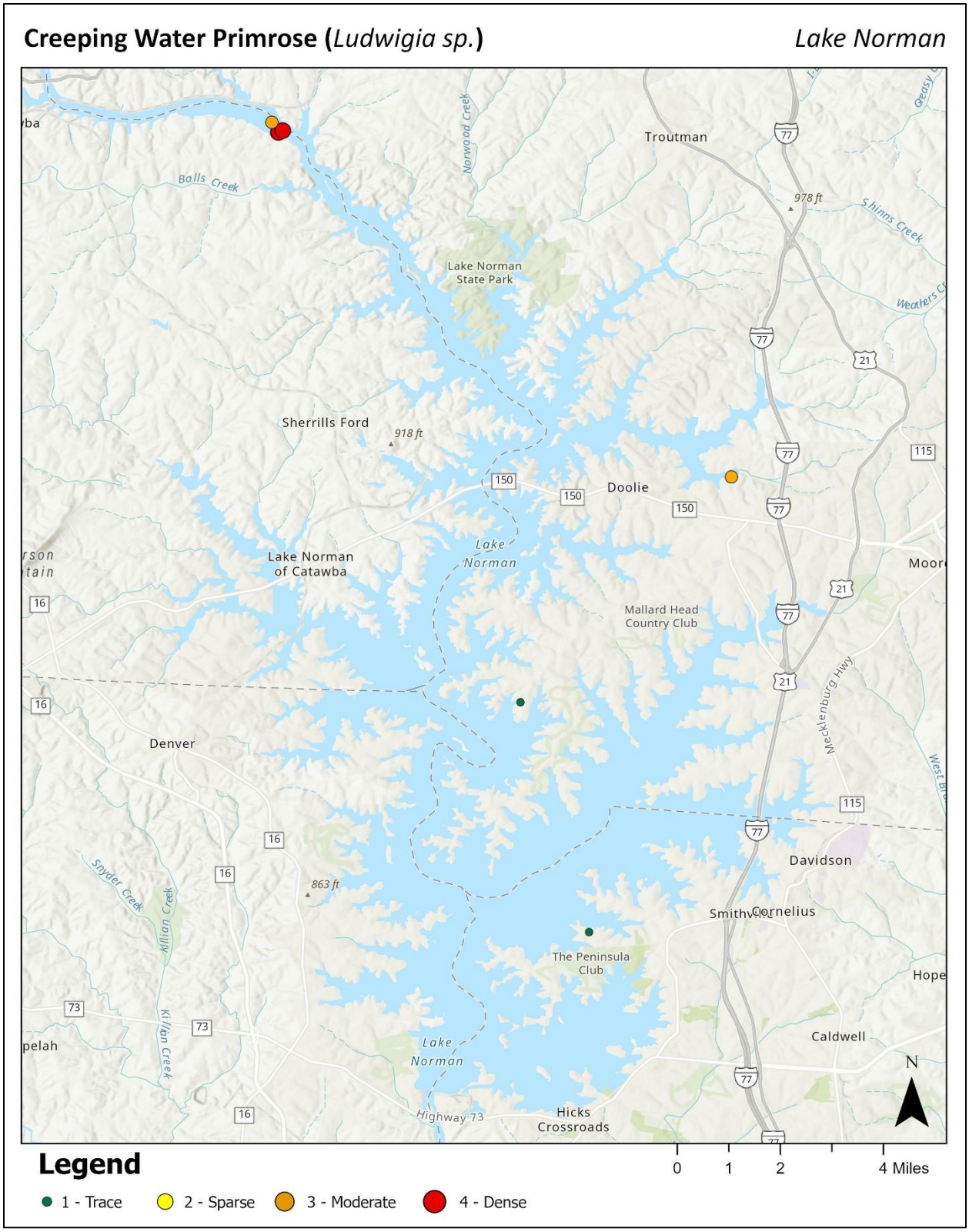

Figure 16: Primrose sites and abundance ratings documented during the 2024 Lake Norman survey.

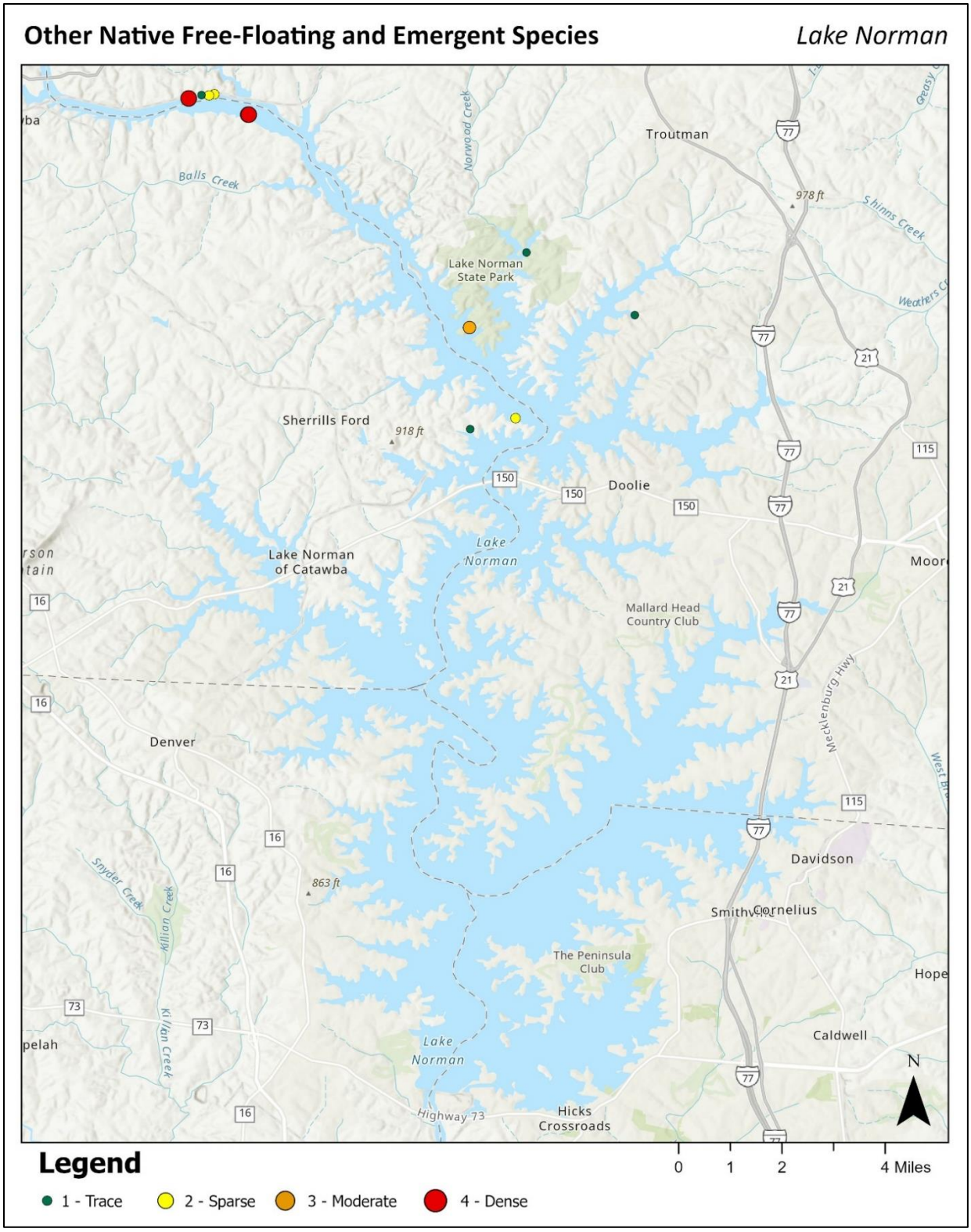

Figure 17: Other native free-floating and emergent species (*Lemna minor*, *Justicia americana*, *Nuphar advena*, and *Nelumbo lutea*) sites and abundance ratings documented during the 2024 Lake Norman survey.

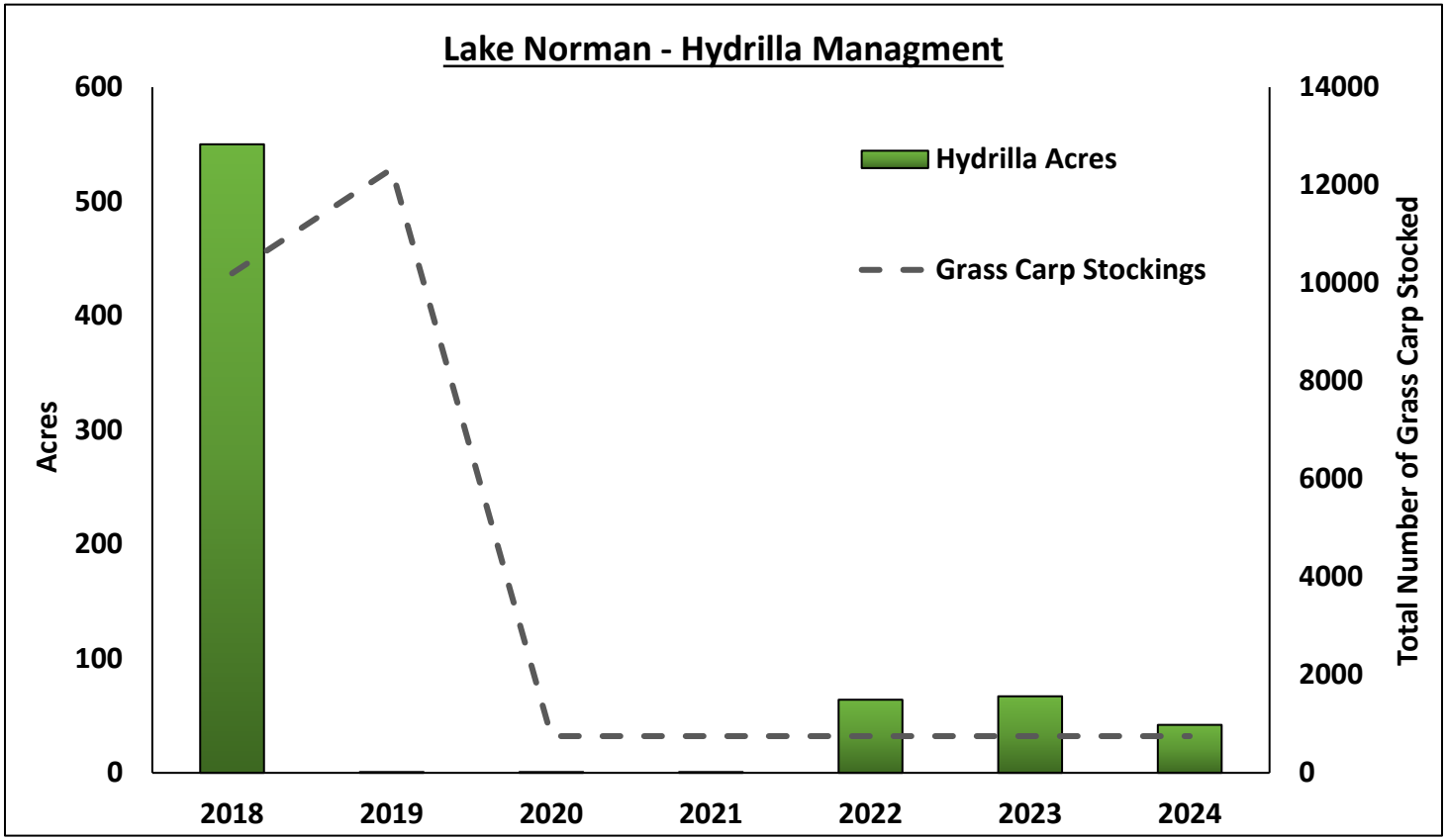

Figure 18: Estimated standing acreage (bars) of hydrilla and total number of grass carp stocked (line) in Lake Norman between 2018 and 2024.

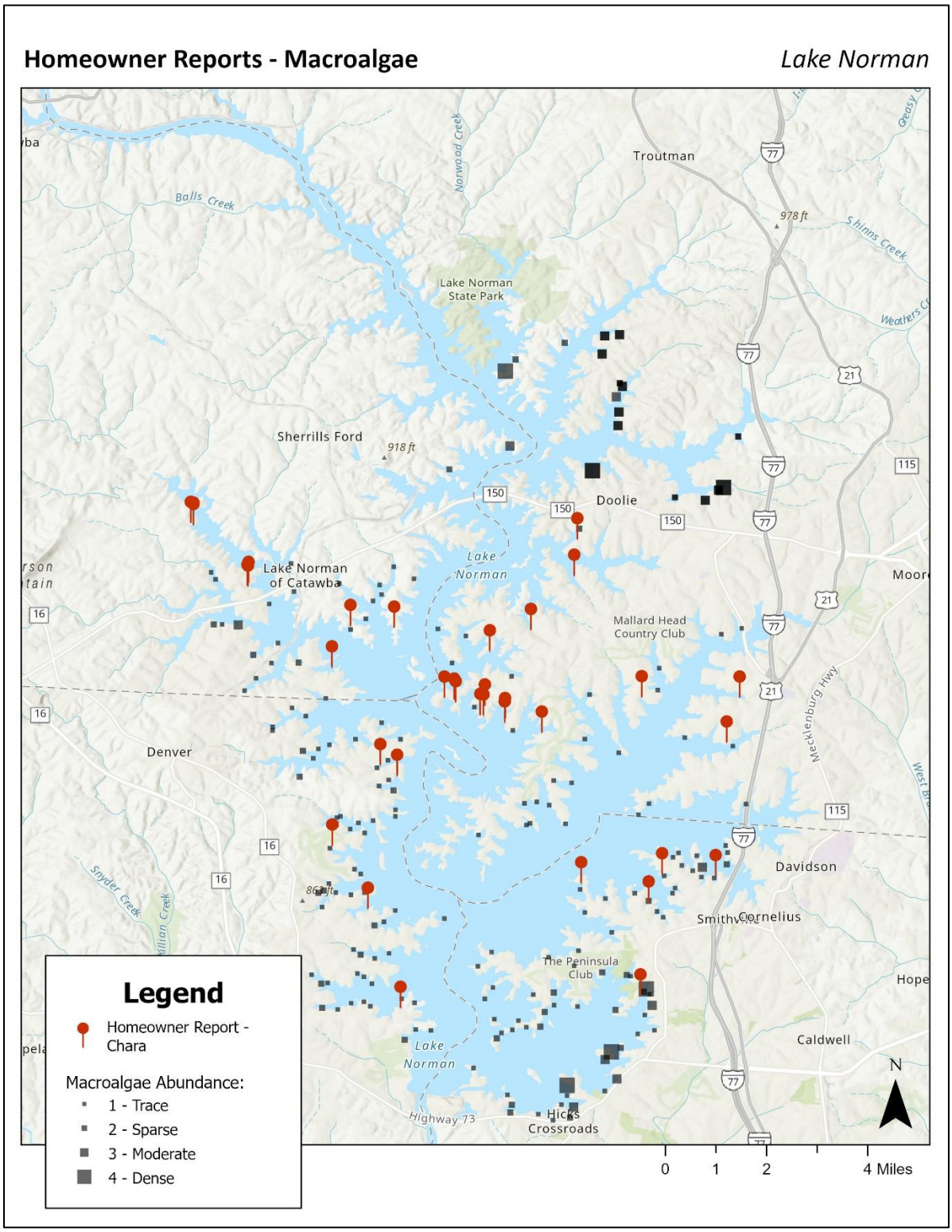

Figure 19: Locations of 2024 macroalgae (*Chara sp.*) homeowner reports at Lake Norman submitted to the Duke Energy Aquatic Plant Reporting Form and sites in which macroalgae was present during the 2024 Lake Norman survey.

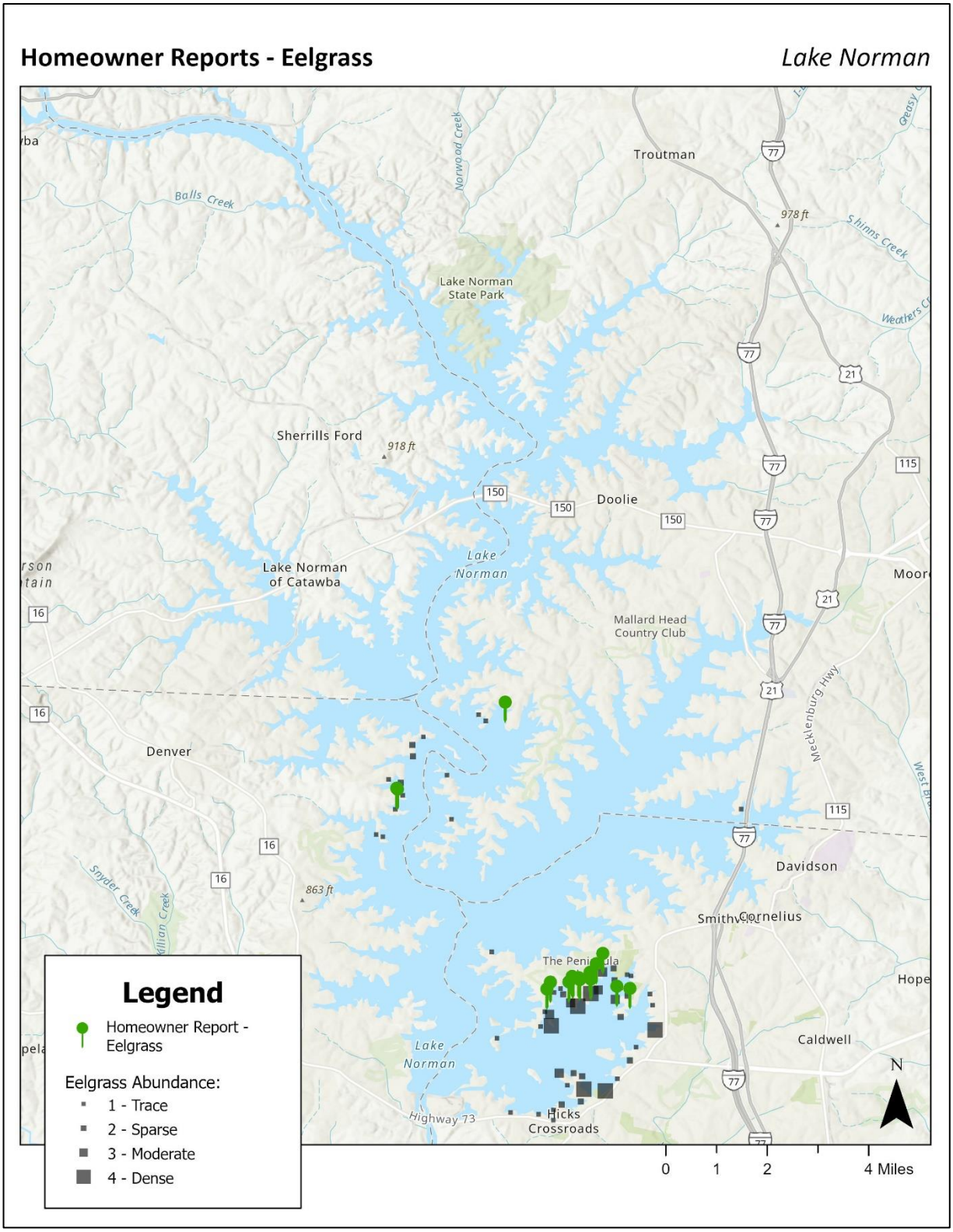

Figure 20: Locations of 2024 eelgrass (*Vallisneria neotropicalis*) homeowner reports at Lake Norman submitted to the Duke Energy Aquatic Plant Reporting Form and sites in which eelgrass was present during the 2024 Lake Norman survey.

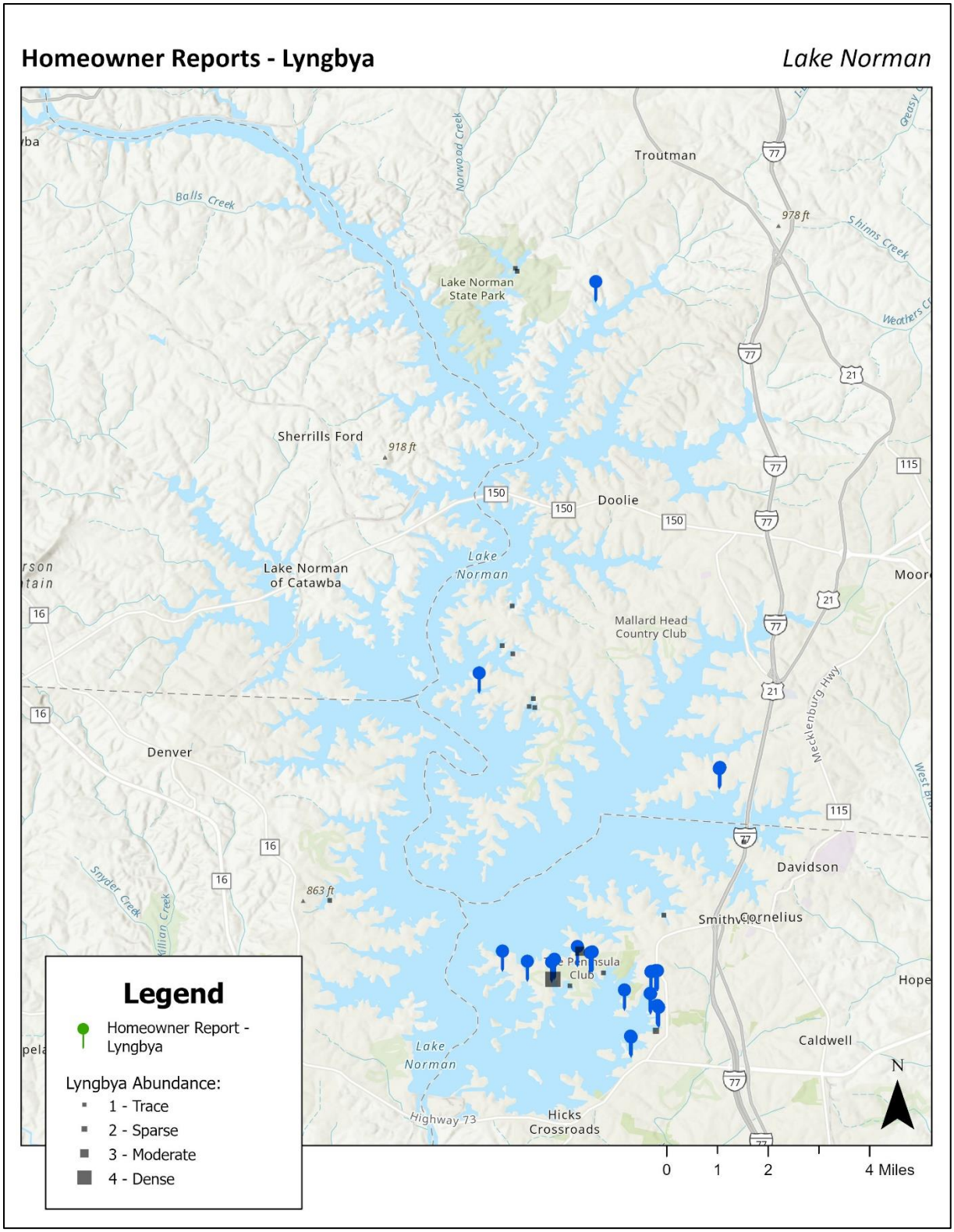

Figure 21: Locations of 2024 lyngbya (*Microseria wollei*) homeowner reports at Lake Norman submitted to the Duke Energy Aquatic Plant Reporting Form and sites in which lyngbya was present during the 2024 Lake Norman survey.