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memorandum

date	November 2, 2026
to	Mark Rosenkranz, Aquatic Insight LLC
cc	Black Lake Special District
from	Rich Miller and Toni Pennington
subject	Black Lake bathymetry and aquatic plant survey results

Black Lake bathymetry, sediment characteristics, and aquatic plant community

Summary and key findings

- Lake morphometry, sediment characteristics, and the aquatic plant community in Black Lake, Thurston, County, Washington were assessed during June 2026.
- Methods employed included hydroacoustic surveys, aerial imagery analysis, point-intercept plant grab sampling, and shoreline observations.
- Hydroacoustic bathymetry modeling produced accurate depth predictions (mean RMSE = 0.83 ft; mean $R^2 = 0.985$), supporting development of updated bathymetric maps, contour maps, and area-volume relationships.
- Black Lake has a surface area of approximately 572 acres, a volume of approximately 10,500 acre-feet, a mean depth of 18.4 feet, and a maximum depth of 30.1 feet at the surveyed water surface elevation
- Four acoustically distinct bottom types were identified. Bottom-type distributions were strongly associated with water depth and likely represent vegetated substrates, mixed mineral sediments, organic-rich depositional sediments, and localized hard-bottom areas. These interpretations remain preliminary as sediment samples were not collected for verification.
- The maximum colonization depth (MCD) for aquatic vegetation was estimated at 13.7 feet.
- Littoral habitat comprises approximately 130.5 acres, representing 22.5% of the lake surface area.
- Floating-leaf plant beds occupied approximately 17.4 acres, representing 13.3% of the littoral zone and about 3% of the lake surface area.

- Sixteen aquatic plant taxa were identified during the point-intercept survey.
- Slender naiad (*Najas flexilis*) was the most widespread submerged species, occurring at 78% of survey sites and dominating the native submerged plant community.
- Fragrant water lily (*Nymphaea odorata*) occupies extensive nearshore habitat and represents the dominant floating-leaf invasive species.
- Curly-leaf pondweed (*Potamogeton crispus*), a Washington Class C noxious weed, was detected at only three survey sites (1.5% frequency of occurrence).
- No Eurasian watermilfoil (*Myriophyllum spicatum*) was detected during the survey.
- Shoreline mapping documented extensive distributions of yellow flag iris (*Iris pseudacorus)*, fragrant water lily, yellow pond lily (*Nuphar polysepala*), and hardstem bulrush (*Schoenoplectus acutus*) around the lake margin.
- Aquatic plant diversity was relatively low, with an average of 2.11 species per sample location, reflecting the dominance of a small number of common species across the littoral zone.
- Results indicate a lake dominated by native submerged vegetation, extensive floating-leaf communities along protected shorelines, limited occurrence of invasive submerged plants, and well-developed littoral habitats concentrated in water depths less than approximately 14 feet.

Hydroacoustic survey and analysis

Data collection

Hydroacoustic data were collected to assess, 1) lake basin morphometry, 2) sediment characteristics, and 3) submerged plant bed characteristics. Data was collected during the week of June 16-19, 2026, using a BioSonics DTX Scientific Echosounder equipped with a 6.7° single-beam 430 kHz transducer. Data were acquired at a sampling frequency of 7 ping per second with a -80 dB detection threshold and a transmit pulse duration of 0.1 ms, resulting in approximately 4.2 samples per pulse and a sample spacing of approximately 1.8 cm. Surveys were conducted at vessel speeds below 5 mph. Position data were provided with an EOS Arrow 100 GPS receiver with sub-meter accuracy. Data were collected along survey tracks that followed the shoreline as close as possible along with parallel transects across the interior of the lake (Figure 1). Transect spacing was approximately 125 ft along the shoreline, where bottom slopes were steeper and aquatic vegetation was present, and 250 ft in the central portion of the lake, where bottom slopes were gentler and sediments were unvegetated.

The transducer was mounted so the acoustic transducer face was positioned 0.25 m below the water surface. Data collection began 0.10 m below the transducer face, providing an effective measurement range from 0.35 m below the water surface to a maximum depth of 10 m. During the survey, the water surface elevation was 124.8 ft (NAVD88) as determined by measurement of the distance from a reference point on a metal piling at the Black Lake Public Boat Launch to the water surface and corrected using Thurston County reference points. This elevation was assumed to represent typical summer water-level conditions. Distinct water marks were observed approximately 13 inches above the water surface, while fainter water marks were visible up to 18 inches above the water surface, indicating evidence of higher recent water levels.

The sonar data were supplemented with shoreline elevations derived from LiDAR data, as well as LiDAR points located within 1 foot vertically above the shoreline. The LiDAR data was collected between June 4 and July 2, 2011, and was assumed to be typical summer water level conditions. These supplemental data were incorporated to improve modeling of the nearshore bathymetry and the shoreline transition zone.

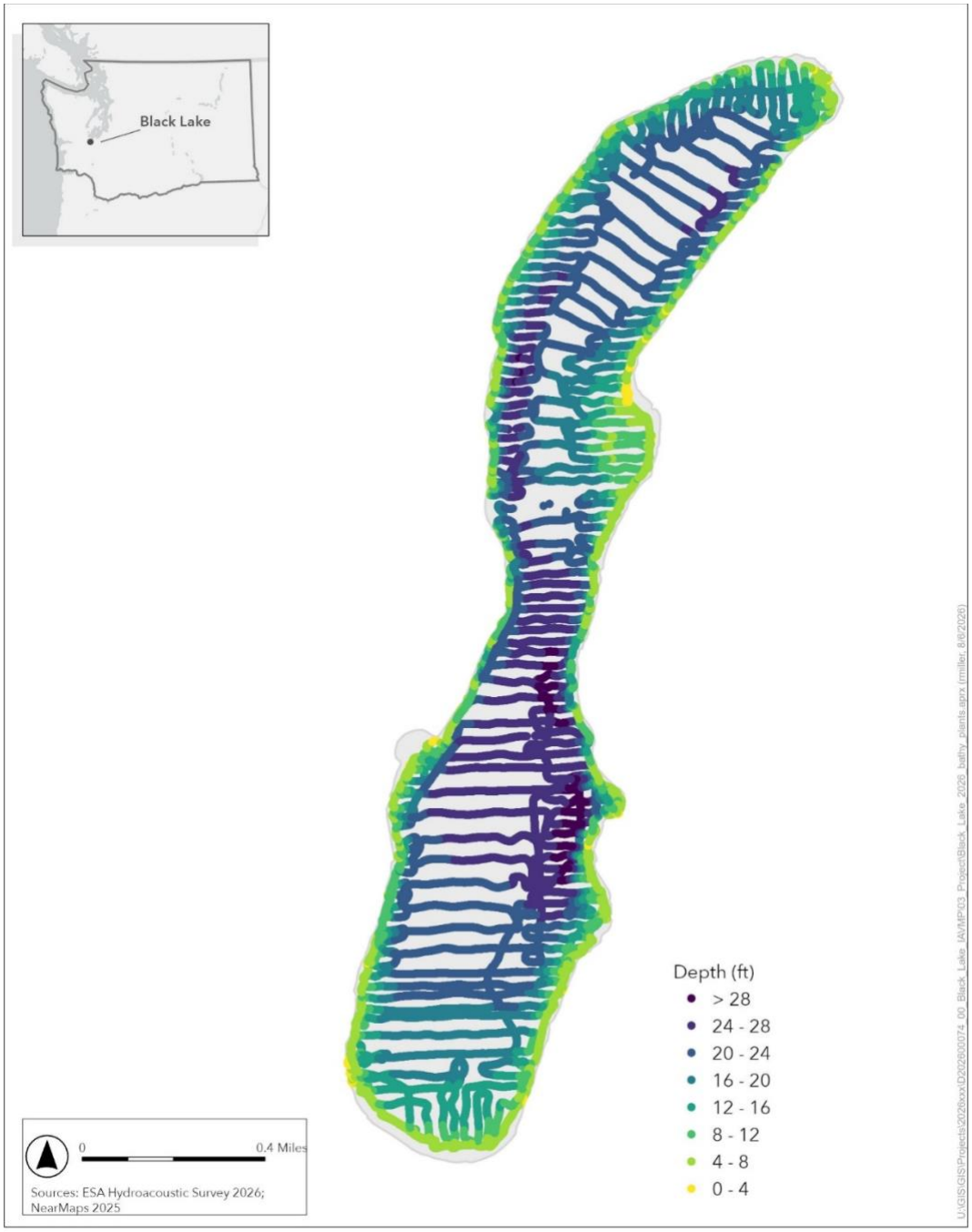


Figure 1. Hydroacoustic survey tracks and measured water depths collected in Black Lake, 2026.

Data processing and analysis

Initial processing

Data were processed using BioSonics Visual Aquatic Post-Processing and Data Visualization Software to identify bottom depth, the top of the aquatic plant canopy, and sediment characteristics at each sample

location. Bottom depths were estimated using automated processing algorithms and then visually reviewed and edited as needed, primarily in areas with dense aquatic vegetation where the sediment-water interface could not be reliably distinguished automatically. Location, bottom depth, canopy height and sediment characteristics were exported as a comma-separated value (.csv) file for further processing. Depth of each point was corrected for transducer draft. Elevations for each observation were calculated relative to the water surface elevation at the time of data collection (124.8 ft). Points with invalid sonar or GPS observations were removed. All data were projected into the NAD83(HARN) Washington State Plane South coordinate system (US survey feet), EPSG:2927.

Bathymetric surface development

Bathymetry was modeled using a Bayesian spatial interpolation framework based on the Integrated Nested Laplace Approximation and Stochastic Partial Differential Equation (INLA-SPDE) approach. The model integrated three primary data sources: (1) hydroacoustic sonar observations collected during the 2026 survey, (2) LiDAR-derived nearshore elevations converted to water depths using the observed lake water-surface elevation, and (3) shoreline constraints represented by regularly spaced points assigned a depth of 0 ft. Model development and prediction were performed in R using the R-INLA package. The combined dataset enabled continuous bathymetric surface generation while preserving shoreline boundaries and improving representation of shallow-water areas where direct sonar measurements were limited. To reduce spatial clustering and computational burden, sonar and LiDAR observations were thinned to fixed spatial resolutions (12-ft and 30-ft grids, respectively). A finite-element mesh was generated around the lake shoreline, and depths were modeled with a Gaussian Matérn spatial field (SPDE) plus a linear easting/northing trend. The SPDE model was fit using Integrated Nested Laplace Approximation (INLA), and depth estimates were subsequently predicted across a 10-ft resolution grid covering the lake.

Bathymetric model accuracy was assessed using 100 repeated spatial holdout iterations. In each iteration, a randomly selected 500-foot segment was withheld from every sonar transect and excluded from model calibration. The bathymetric model was then refit using the remaining sonar observations together with shoreline and LiDAR-derived elevation constraints, and depths were predicted at the withheld locations. Model performance was strong, yielding a mean Root Mean Square Error (RMSE) of 0.83 ± 0.24 ft, a Mean Absolute Error (MAE) of 0.44 ± 0.10 ft, a mean bias of −0.10 ± 0.11 ft, and a coefficient of determination (R^2) of 0.985 ± 0.015. These results indicate excellent predictive accuracy and minimal systematic error across the area surveyed.

Resulting products include a bathymetric raster and contours derived from the raster. The bathymetric raster was smoothed using a focal median filter and converted into 2-ft depth contours. The bathymetric surface and contours were exported for mapping in ArcGIS Pro (Figure 2). Following contour generation, minor manual edits were made to the 2- and 4-ft contours where necessary to prevent contours from intersecting the shoreline. In addition, the 22- and 24-ft contours were adjusted within a small area along the west-central shoreline where data density was insufficient to support reliable model predictions.

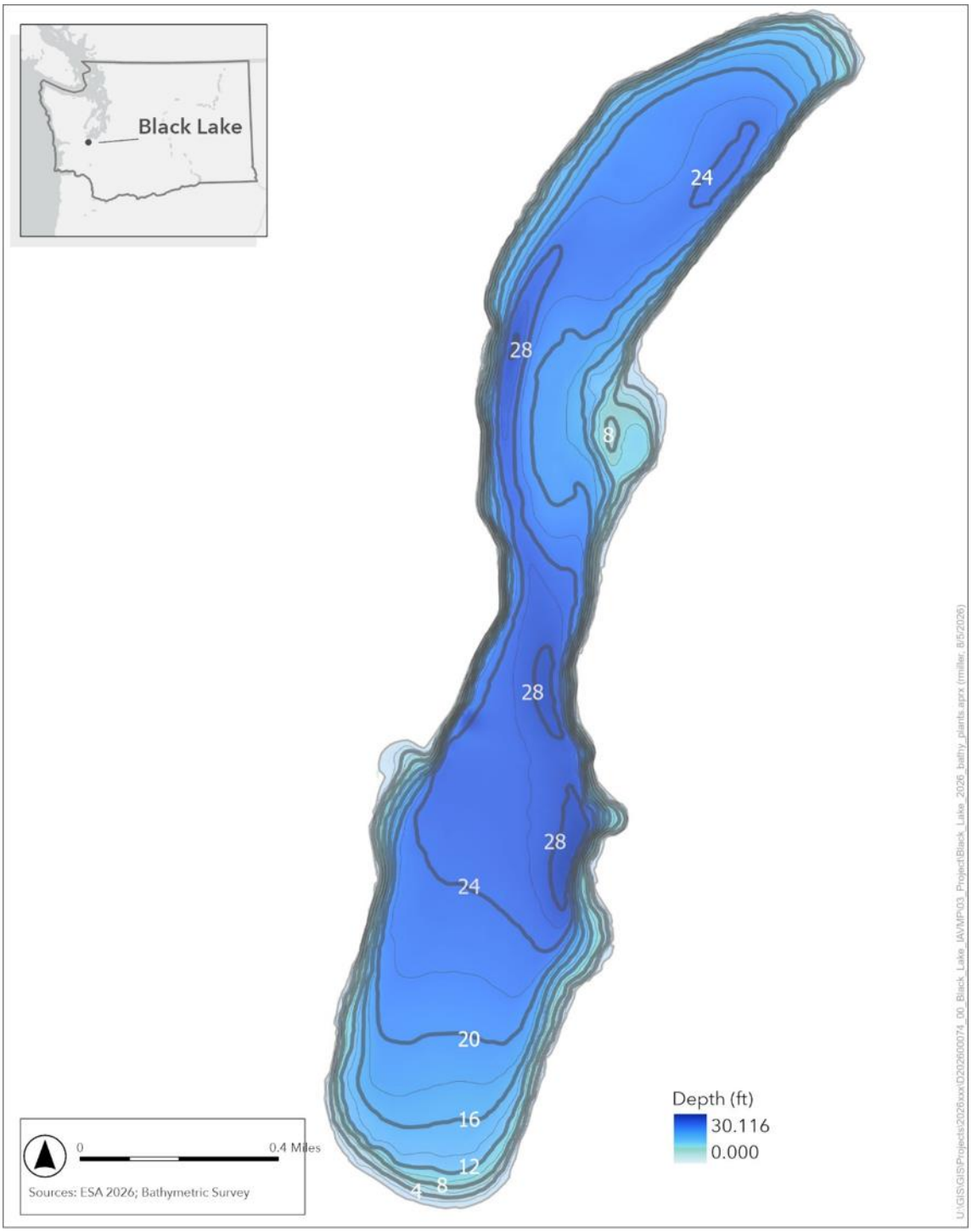


Figure 2. Black Lake two-foot bathymetric contours and bathymetric raster surface derived from the 2026 hydroacoustic survey at a water surface elevation of 124.8 ft.

Bathymetric summary metrics (Table 1), area-depth relationships (Table 2, Figure 3), and storage-depth relationships (Table 2, Figure 3) were calculated from the final bathymetric surface.

Table 1
Black Lake morphometric statistics derived from hydroacoustic survey data, June 16-19, 2026.

Metric	Value at 124.8 ft WSEL
Surface area	572 ac (232 ha)
Volume	10,500 ac-ft (12.95 MCM)
Mean depth	18.4 ft (5.61 m)
Maximum depth	30.1 ft (9.17 m)

WSEL = Water surface elevation

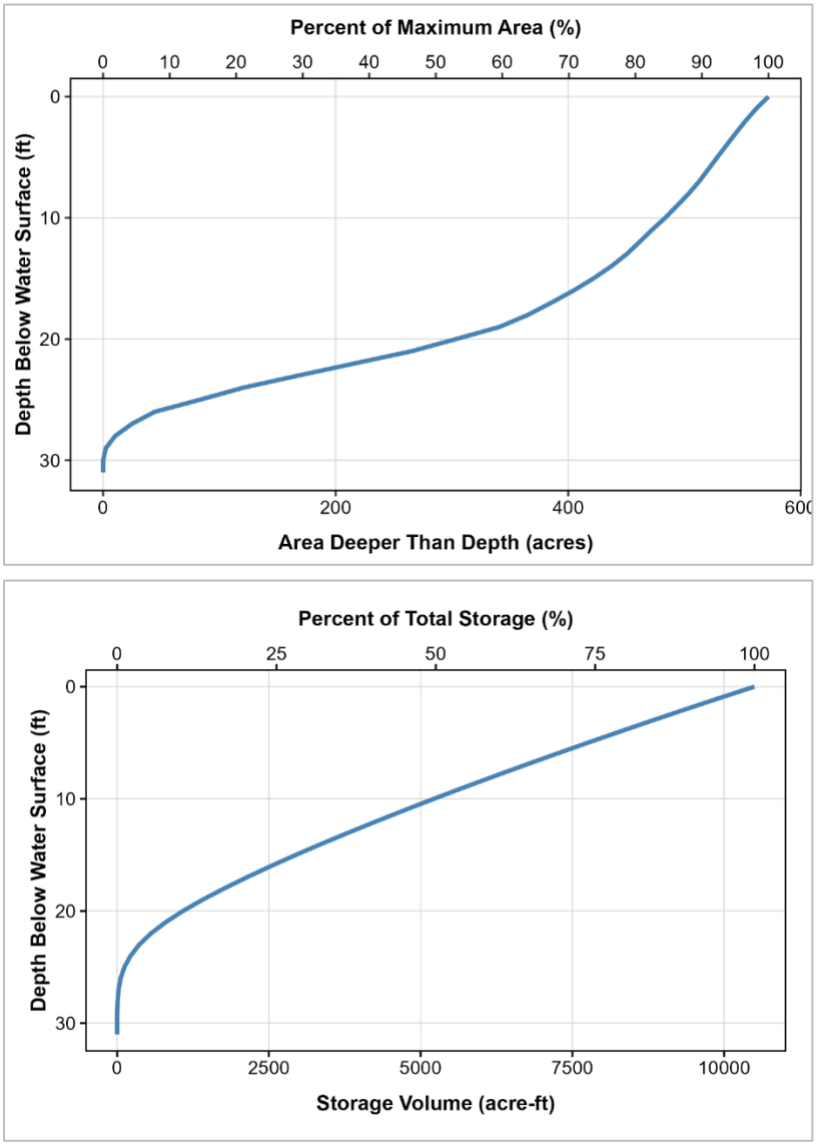


Figure 3. Black Lake Black Lake surface area – depth plot (top) and storage – depth plot (bottom).

Table 2
Lake Surface Area and Volume as a Function of Depth. Green shading indicates the littoral zone identified from the depth-aquatic plant occurrence analysis.

Depth below full pool		Surface area			Volume		
feet	meters	acres	hectares	% Area Remaining	acre-feet	Millions of cubic meters	% Storage Remaining
0	0.0	572	232	100	10,500	12.95	100
1	0.3	562	227	98	9,933	12.25	95
2	0.6	553	224	97	9,376	11.57	89
3	0.9	544	220	95	8,828	10.89	84
4	1.2	536	217	94	8,287	10.22	79
5	1.5	528	214	92	7,755	9.57	74
6	1.8	520	211	91	7,231	8.92	69
7	2.1	513	207	89	6,714	8.28	64
8	2.4	504	204	88	6,206	7.65	59
9	2.7	494	200	86	5,707	7.04	54
10	3.0	483	196	84	5,218	6.44	50
11	3.4	472	191	82	4,741	5.85	45
12	3.7	461	187	81	4,274	5.27	41
13	4.0	450	182	78	3,818	4.71	36
14	4.3	437	177	76	3,374	4.16	32
15	4.6	422	171	74	2,945	3.63	28
16	4.9	405	164	71	2,531	3.12	24
17	5.2	386	156	67	2,136	2.64	20
18	5.5	366	148	64	1,761	2.17	17
19	5.8	341	138	59	1,407	1.74	13
20	6.1	304	123	53	1,084	1.34	10
21	6.4	265	107	46	800	0.99	8
22	6.7	217	88	38	557	0.69	5
23	7.0	168	68	29	364	0.45	3
24	7.3	121	49	21	221	0.27	2
25	7.6	83	34	15	119	0.15	1
26	7.9	44	18	8	58	0.07	1
27	8.2	25	10	4	24	0.03	< 1
28	8.5	10	4	2	7	0.01	< 1
29	8.8	2	1	< 1	1	< 0.01	< 1
30	9.1	< 1	< 1	< 1	< 1	< 0.01	< 1

Source: ESA, June 16-19, 2026, hydroacoustic survey analysis.

Hydroacoustic sediment characterization

Bottom typing was performed using the BioSonics Visual Habitat software package and the bottom-classification algorithms incorporated within the BioSonics DTX echosounder processing workflow. Bottom-type classifications were derived from the acoustic characteristics of the bottom echo, including measures of echo strength, echo shape, and other attributes of the returned signal associated with substrate hardness and roughness (Figure 4). Each acoustic observation was assigned membership values for four bottom classes, representing the degree of similarity between the observed acoustic response and each class.

For each observation, the class with the highest membership value was assigned as the dominant bottom type. Acoustic classifications were exported from BioSonics software and spatially summarized in R. To reduce small-scale noise and improve visualization, point classifications were aggregated to a 25-foot grid and generalized using a neighborhood majority filter. Resulting bottom-type polygons therefore represent generalized acoustic habitat zones rather than discrete substrate boundaries.

Because no sediment grab samples or direct substrate observations were collected during the survey, bottom-type interpretations should be considered preliminary. Assigned substrate descriptions are based on observed depth distributions, spatial patterns, and general relationships between acoustic bottom-return characteristics and substrate composition.

BioSonics bottom typing identified four acoustically distinct bottom classes that were strongly associated with water depth (Table 3). Type 3 was the dominant mapped bottom type, occupying 46% of the lake area, followed by Type 1 (29%), Type 2 (24%), and Type 4 (0.6%). Mean depths ranged from 10.9 ft for Type 2 to 22.6 ft for Type 1 (Figure 5). Analysis of variance indicated strong separation among bottom classes ($F = 5336$, $p < 0.001$), and all pairwise class comparisons were significant (Tukey HSD, $p < 0.001$). Classification confidence was moderate to high for all classes (mean confidence = 0.62-0.72), suggesting that the observed patterns represent persistent acoustic differences rather than random variability. Confidence values represent the maximum class-membership value assigned by the BioSonics classification algorithm and provide an indication of classification certainty (Table 3).

Type 1 sediments were concentrated within deeper depositional areas and is consistent with expectations for soft, organic-rich sediments such as gyttja (Figure 6). Type 2 occurred primarily within depths associated with the littoral zone identified by the hydroacoustic vegetation analysis and was concentrated along lake margins where aquatic vegetation was most prevalent. This association suggests that acoustic returns assigned to Type 2 were influenced by vegetation and vegetated sediments. Type 3 occupied nearly half of the lake area and occurred primarily at intermediate depths between the shallow vegetated littoral zone and deeper depositional basins. This pattern is consistent with mixed organic-mineral sediments or consolidated mineral substrates. Because direct sediment samples were not collected, this interpretation remains preliminary. Type 4 was uncommon and occurred as small, isolated patches, consistent with localized areas of relatively hard substrate. Because direct sediment observations were not collected, these interpretations should be regarded as hypotheses based on acoustic response patterns rather than confirmed substrate classifications.

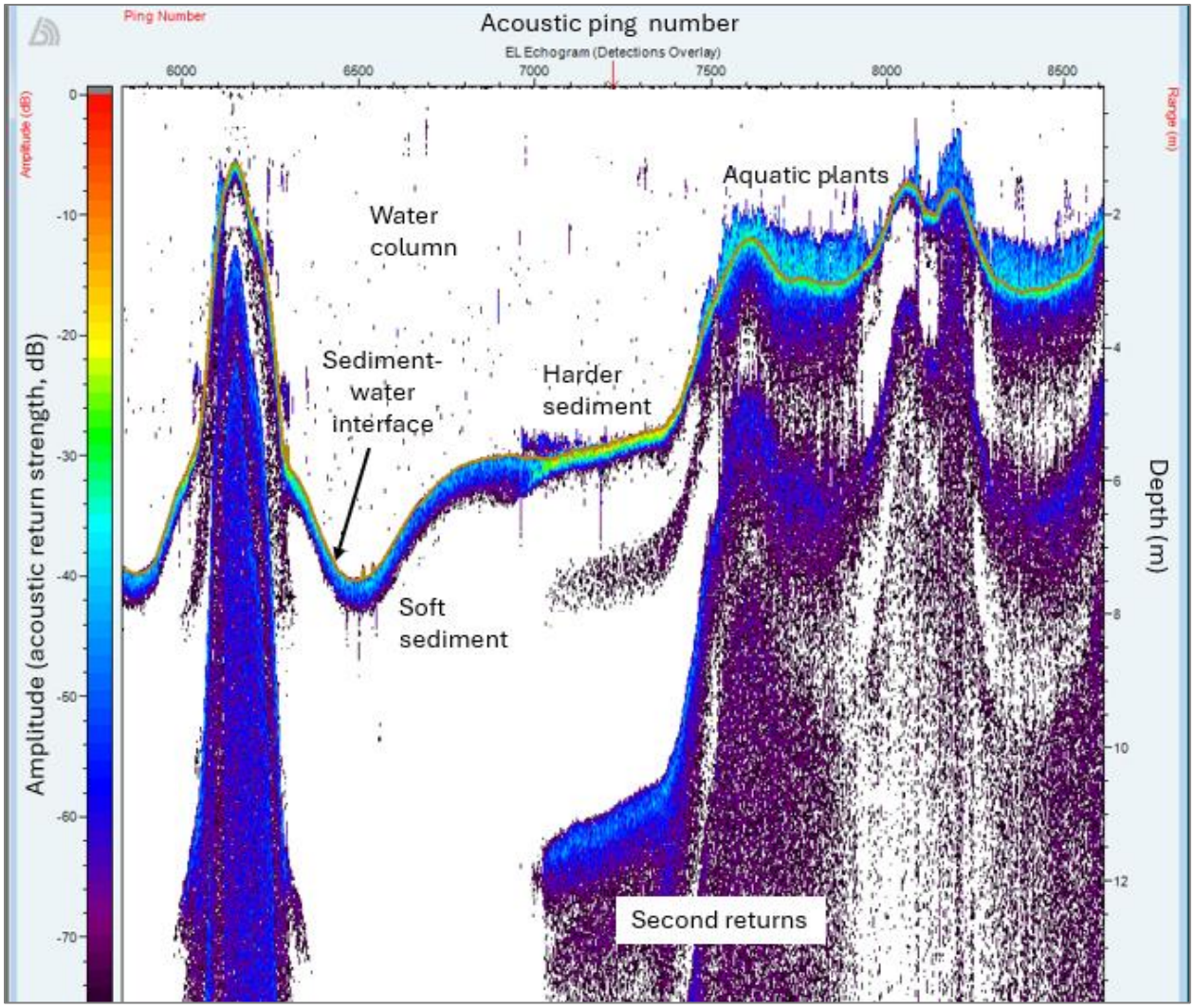


Figure 4. BioSonics echogram of Black Lake showing the sediment–water interface (brown line), acoustic return strength by ping (warmer colors indicate stronger returns), secondary returns, and areas of soft sediment, hard sediment, and aquatic vegetation.

Table 3.
Summary of BioSonics Acoustic bottom types identified in Black Lake, 2026.

Bottom type	Interpreted substrate*	Area (acres)	Area (%)	Mean Depth (ft)	Confidence
Type 1	Organic-rich gyttja	168.7	28.9	22.6	0.72
Type 2	Vegetated substrate	141.8	24.3	10.9	0.71
Type 3	Mineral or mixed sediment	269.8	46.2	17.9	0.65
Type 4	Hard bottom	3.5	0.6	13.9	0.62

* Substrate interpretations are preliminary and based on acoustic signatures, depth distributions, and spatial patterns; interpretations were not independently verified through sediment sampling.

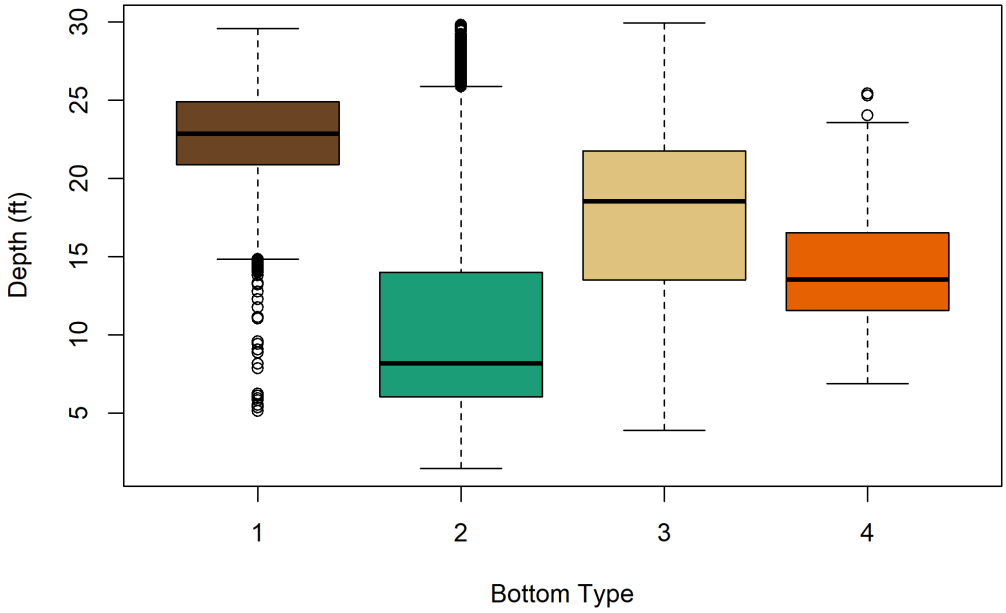


Figure 5. Boxplots of BioSonics acoustic bottom-type classification of Black Lake by depth. Substrate interpretations are preliminary and based on acoustic data and depth relationships. Type 1 likely represents organic-rich gyttja (soft bottom), Type 2 represents vegetated substrate, Type 3 represents mineral or mixed sediment, and Type 4 represents hard bottom. Contours represent 2-ft bathymetric intervals.

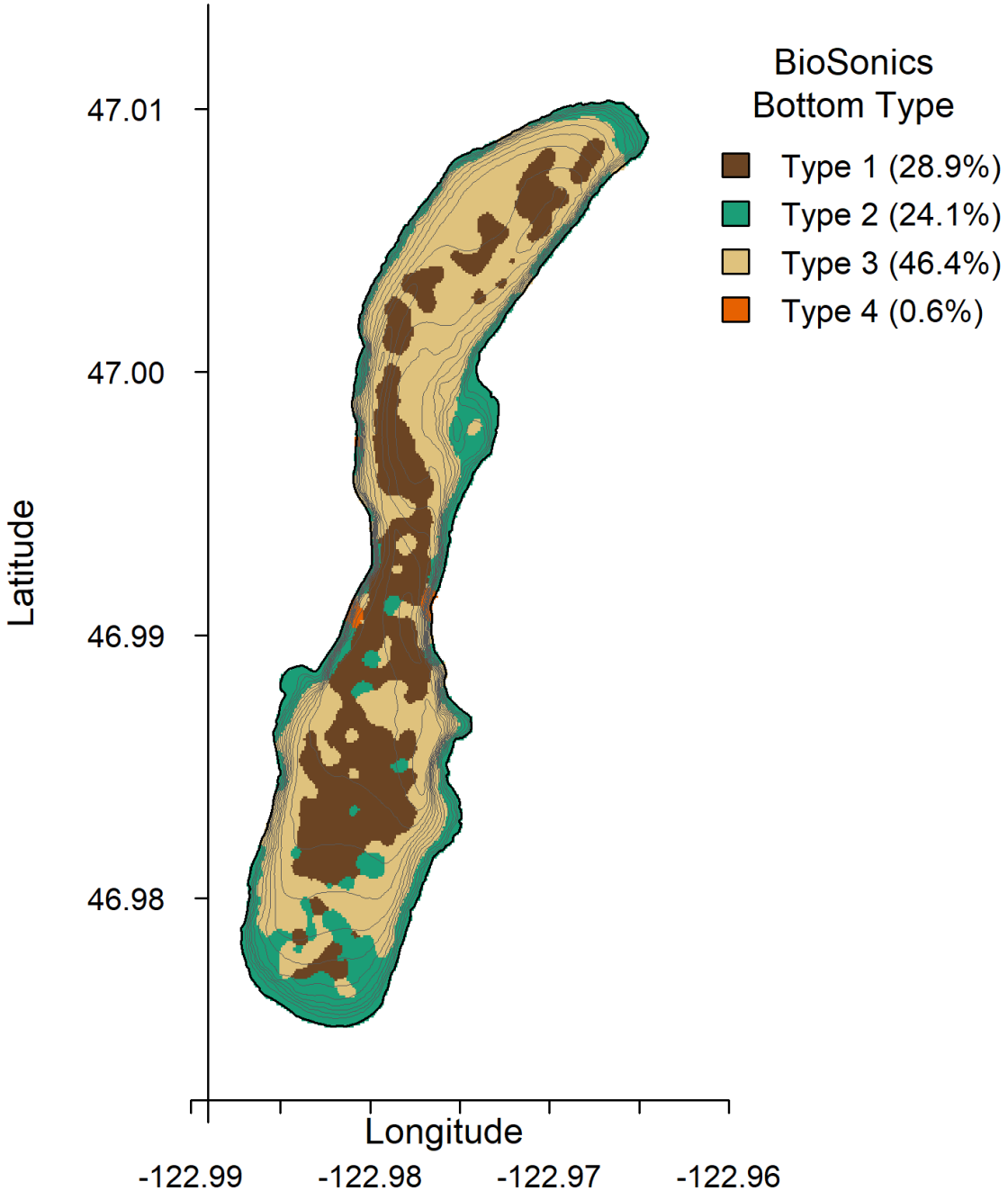


Figure 6. BioSonics acoustic bottom-type classification of Black Lake. Substrate interpretations are preliminary and based on acoustic data and observed depth relationships. Type 1 likely represents organic-rich gyttja (soft bottom), Type 2 represents vegetated substrate, Type 3 represents mineral or mixed sediment, and Type 4 represents hard bottom. Contours represent 2-ft bathymetric intervals.

Hydroacoustic Vegetation Analysis

Hydroacoustic survey data were processed to characterize submerged aquatic vegetation throughout the lake. For each sonar observation, vegetation presence/absence, plant height, and depth to the top of the vegetation canopy were derived from the acoustic returns. The maximum colonization depth (MCD), which defines the outer boundary of the littoral zone where aquatic plants are capable of growth, was estimated at 13.7 ft. MCD was defined as the 95th percentile of water depths where vegetation exceeded 0.1 m (0.33 ft) in height. The area of the littoral zone was 130.5 acres, or 22.5% of the total lake area.

Plant height within the littoral zone was modeled using the same Integrated Nested Laplace Approximation with Stochastic Partial Differential Equations (INLA-SPDE) framework used for bathymetric modeling. The model incorporated observed plant heights, broad-scale spatial trend components, and spatial autocorrelation to predict vegetation height continuously across the lake. Predicted plant heights were subsequently combined with the bathymetric surface to estimate the depth from the water surface to the top of the aquatic plant canopy (canopy top depth).

Model performance was evaluated using 10-fold spatial block cross-validation, which accounts for spatial dependence among neighboring sonar observations and provides a more realistic assessment of predictive accuracy than conventional random cross-validation. The model achieved a root mean square error (RMSE) of 0.73 ft, a mean absolute error (MAE) of 0.56 ft, and negligible bias (-0.02 ft), indicating that predictions were generally accurate and unbiased. The cross-validated coefficient of determination (R^2 = 0.22) suggests that although the model successfully captured broad spatial patterns in vegetation height, substantial fine-scale variability remained unexplained. Overall, the model was well suited for mapping lake-wide vegetation patterns and identifying areas of dense growth, although predictions at individual locations should be interpreted with moderate uncertainty.

Predicted plant heights were mapped throughout the littoral zone (Figure 7). These results were combined with the bathymetric model to estimate the proximity of aquatic vegetation to the water surface, expressed as the vertical distance between the surface and the top of the plant canopy. Canopy top depths were classified according to their potential effect on recreational use of the lake: less than 1 ft was considered high impact, 1 to 3 ft was considered moderate impact, 3 to 6 ft was considered low impact, and greater than 6 ft was considered minimal impact (Figure 8). These classifications provide a practical framework for identifying areas where aquatic vegetation may interfere with boating, swimming, fishing, and other recreational activities. Note, this survey characterizes the plant community on the survey day in June and may not represent plant height later in the growing season.

Table 4.
Black Lake littoral zone summary of Black Lake, 2026.

Metric	Value	Source
Maximum colonization depth	13.7 ft	ESA: June 2026 BioSonics survey and model
Littoral zone area	130.5 ac	ESA: June 2026 BioSonics survey and model
Percent of lake area	22%	ESA: June 2026 BioSonics survey and model
Floating-leaf bed area	17.4 ac	NearMaps: 8/22/25 aerial imagery
Floating-leaf beds as % littoral	13%	NearMaps: 8/22/25 aerial imagery: ESA model

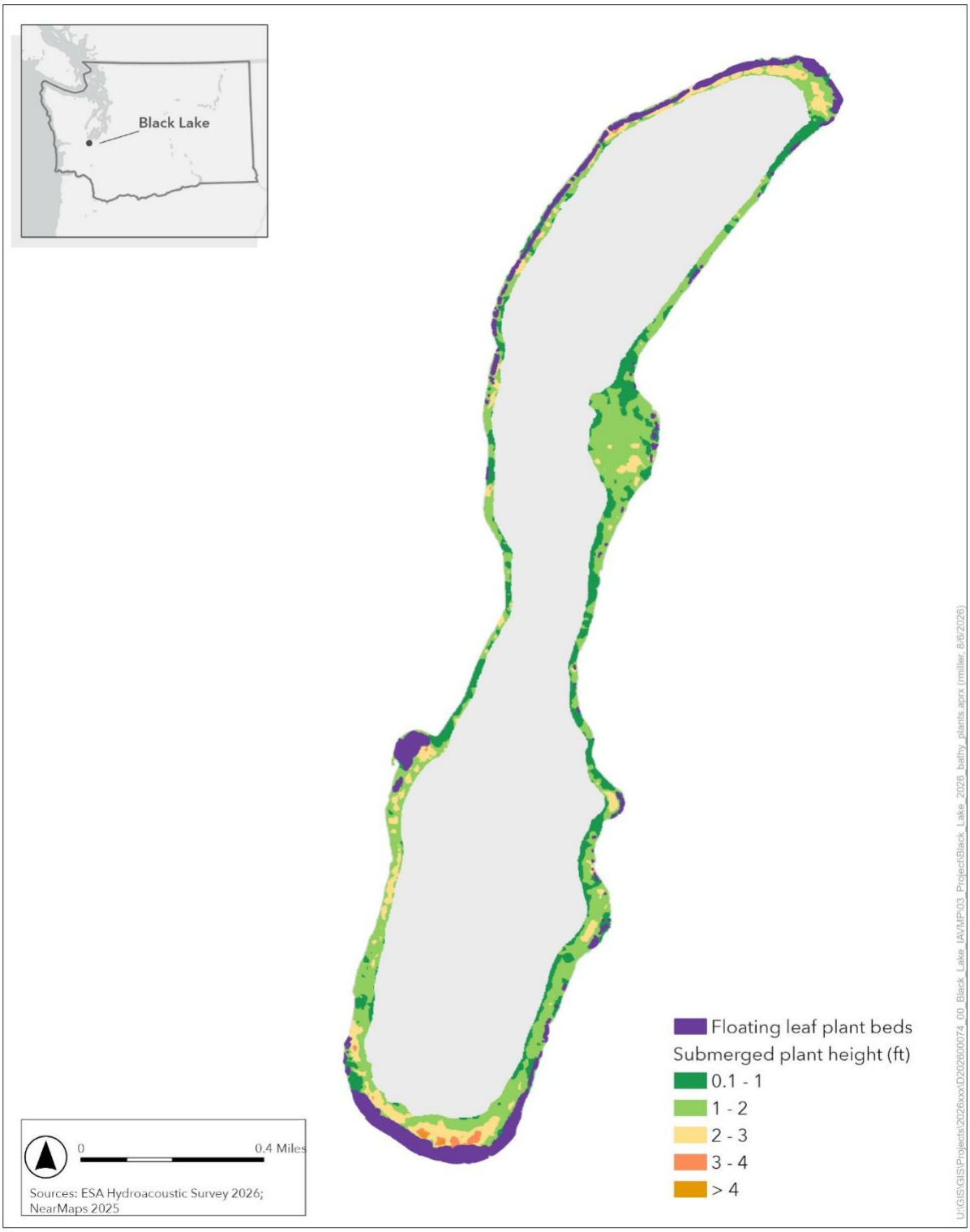


Figure 7. Black Lake aquatic plant canopy height above the sediment (ft) and floating leaf aquatic plant beds. From 2026 hydroacoustic survey and August 22, 2025, NearMaps aerial imagery.

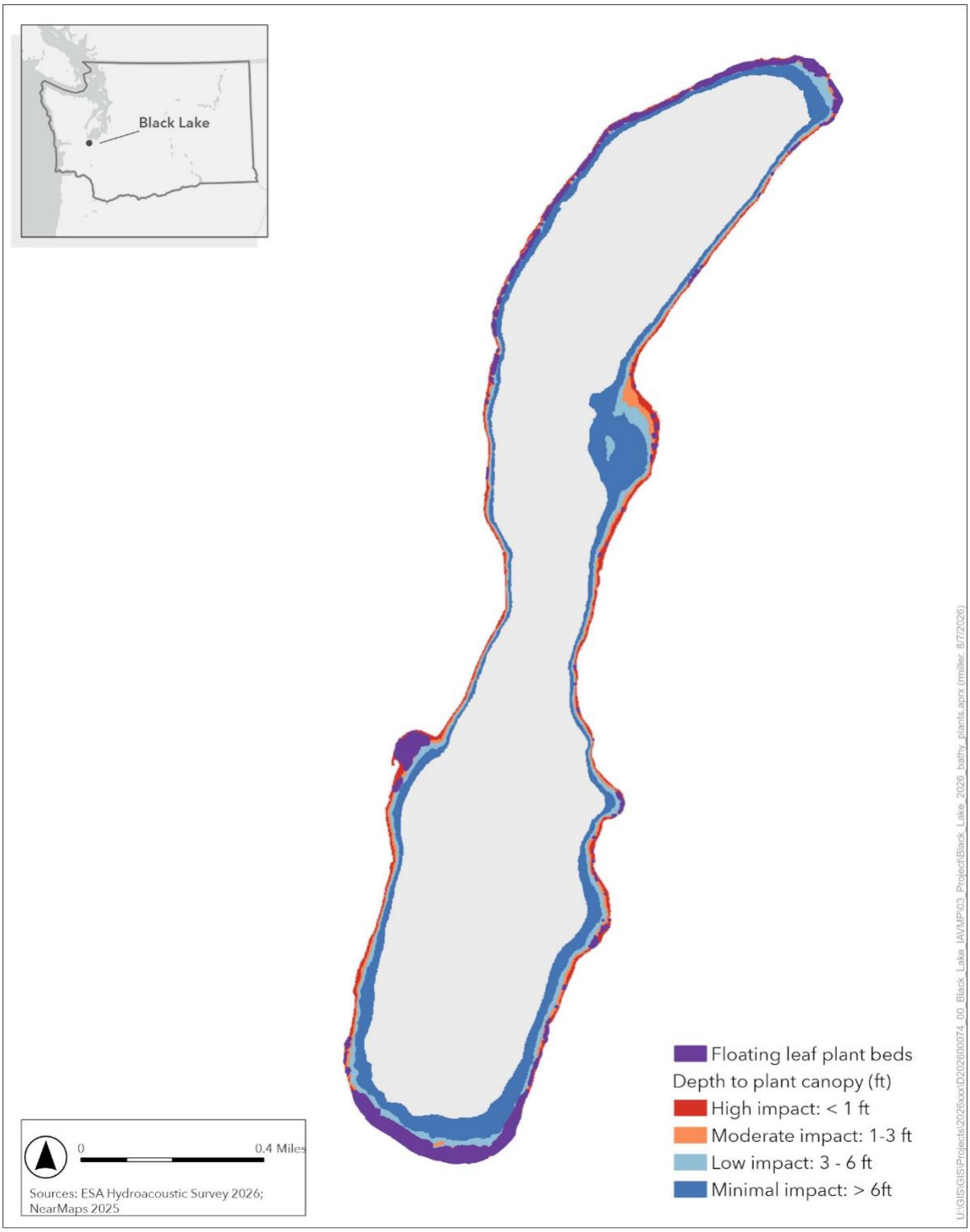


Figure 8. Black Lake distance from the water surface to the aquatic plant canopy height in the littoral zone along with the floating leaf aquatic plant beds. From 2026 hydroacoustic survey and August 22, 2025, NearMaps aerial imagery.

Grab sample plant survey

An aquatic plant survey was conducted in June 2026 using a systematic grid-based sampling design with 200 survey points spaced at approximately 150 ft intervals throughout the littoral zone. Aquatic vegetation was sampled at each point using a double-sided thatch rake attached to a graduated pole. The rake was lowered to the lake bottom, twisted 360 degrees, retrieved through the water column, and all plant material collected on the rake was identified to the lowest practical taxonomic level.

For each species collected, abundance was recorded using a semi-quantitative rating system based on the volume of plant material present on the rake: sparse (1), moderate (2), and dense: near 100% coverage of the rake tines (3). Water depth was recorded at each sampling location using the graduated pole. All sampling locations, species records, abundance ratings, and depth measurements were recorded electronically using ArcGIS Field Maps.

Frequency of occurrence (FOO) was calculated for each species as the percentage of survey points at which each species was detected (Table 5). Exact binomial 95% confidence intervals (CI's) were calculated for each frequency estimate. Sixteen species were encountered, two of which are listed as Class C noxious weeds in Washington: fragrant waterlily which was present at 19% of sites and curlyleaf pondweed (*Potamogeton crispus*) which was present at 1.5% of sites. Slender naiad (*Najas flexilis*), a native species, was the most common species at 78% of the littoral sites.

Aquatic plant diversity at the site level was relatively low (Table 6). Across 200 survey points, mean species richness was 2.11 species per site (SD = 1.57), indicating that most sampling locations supported only one to three species. Mean Shannon diversity (0.57 ± 0.57 SD) and Simpson diversity (0.44 ± 0.35 SD) were likewise low, reflecting the widespread occurrence of a few common taxa and the relatively infrequent occurrence of most other species. In particular, slender naiad was substantially more frequent than any other species. Despite low richness, mean evenness was high (0.93 ± 0.06 SD), suggesting that at sites where multiple species were present, species abundances tended to be relatively balanced rather than strongly dominated by a single taxon.

Overall plant density at sampling sites is provided in Figure 10. Distributions by species encountered are provided in Figure 11 to Figure 30. Slender naiad occurred across nearly the entire vegetated depth range of the lake (Figure 11), from shallow nearshore habitats to depths approaching the maximum colonization depth identified in the hydroacoustic survey. Its broad depth distribution and high frequency of occurrence indicate that it is the dominant submerged macrophyte in Black Lake.

Other less frequent species distributions were not uniform across the littoral zone. Submerged species, including *Nitella* spp., Canadian waterweed (*Elodea canadensis*), ribbonleaf pondweed (*Potamogeton epihydrus*), and largeleaf pondweed (*P. amplifolius*), were most common in intermediate-depth habitats and occurred in localized patches. Floating-leaved species, particularly fragrant waterlily (*Nymphaea odorata*), were concentrated in protected nearshore areas. Curly-leaf pondweed (*Potamogeton crispus*) was uncommon and detected at only three survey locations. Notably, no spiked watermilfoil (*Myriophyllum spicatum*) was detected. Collectively, these patterns indicate a littoral plant community dominated by the widespread occurrence of slender naiad, large areas of floating leaf species near the margins, and a diverse assemblage of less common species throughout the lake.

Table 5.
Frequency of occurrence of aquatic plant species in 200 point samples collected from the Black Lake littoral zone, June 2026.

Species	Common name	Status	Freq. of occur. (95 % CI[c])
Najas flexilis	Slender naiad	Native	78 (72 - 84)
Nitella spp.	stonewort	Native	24 (18 - 31)
Elodea canadensis	Canadian waterweed	Native	21 (16 - 27)
Potamogeton epihydrus	Ribbonleaf pondweed	Native	20 (15 - 26)
Nymphaea odorata	Fragrant water lily	Class C Noxious Weed[a,b]	19 (14 - 25)
Potamogeton amplifolius	Largeleaf pondweed	Native	13.5 (9 - 19)
Potamogeton zosteriformis	Flat-stem pondweed	Native	9.5 (6 - 14)
Schoenoplectus acutus	Bulrush	Native[b]	8 (5 - 13)
Ceratophyllum demersum	Coontail	Native	4.5 (2 - 8)
Nuphar polysepala	Yellow pond lily	Native[b]	4 (2 - 8)
Chara spp.	Muskgrass	Native	3 (1 - 6)
Potamogeton richardsonii	Clasping-leaf pondweed	Native	2 (1 - 5)
Potamogeton crispus	Curly-leaf pondweed	Class C Noxious Weed[a]	1.5 (0 - 4)
Utricularia vulgaris	Common bladderwort	Native	1.5 (0 - 4)
Potamogeton foliosus	Leafy pondweed	Native	1 (0 - 4)
Typha latifolia	Broadleaf cattail	Native[b]	0.5 (0 - 3)
	bare sediment		11 (7 - 16)

Notes:

a. Control is encouraged but generally not required because it is widespread in Washington.
b. Frequency of occurrence of emergent and floating leaved plant species is not representative of true coverage using the point sampling method.
c. CI = Confidence Interval

Source: Grab sample survey, June 2026, ESA.

Table 6.
Diversity indices for the aquatic plant community sampled in Black Lake's littoral zone, June 2026.

Index *	Mean ± standard deviation
Richness	2.11 ± 1.57
Shannon diversity (H')	0.57 ± 0.57
Simpson diversity (1-D)	0.44 ± 0.35
Pielou's evenness (J')	0.93 ± 0.06

* Richness represents the number of species per site. Shannon and Simpson indices are measures of species diversity, with larger values indicating greater diversity. Evenness (Pielou's J') describes how equally species are represented within a site, with values approaching 1 indicating a more even distribution of abundances

Aerial imagery analysis of floating leaf plant beds

Floating-leaf aquatic plant beds, consisting primarily of fragrant water lily (*Nymphaea odorata*) with smaller areas of yellow pond lily (*Nuphar polysepala*), were delineated from 1-ft resolution Nearmap aerial imagery acquired on August 22, 2025, using ArcGIS Pro (Figure 9). A total of 17.4 acres of floating leaf plants were delineated, which is 13.3 % of the littoral zone, and 3% of the lake area. In addition to providing a map of floating-leaf vegetation distribution, these delineations identified areas where hydroacoustic coverage was limited due to navigation constraints through dense surface vegetation.

Visual shoreline emergent and floating leaf plant survey

To supplement the rake survey, a visual shoreline survey was conducted to document presence of the most abundant shoreline emergent and floating leaf plant species: yellow flag iris, fragrant water lily, yellow pond lily, and hardstem bulrush. Surveys were conducted by slowly (> 5 mph) navigating around the lake perimeter while rapidly recording presence of each species using ESRI QuickCapture. Fragrant water lily and yellow flag iris (*Iris pseudacorus*) were the most common invasive species (Table 7.

Count of Black Lake shoreline plant observations, June 2026.Table 7). Hardstem bulrush was the most common native species. Shoreline distributions of fragrant water lily, yellow flag iris, hardstem bulrush, and yellow pond lily are shown in Figures 15, 16, 20, and 24, respectively.

Table 7.
Count of Black Lake shoreline plant observations, June 2026.

Species	ESRI QuickCapture observations
Fragrant water lily	1137
Hardstem bulrush	601
Yellow flag iris	362
Yellow pond lily	210
Broadleaf cattail	18

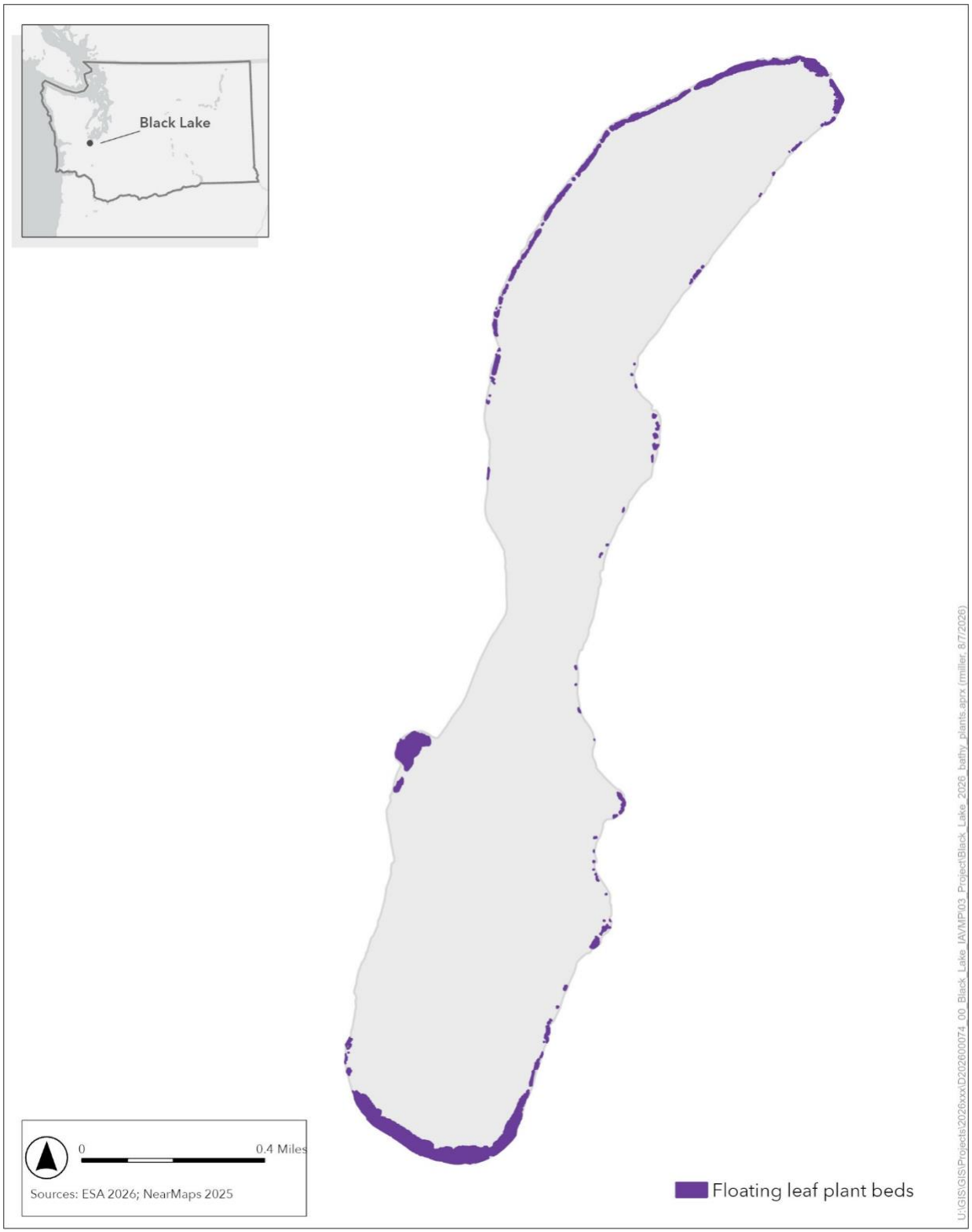


Figure 9. Black Lake floating leaf aquatic plant beds delineated from August 22, 2025, NearMaps imagery.

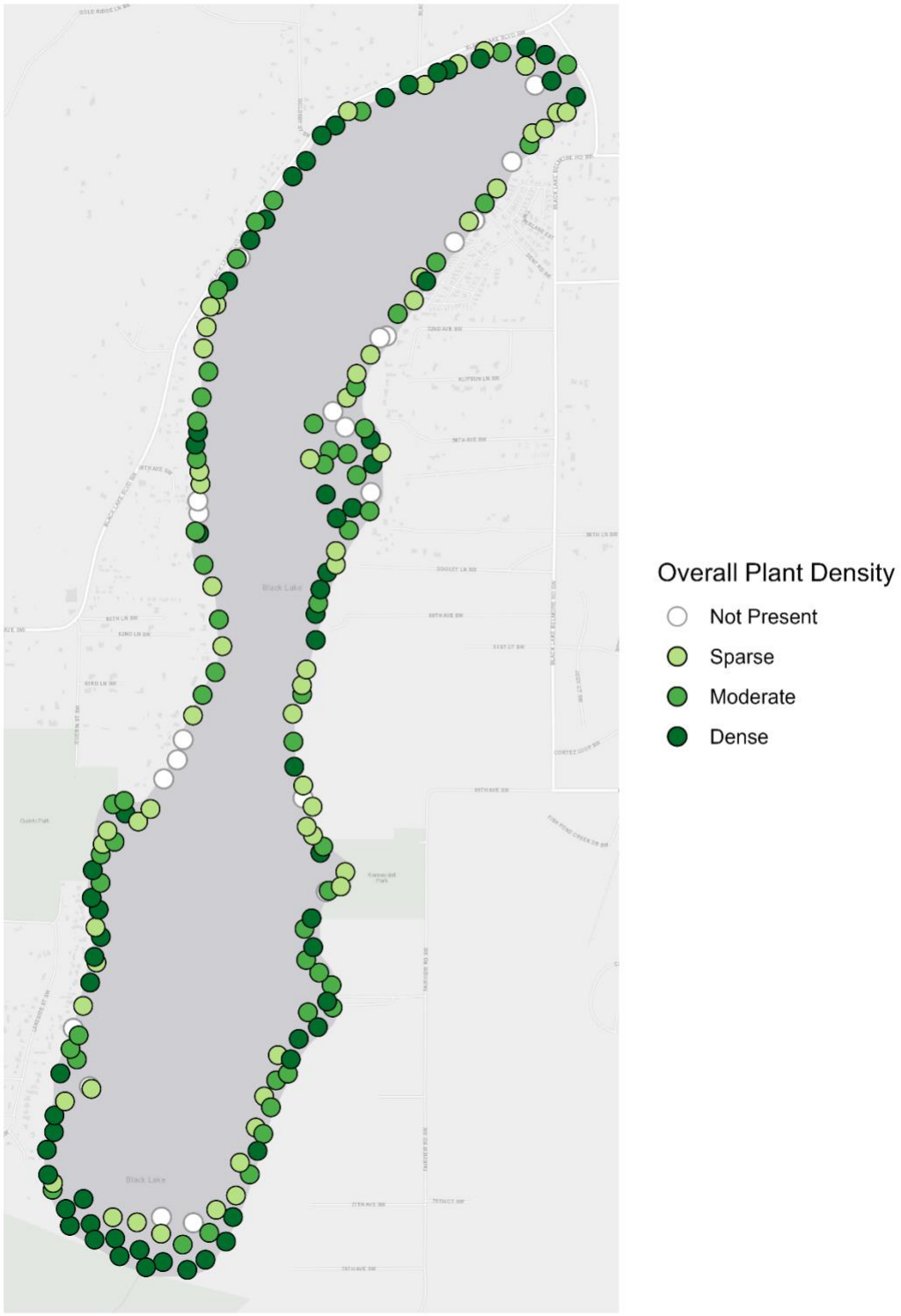


Figure 10. Spatial distribution and relative density of aquatic plants recorded in Black Lake, Washington. Marker color indicates density class (1 = sparse, 2 = moderate, 3 = dense) and white markers show surveyed sample sites without plants. Source: ESA, aquatic plant rake survey, June 2026.

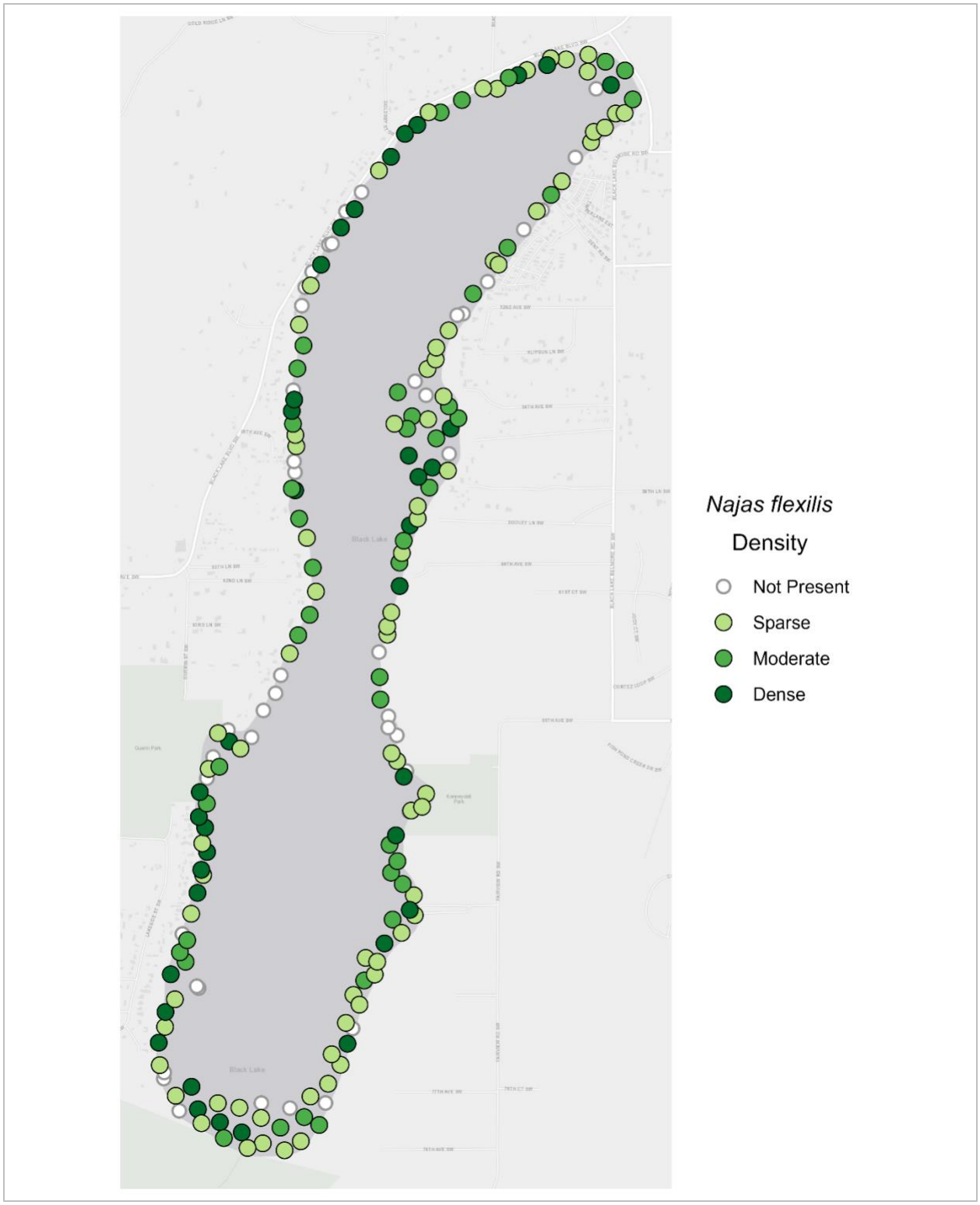


Figure 11. Spatial distribution and relative density of *Najas flexilis* (slender waternymph) recorded in Black Lake, Washington. Marker color indicates density class (1 = sparse, 2 = moderate, 3 = dense) and white circles are other surveyed sample sites. Source: ESA, aquatic plant rake survey, June 2026.

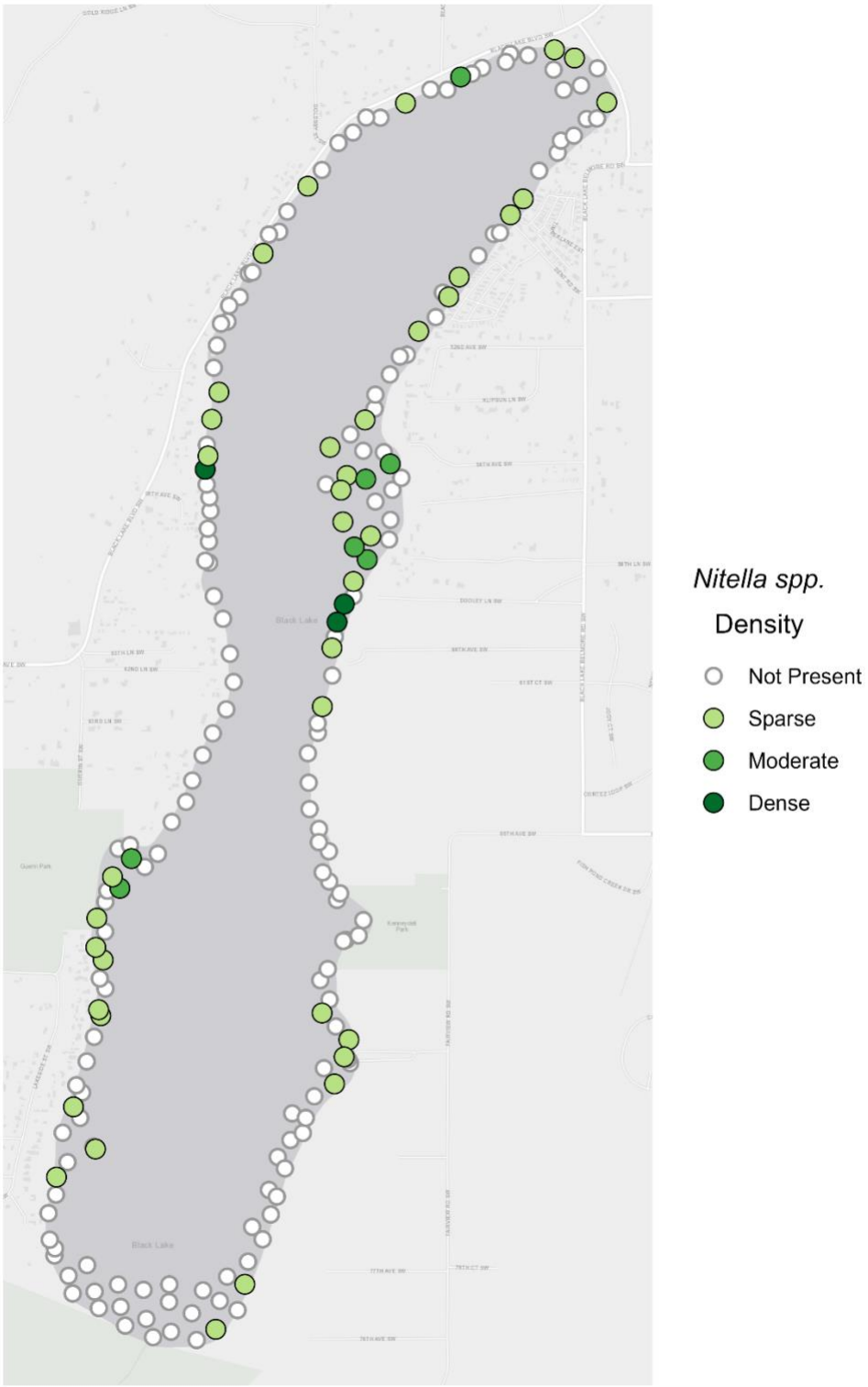


Figure 12. Spatial distribution and relative density of *Nitella* spp. (stonewort) recorded in Black Lake, Washington. Marker color indicates density class (1 = sparse, 2 = moderate, 3 = dense) and white circles are other surveyed sample sites. Source: ESA, aquatic plant rake survey, June 2026.

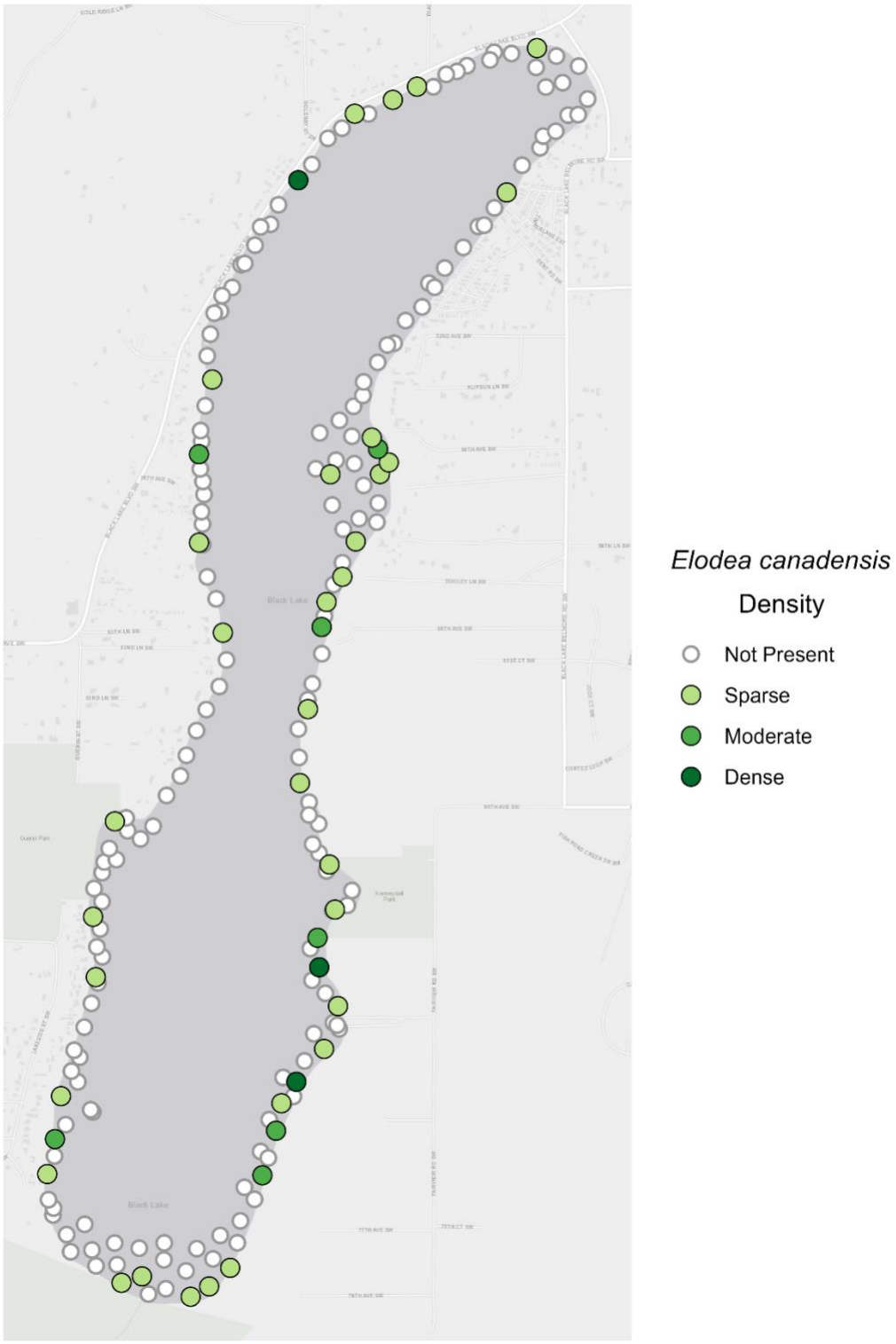


Figure 13. Spatial distribution and relative density of *Elodea canadensis* (Canadian waterweed) recorded in Black Lake, Washington. Marker color indicates density class (1 = sparse, 2 = moderate, 3 = dense) and white circles are other surveyed sample sites. Source: ESA, aquatic plant rake survey, June 2026.

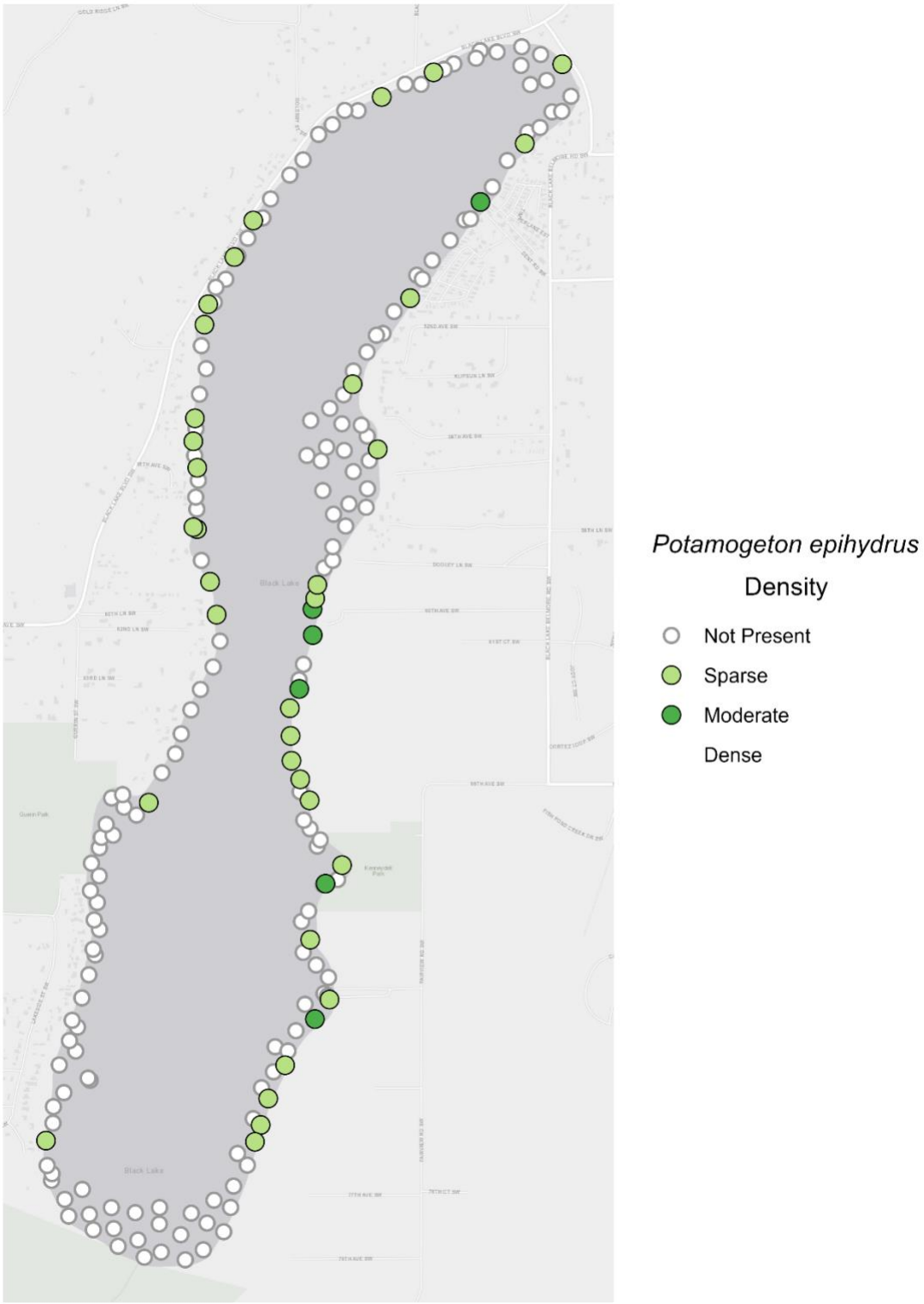


Figure 14. Spatial distribution and relative density of *Potamogeton epihydrus* (ribbonleaf pondweed) recorded in Black Lake, Washington. Marker color indicates density class (1 = sparse, 2 = moderate, 3 = dense) and white circles are other surveyed sample sites. Source: ESA, aquatic plant rake survey, June 2026.

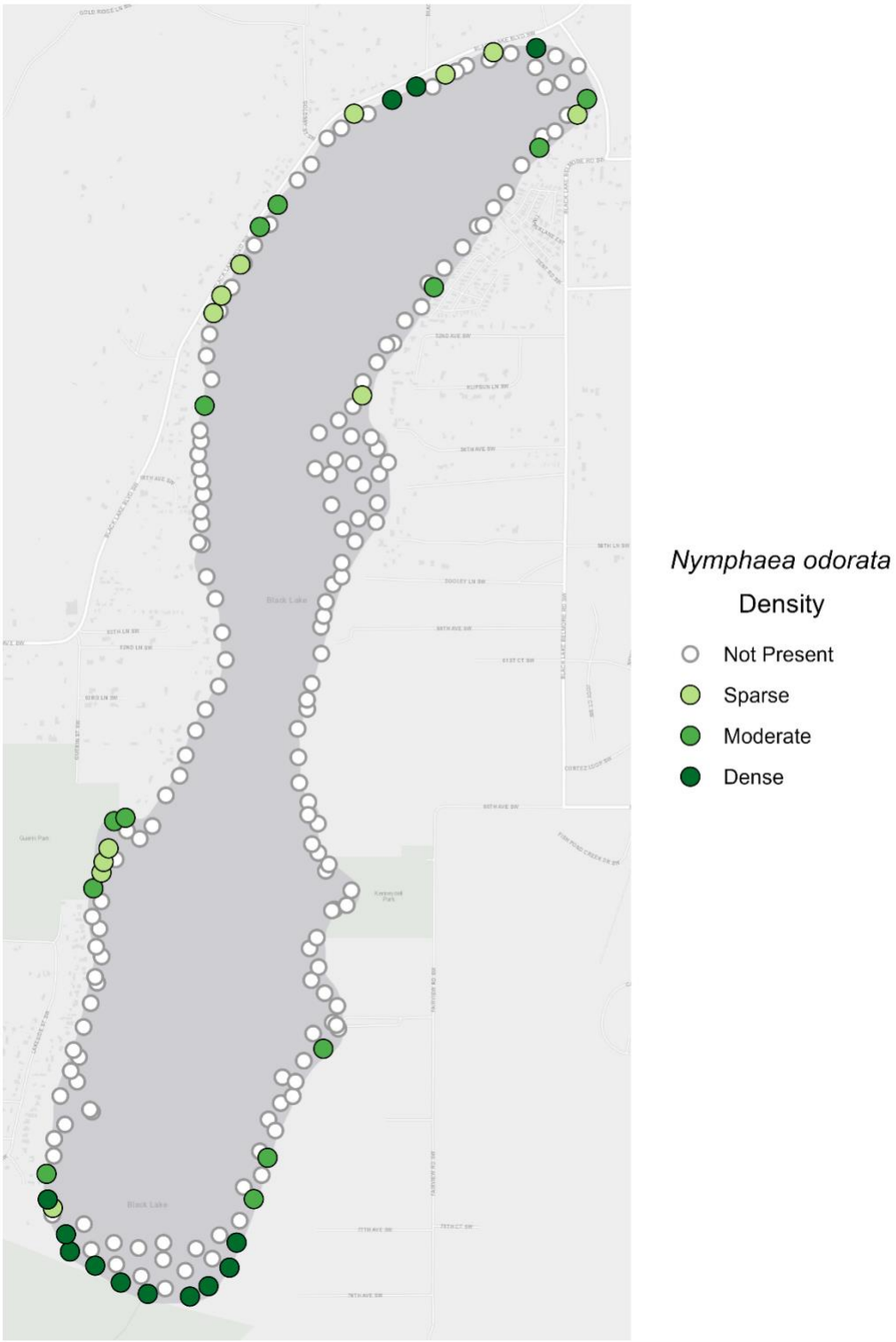


Figure 15. Spatial distribution and relative density of *Nymphaea odorata* (fragrant water lily) recorded in Black Lake, Washington. Marker color indicates density class (1 = sparse, 2 = moderate, 3 = dense) and white circles are other surveyed sample sites. Source: ESA, aquatic plant rake survey, June 2026.

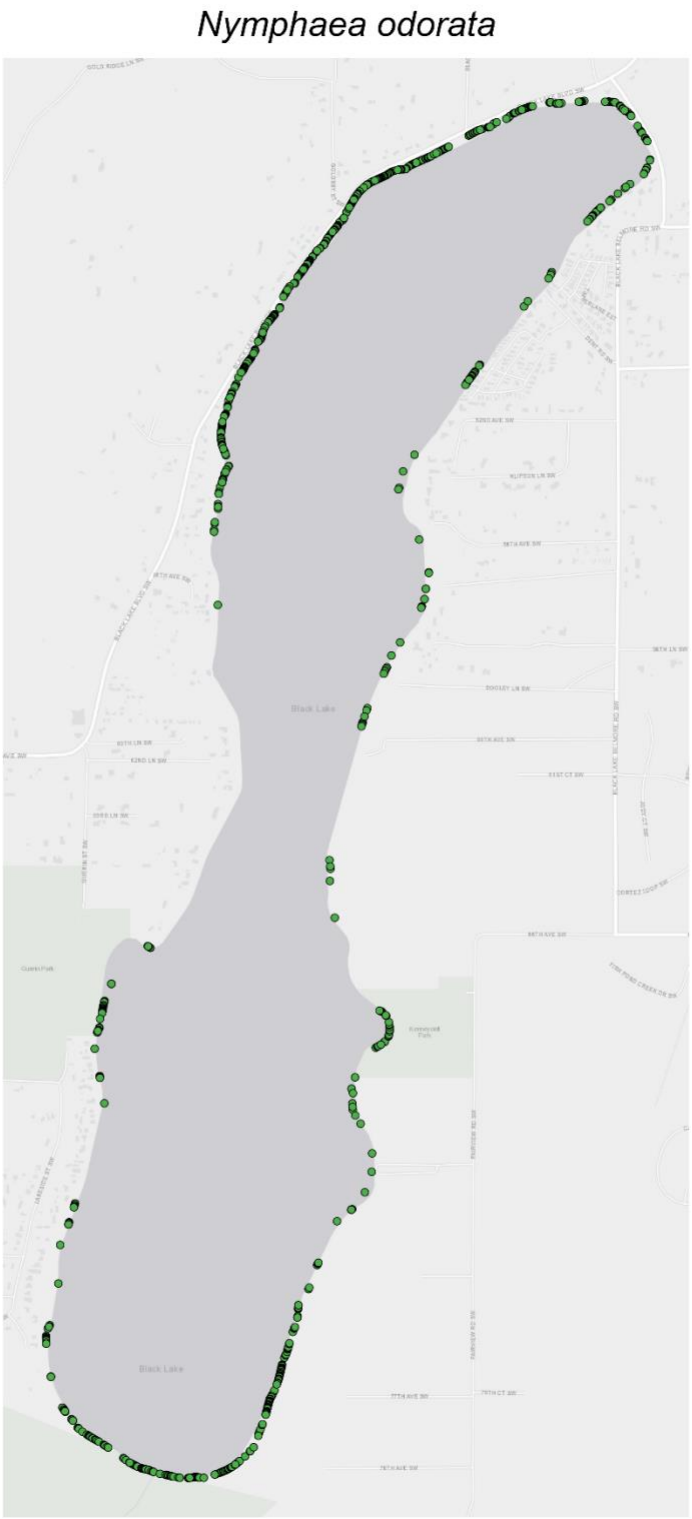


Figure 16. Observations of *Nymphaea odorata* (fragrant water lily) along the shoreline of Black Lake, Washington. Source: ESA QuickCapture aquatic plant survey, June 2026.

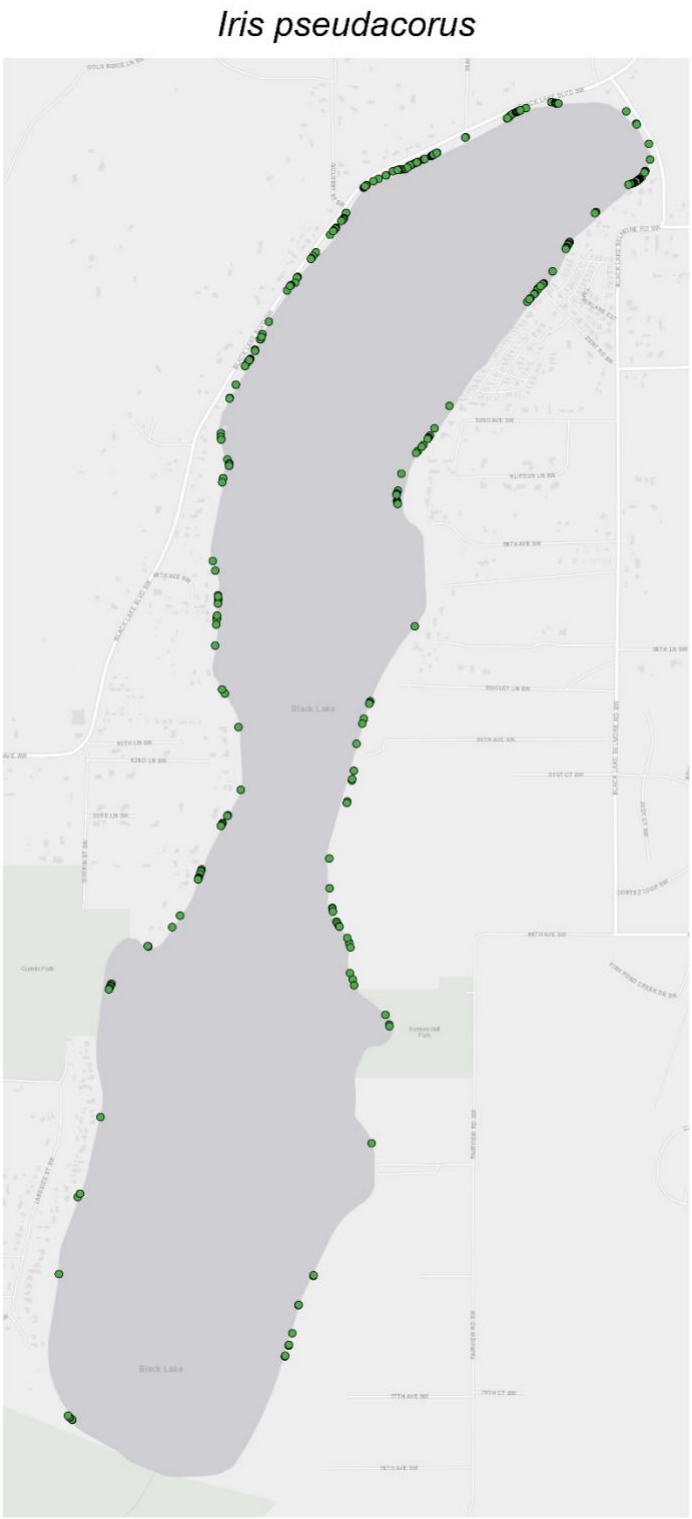


Figure 17. Observations of *Iris pseudacorus* (yellow flag iris) along the shoreline of Black Lake, Washington. Source: ESA QuickCapture aquatic plant survey, June 2026.

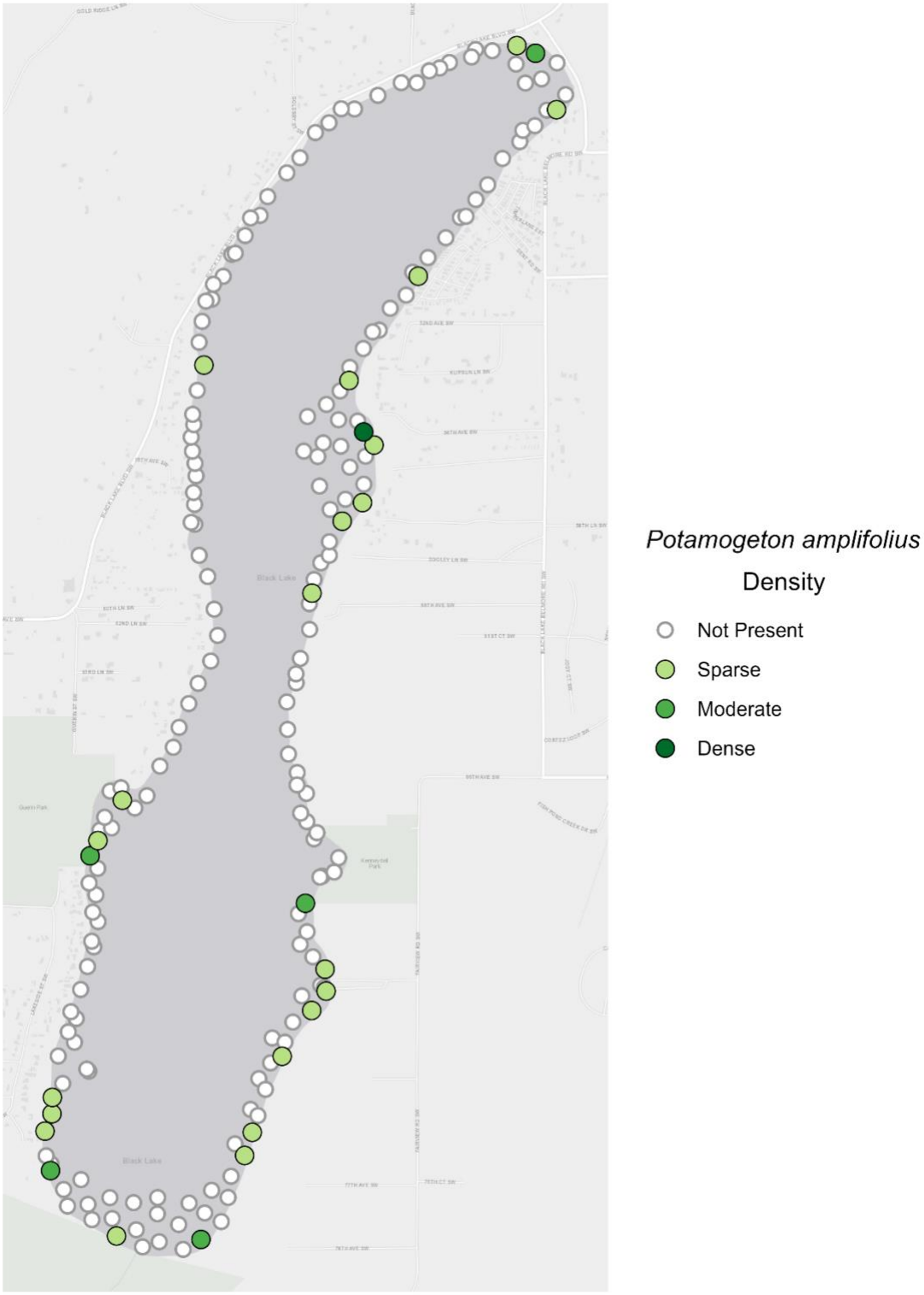


Figure 18. Spatial distribution and relative density of *Potamogeton amplifolius* (bigleaf pondweed) recorded in Black Lake, Washington. Marker color indicates density class (1 = sparse, 2 = moderate, 3 = dense) and white circles are other surveyed sample sites. Source: ESA, aquatic plant rake survey, June 2026.

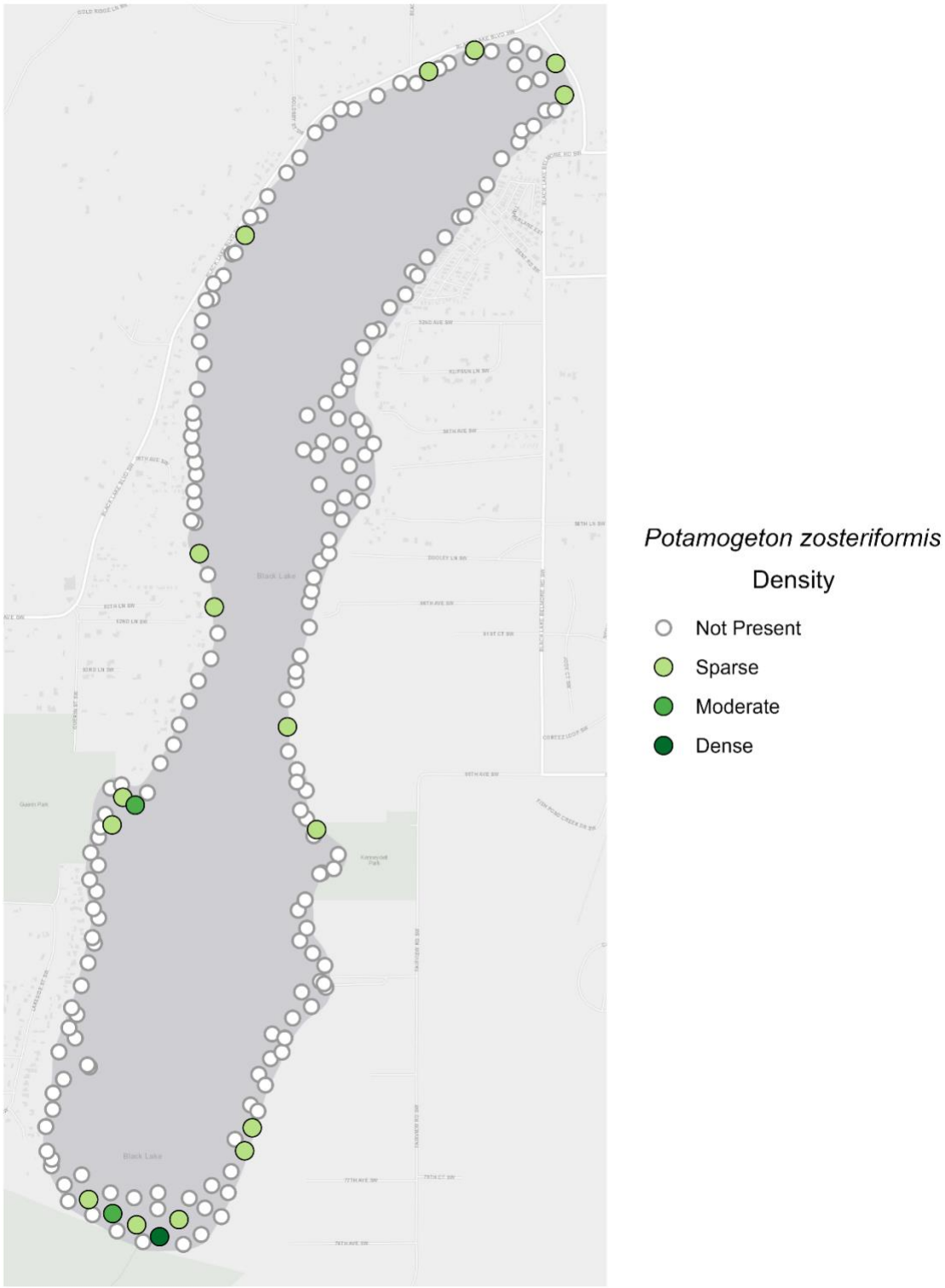


Figure 19. Spatial distribution and relative density of *Potamogeton zosteriformis* (flat-stem pondweed) recorded in Black Lake, Washington. Marker color indicates density class (1 = sparse, 2 = moderate, 3 = dense) and white circles are other surveyed sample sites. Source: ESA, aquatic plant rake survey, June 2026.

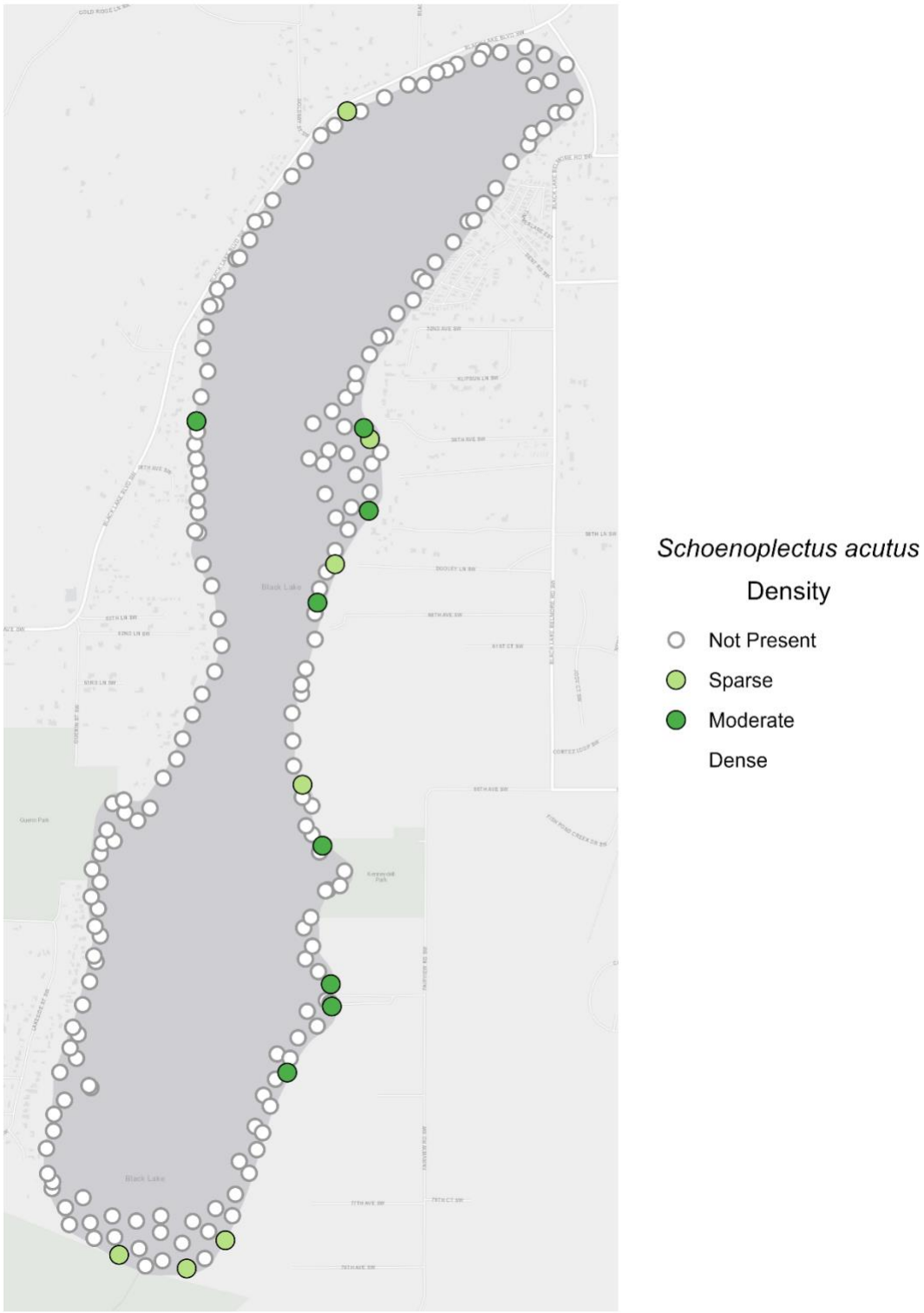


Figure 20. Spatial distribution and relative density of *Schoenoplectus acutus* (hardstem bulrush) recorded in Black Lake, Washington. Marker color indicates density class (1 = sparse, 2 = moderate, 3 = dense) and white circles are other surveyed sample sites. Source: ESA, aquatic plant rake survey, June 2026.

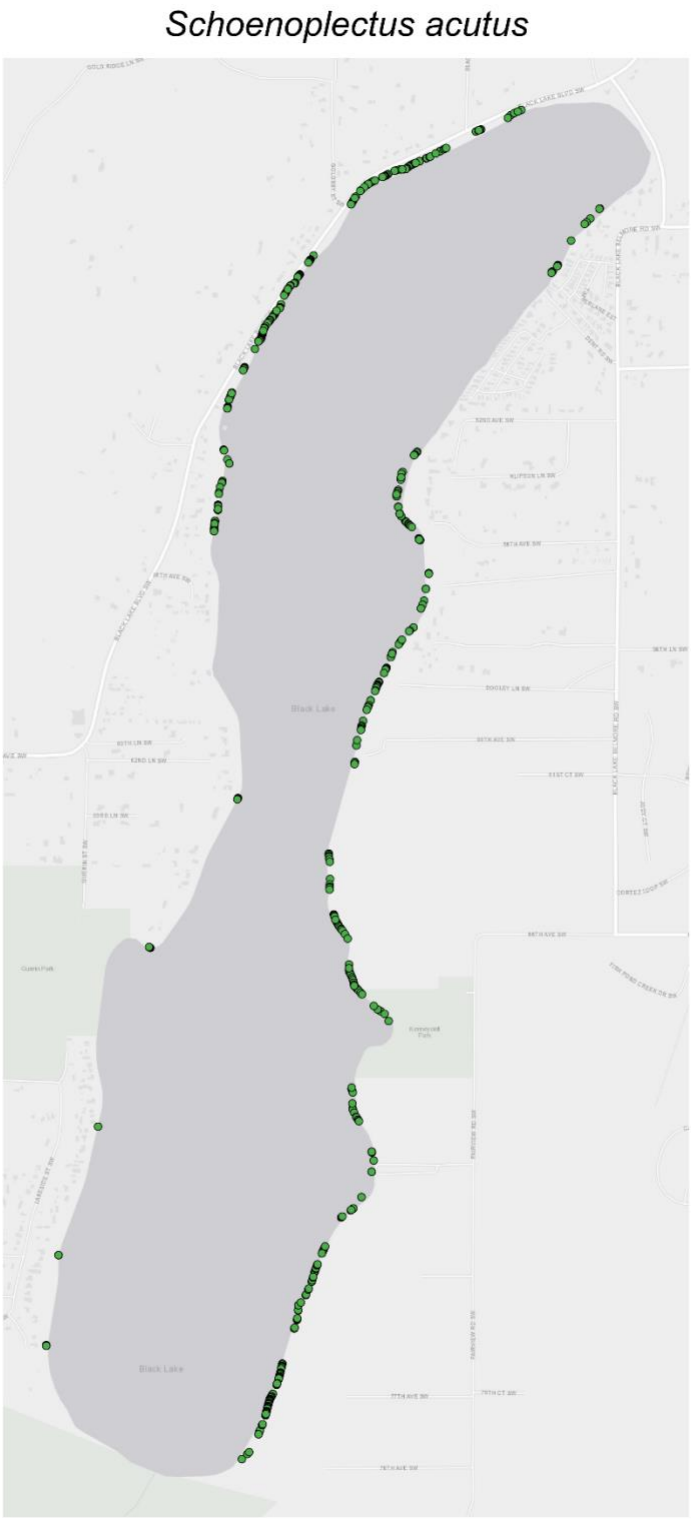


Figure 21. Observations of *Schoenoplectus acutus* (hardstem bulrush) along the shoreline of Black Lake, Washington. Source: ESA aquatic plant survey, June 2026.

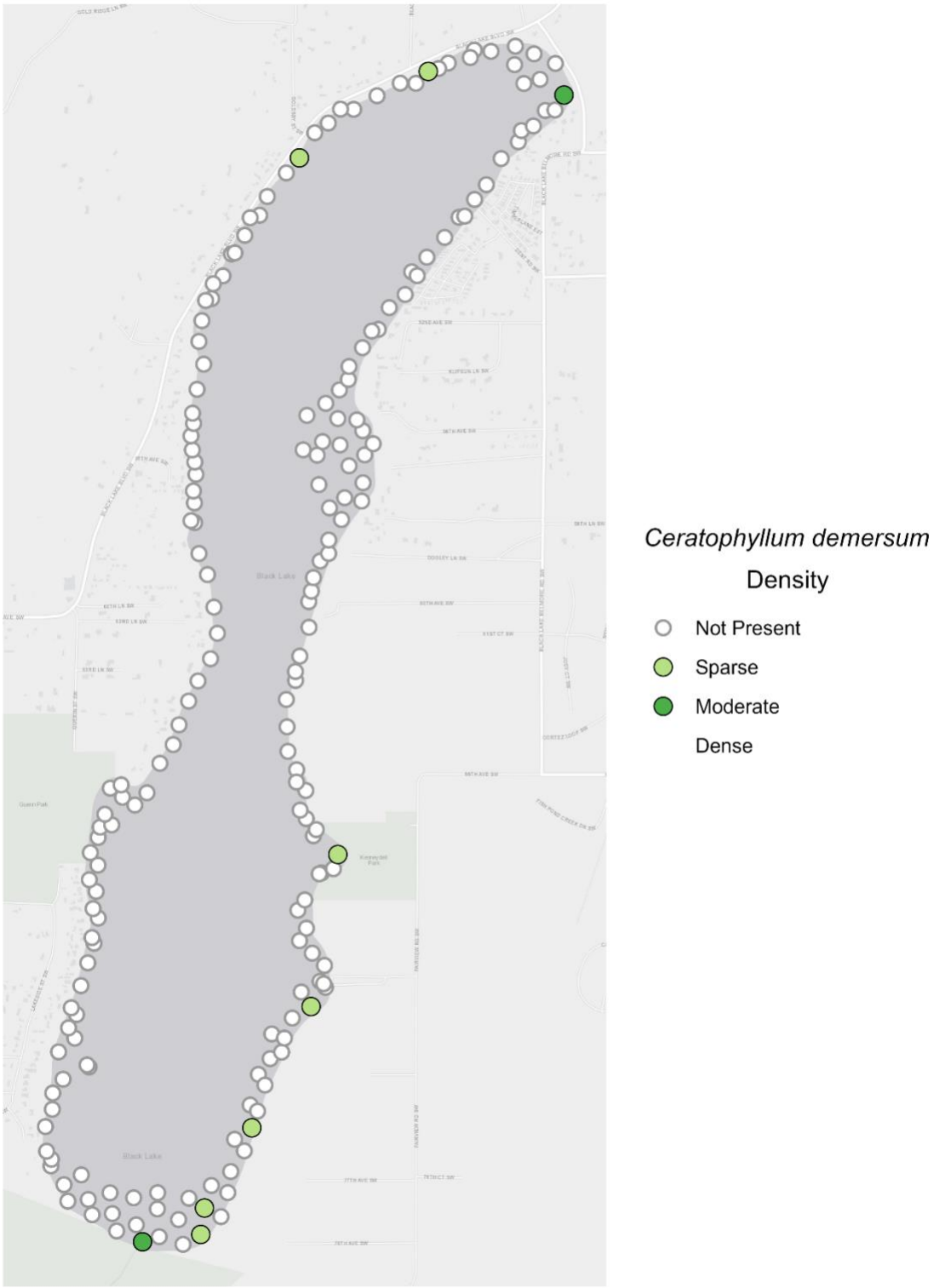


Figure 22. Spatial distribution and relative density of *Ceratophyllum demersum* (coontail) recorded in Black Lake, Washington. Marker color indicates density class (1 = sparse, 2 = moderate, 3 = dense) and white circles are other surveyed sample sites. Source: ESA, aquatic plant rake survey, June 2026.

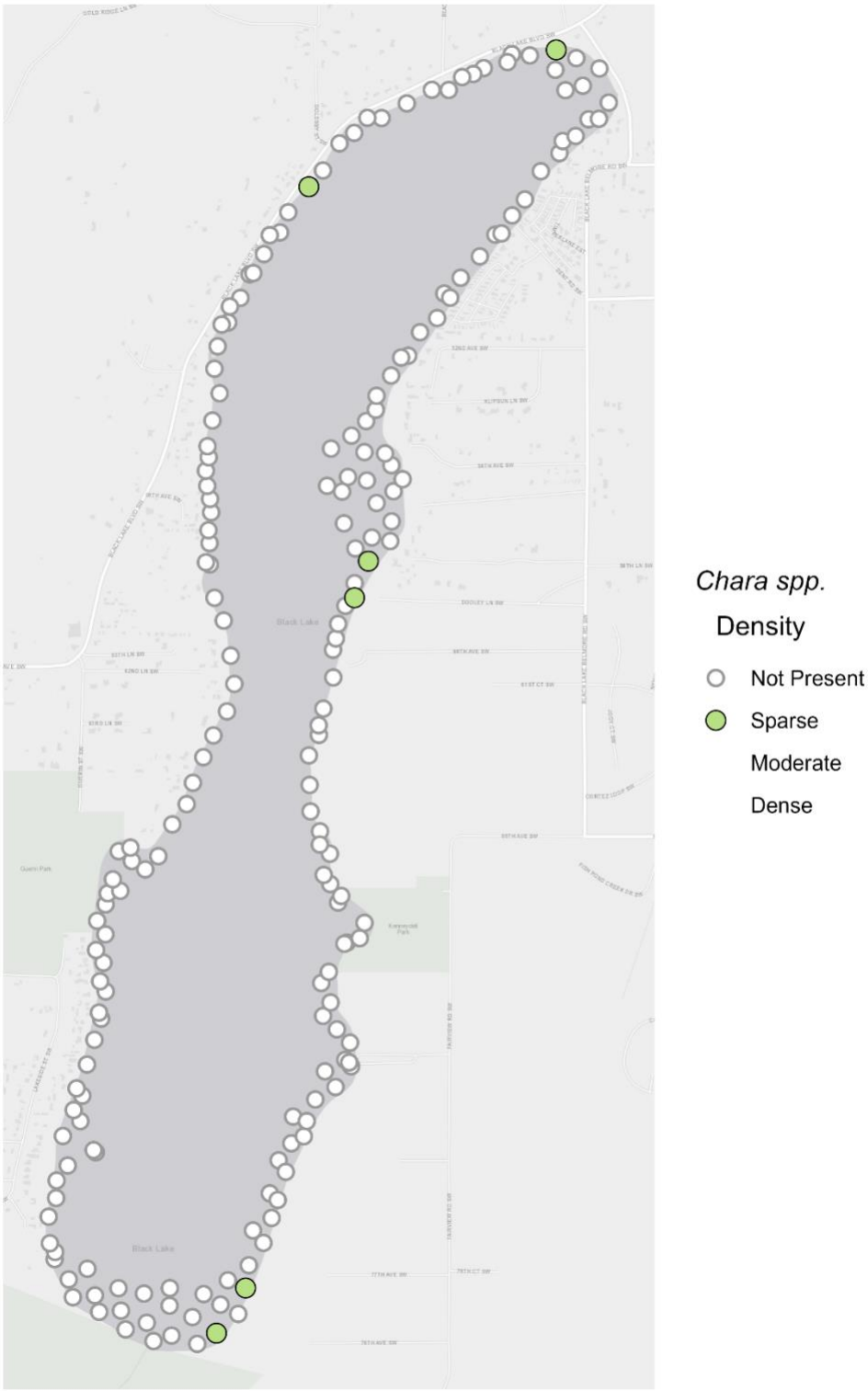


Figure 23. Spatial distribution and relative density of *Chara* spp. (muskgrass) recorded in Black Lake, Washington. Marker color indicates density class (1 = sparse, 2 = moderate, 3 = dense) and white circles are other surveyed sample sites. Source: ESA, aquatic plant rake survey, June 2026.

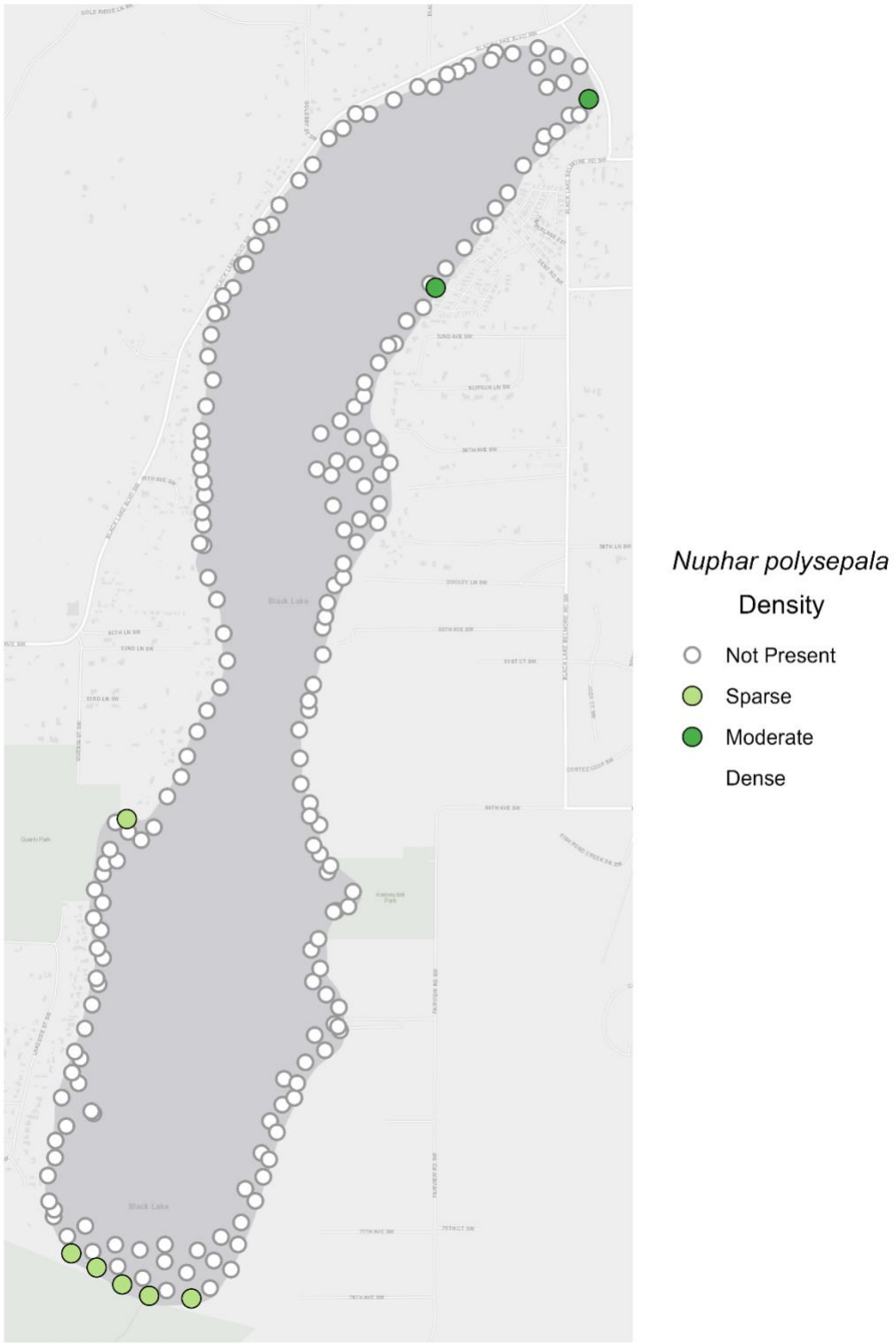


Figure 24. Spatial distribution and relative density of *Nuphar polysepala* (yellow water lily) recorded in Black Lake, Washington. Marker color indicates density class (1 = sparse, 2 = moderate, 3 = dense) and white circles are other surveyed sample sites. Source: ESA, aquatic plant rake survey, June 2026.

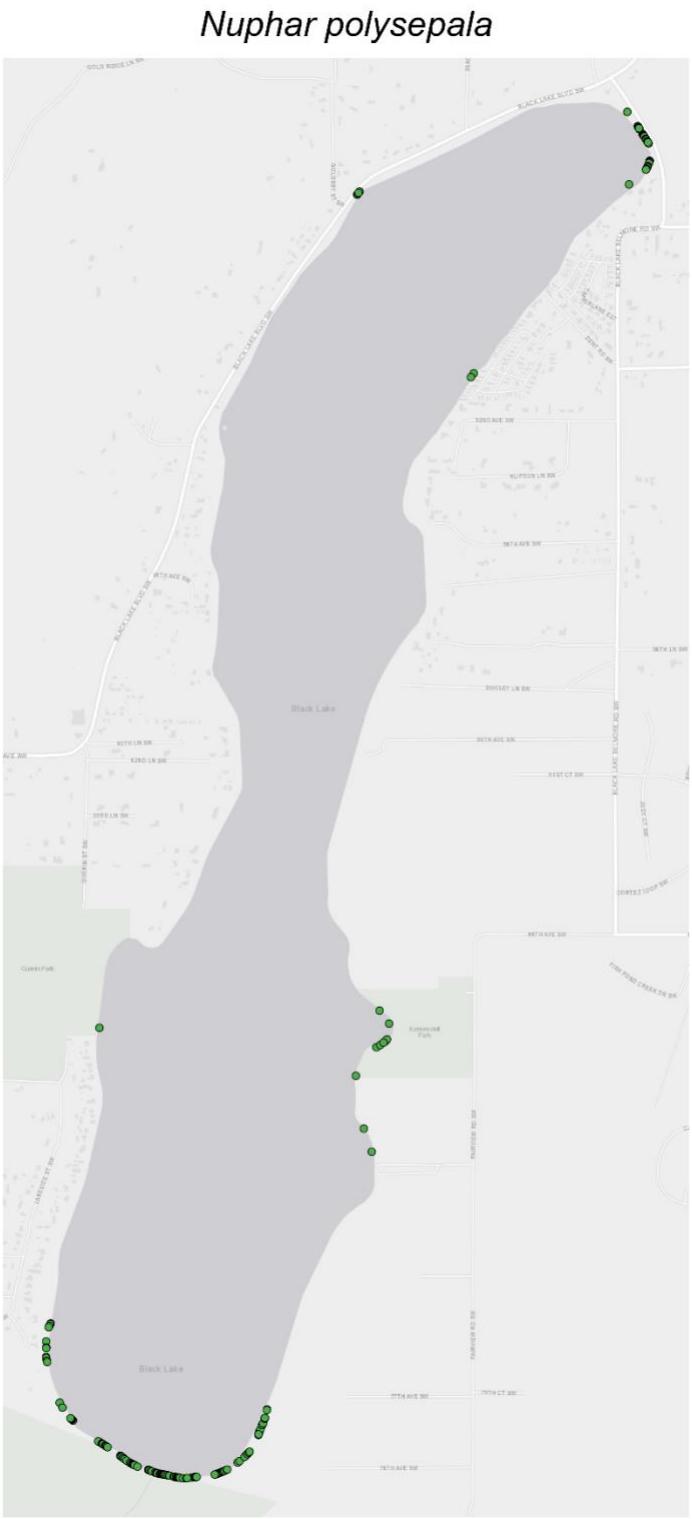


Figure 25. Observations of *Nuphar polysepala* (yellow water lily) along the shoreline of Black Lake, Washington. Source: ESA QuickCapture aquatic plant survey, June 2026.

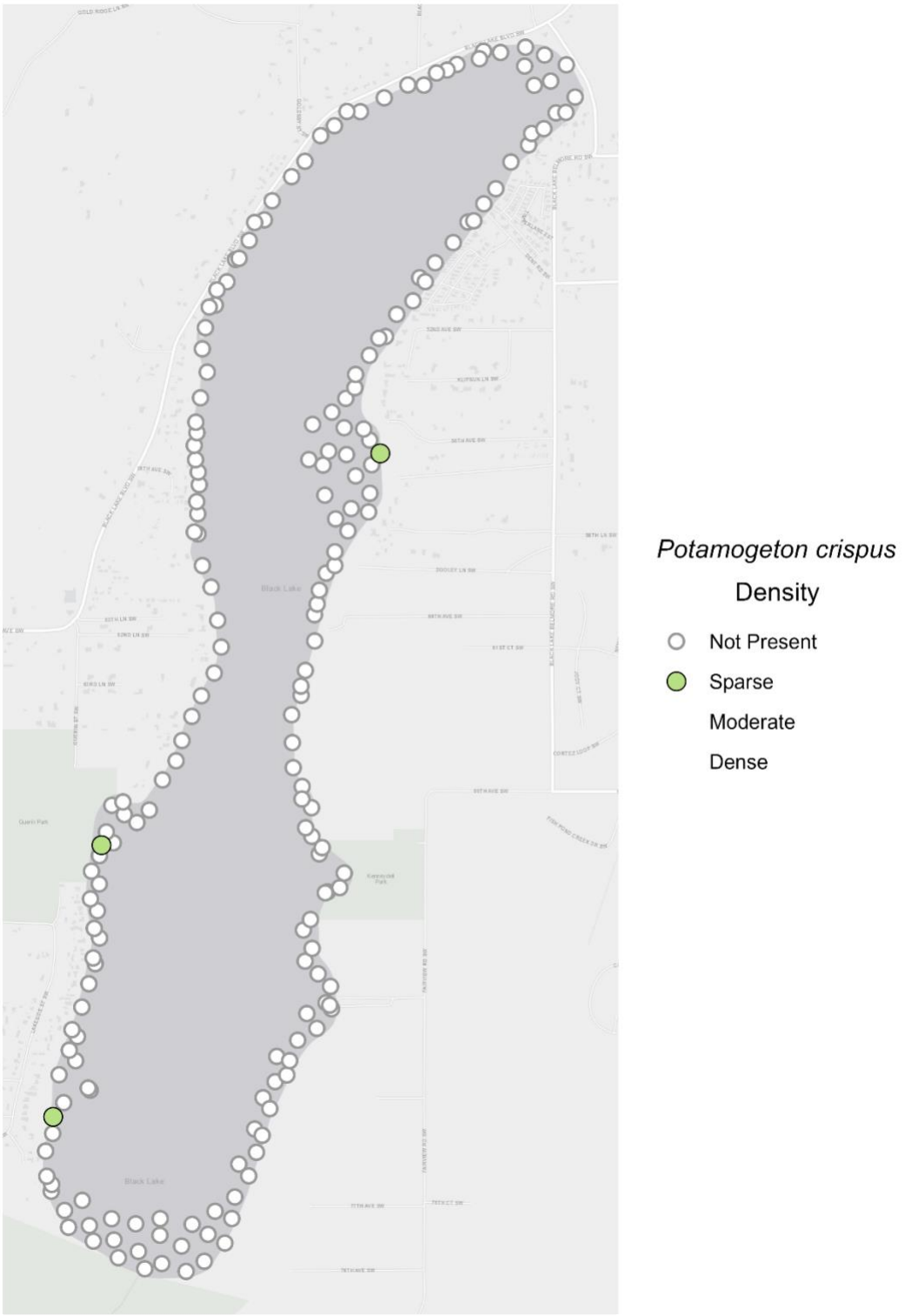


Figure 26. Spatial distribution and relative density of *Potamogeton crispus* (curlyleaf pondweed) recorded in Black Lake, Washington. Marker color indicates density class (1 = sparse, 2 = moderate, 3 = dense) and white circles are other surveyed sample sites. Source: ESA, aquatic plant rake survey, June 2026.

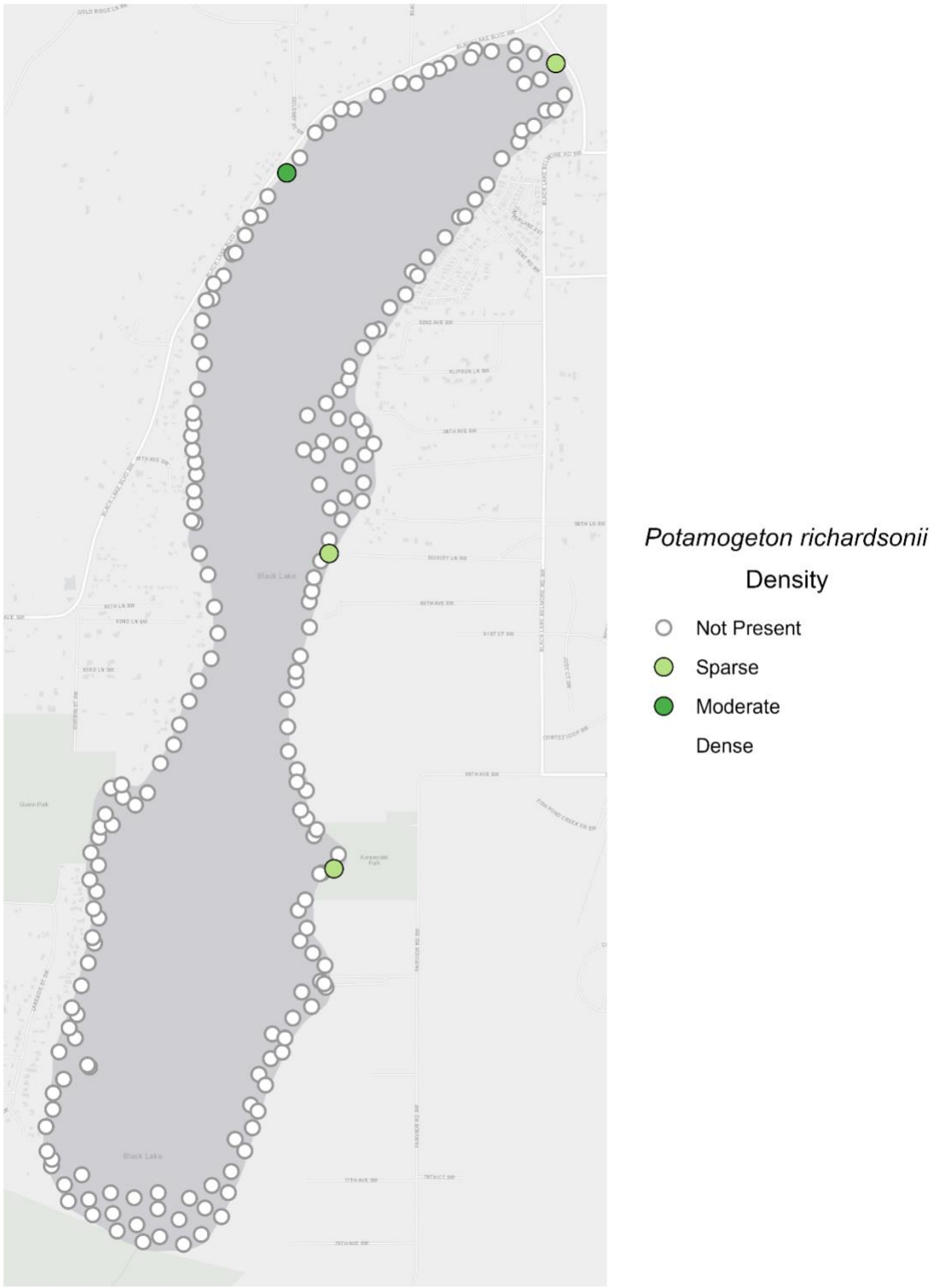


Figure 27. Spatial distribution and relative density of *Potamogeton richardsonii* (Richardson's pondweed) recorded in Black Lake, Washington. Marker color indicates density class (1 = sparse, 2 = moderate, 3 = dense) and white circles are other surveyed sample sites. Source: ESA, aquatic plant rake survey, June 2026.

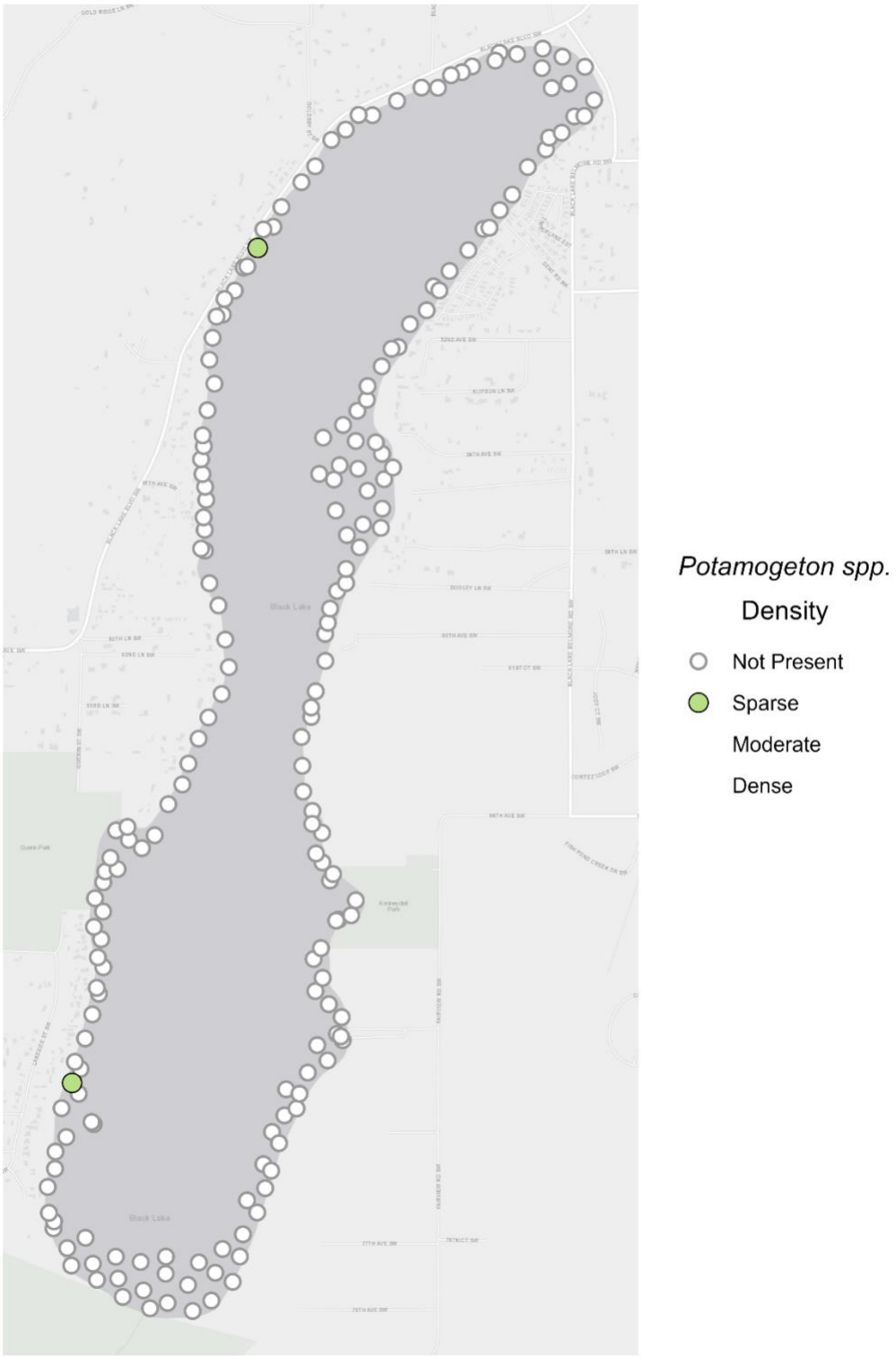


Figure 28. Spatial distribution and relative density of *Potamogeton spp.* (thin leaf pondweed species) recorded in Black Lake, Washington. Marker color indicates density class (1 = sparse, 2 = moderate, 3 = dense) and white circles are other surveyed sample sites. Source: ESA, aquatic plant rake survey, June 2026.

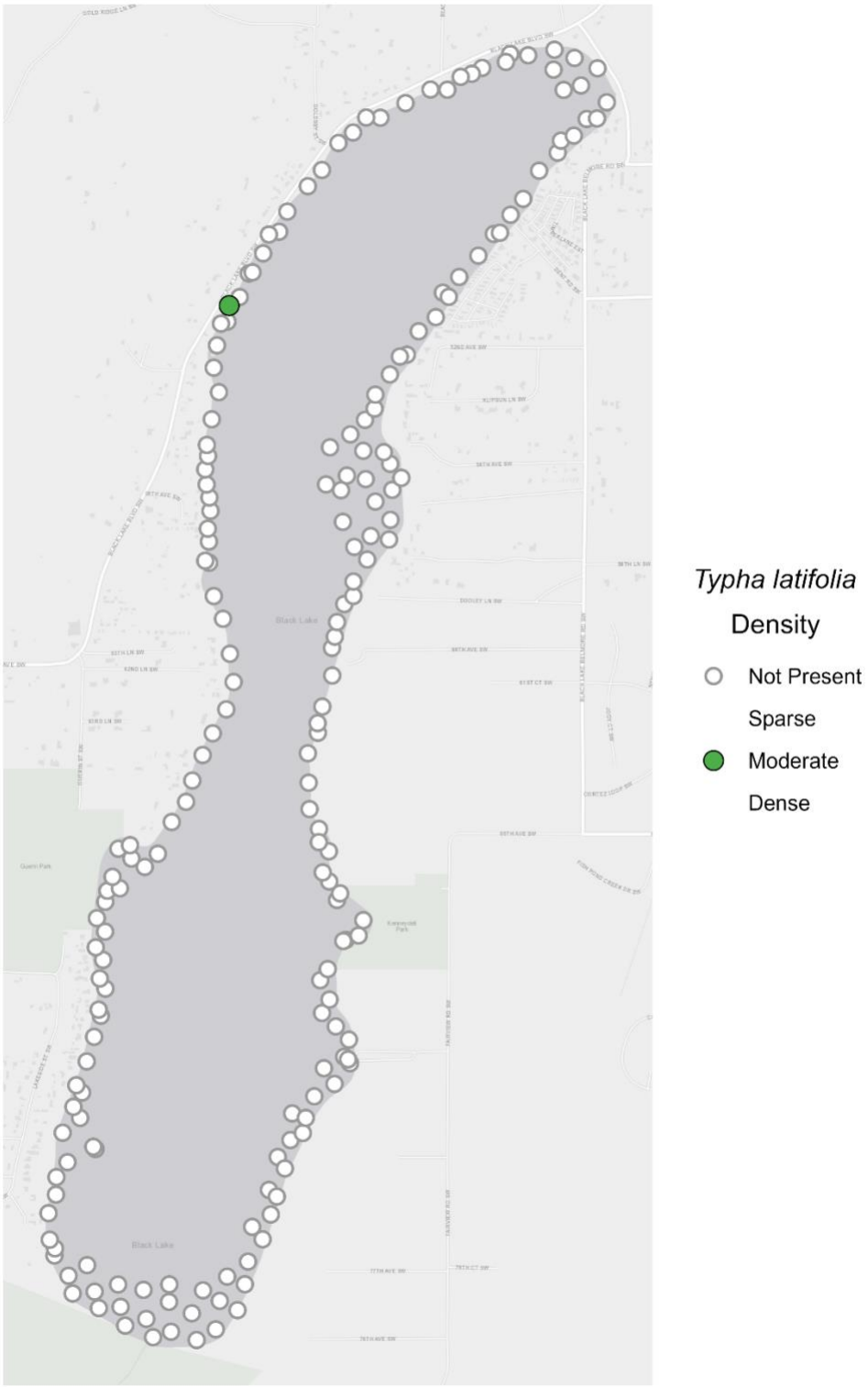


Figure 29. Spatial distribution and relative density of *Typha latifolia* (broadleaf cattail) recorded in Black Lake, Washington. Marker color indicates density class (1 = sparse, 2 = moderate, 3 = dense) and white circles are other surveyed sample sites. Source: ESA, aquatic plant rake survey, June 2026.

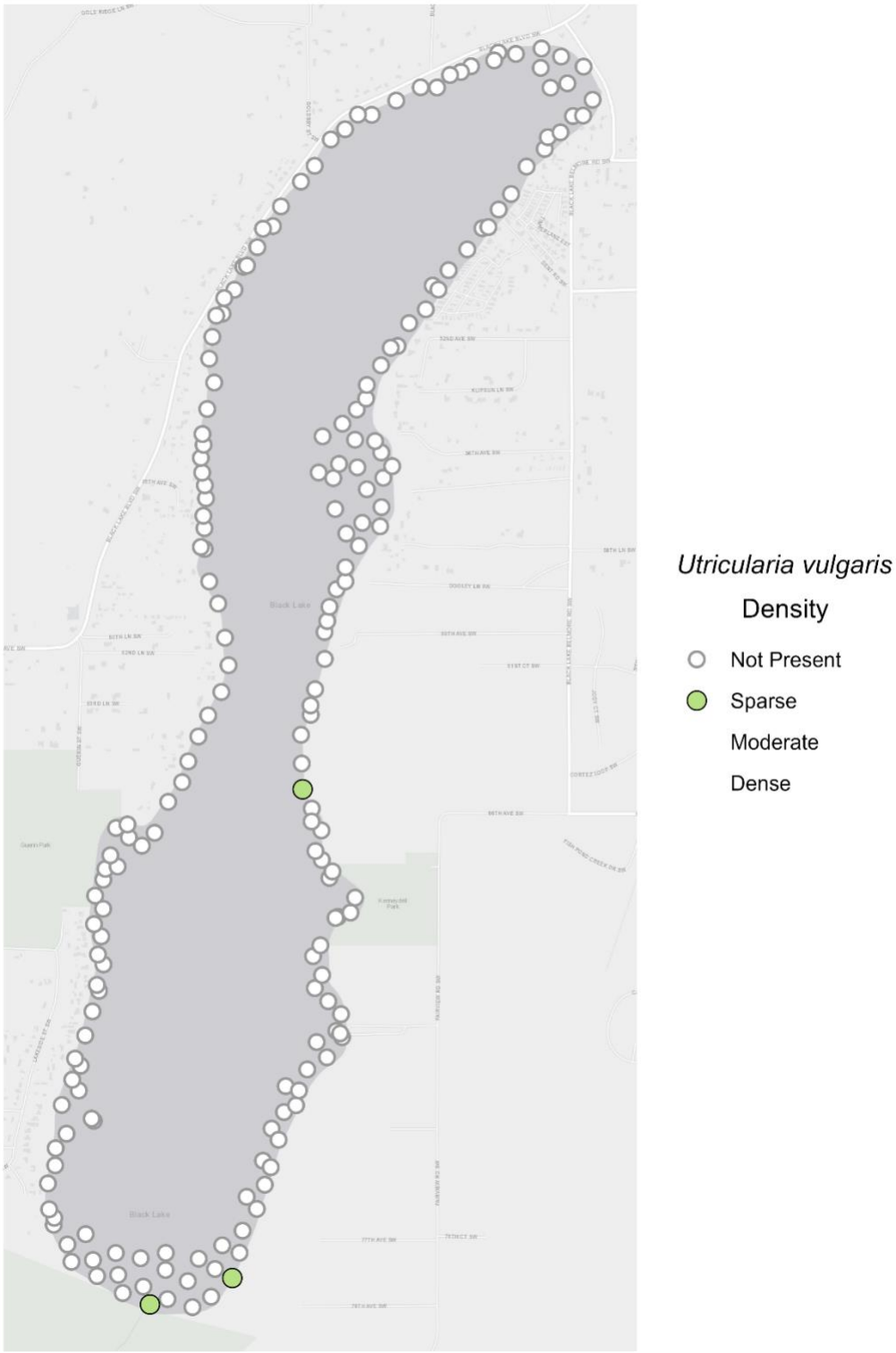


Figure 30. Spatial distribution and relative density of *Utricularia vulgaris* (common bladderwort) recorded in Black Lake, Washington. Marker color indicates density class (1 = sparse, 2 = moderate, 3 = dense) and white circles are other surveyed sample sites. Source: ESA, aquatic plant rake survey, June 2026.