

2005 Lake Vegetation Index Seasonal Variability Study

FDEP Bureau of Laboratories

10/1/2006

2005 Lake Vegetation Index (LVI) Seasonal Variability Study

Background and Objectives

The Lake Vegetation Index (LVI) is a multi-metric index that uses plant species and community attributes to judge the level of adverse human impact on a lake. The premise of the method is the Floristic Quality Assessment (FQA), introduced by Swink and Wilhelm (1994) in the Midwest to rate natural areas. The cornerstone of their method was the coefficient of conservatism (C of C), which is a species-specific score that represents an estimated probability that a plant species is likely to occur in a landscape relatively unaltered from pre-settlement condition. The four metrics of Florida's LVI are percent (%) Exotic taxa (FLEPPC Categories I & II), % Native taxa, % Sensitive taxa (C of C > 7), and the C of C score of the dominant species (Fore 2005).

During the development of the LVI, few data were available to compare scores at a single lake during various times of the year. Ultimately, we have decided that plant sampling should only be conducted when plants are growing and visible (May-November), but we had little information about whether or not the score for a single lake would vary by sampling date. Therefore, we sampled 29 lakes throughout the state in both late spring (May-June) and fall (October-November) of 2005, with the following objectives:

- Determine if seasonal conditions cause the LVI to yield different assessments at two different times of year.
- Determine if May-November is an appropriate sampling window for the LVI method.

Methods

Lakes For this project, we sampled a subset of lakes used in the Dissolved Oxygen/Nutrient Monitoring Project (DO Study) of 2005-06. Figure 1 contains a map of lakes included in this project. Lakes were chosen at random to represent a cross-section of the state and landscape development intensities (LDI) sampled in the DO Study. Several lakes were chosen specifically because there was existing FQI (Florida's predecessor to LVI) or LVI data from previous years; however, we did not make any comparisons with older data due to changes in the method since those data were collected.

Sampling Plant sampling followed DEP Draft SOP FS 7210. We sampled 4 of 12 lake sections in both spring and fall. However, during the spring season, we recorded plants in 2 columns, each column representing a 2-section sample, and in fall, we recorded plants in both 2 columns and 4 columns (for 4 1-section samples). The same teams did not sample both dates at a given lake, but for most lakes, there was one person involved in sampling both seasons. We did not as a rule sample the same set of lake sections for both seasons, but rather made a random choice to start at section 1, 2, or 3 each time. Twenty-eight lakes were sampled in spring and fall, while one lake (Lake Fannie) was sampled in spring and summer.

Data Analysis Four lakes (Buck, Iamonia, Miccosukee, Nona) were not included in the analysis because we did not have data for both seasons. For the remaining 29 lakes, we conducted a non-parametric Wilcoxon matched pairs test between spring and fall 2-column LVI scores to determine if there was a difference between seasons. We conducted the same analysis between fall 2-column and fall 4-column LVI scores to ensure that both types of data recording yielded the same answer. The Wilcoxon matched pairs test is the non-parametric test that compares two paired groups. The difference between each set of pairs (e.g., spring – fall LVI

scores at a lake) is compared to zero. We used the non-parametric tests because the paired differences were not normally distributed, a requirement of the paired t-test. LVI scores and component metrics were graphed for a visual comparison between seasons for each site.

We conducted a correlation analysis among LVI scores, water chemistry, and Landscape Development Intensity (LDI) for each season to understand the relationships between water chemistry and the plant community. We conducted a non-metric multidimentional scaling (NMDS) analysis using Bray-Curtis similarity and presence/absence data (pooled spring and fall) of plant taxa to determine the similarity among lakes. We used bubble plots to discern patterns in water chemistry among vegetatively similar lakes. For these plots, we used water chemistry data from the LVI sampling events, as well as data collected for the Dissolved Oxygen study during 2005 at the same lakes.

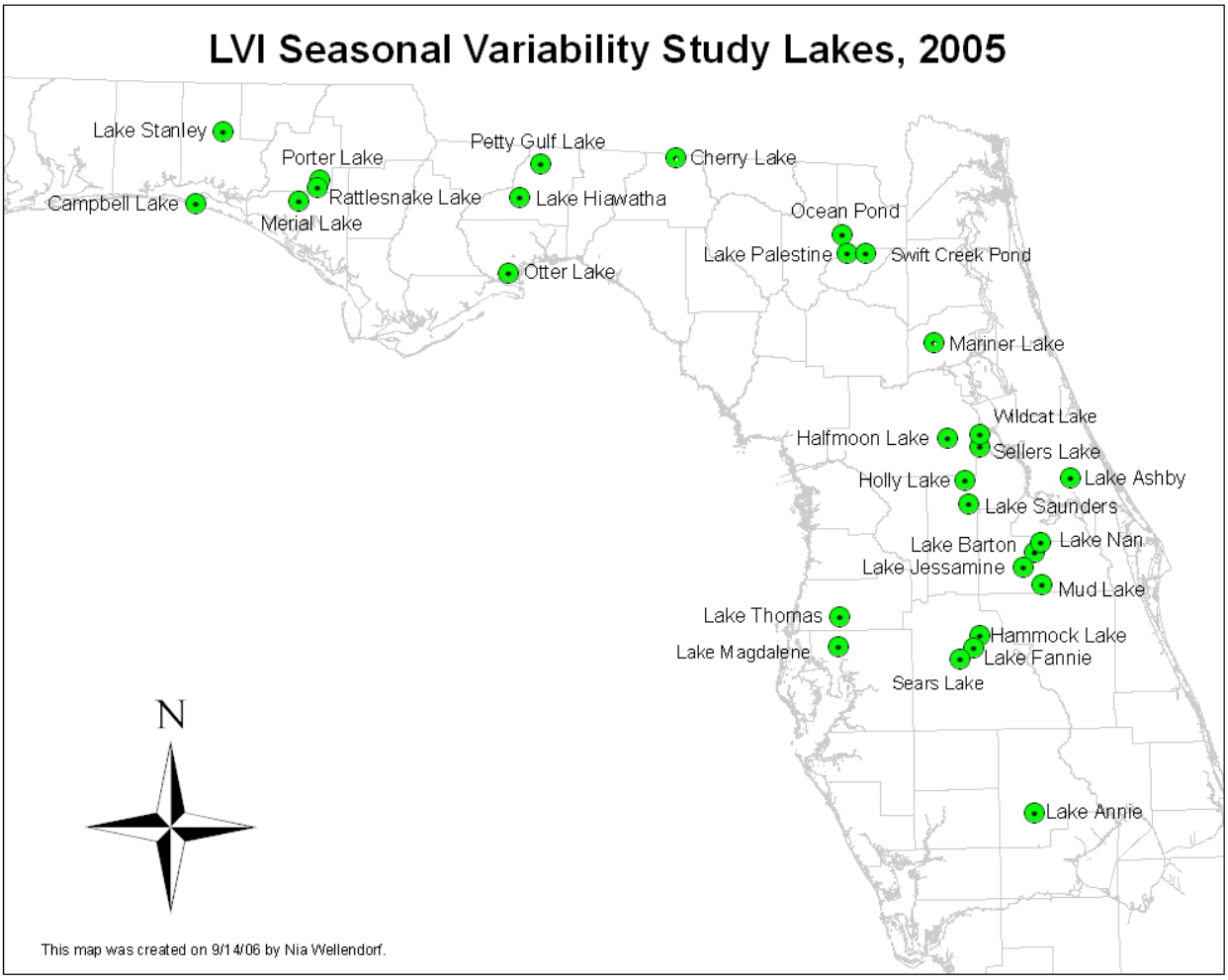


Figure 1. Location of study lakes.

Results

LVI Scores LVI scores (2-column) for the 29 lakes ranged from 29 to 93 in spring, with a median of 71.5, and from 29 to 96.5 in fall, with a median of 68 (Figure 2). Spring and fall 2-column LVI scores were not significantly different ($p = 0.90$; Wilcoxon matched pairs test). Fall 2-column and 4-column LVI scores were also not significantly different ($p = 0.99$; Wilcoxon matched pairs test). Spring and fall 2-column LVI scores differed by ≤ 5 points for 12 lakes

(42%), 5-10 points for 10 lakes (34%), 10-15 for 4 lakes (14%), and > 15 for 3 lakes (10%)(Figure 3). The 7 lakes for which the spring and fall scores were > 10 points apart are further discussed below. Fall 2-column and 4-column scores were < 5 points apart for 24 lakes (86%), 5-10 points apart for 3 lakes (11%), and > 10 points apart for 1 lake (3%). Fall 4-column data were not collected for 1 lake (Lake Fannie).

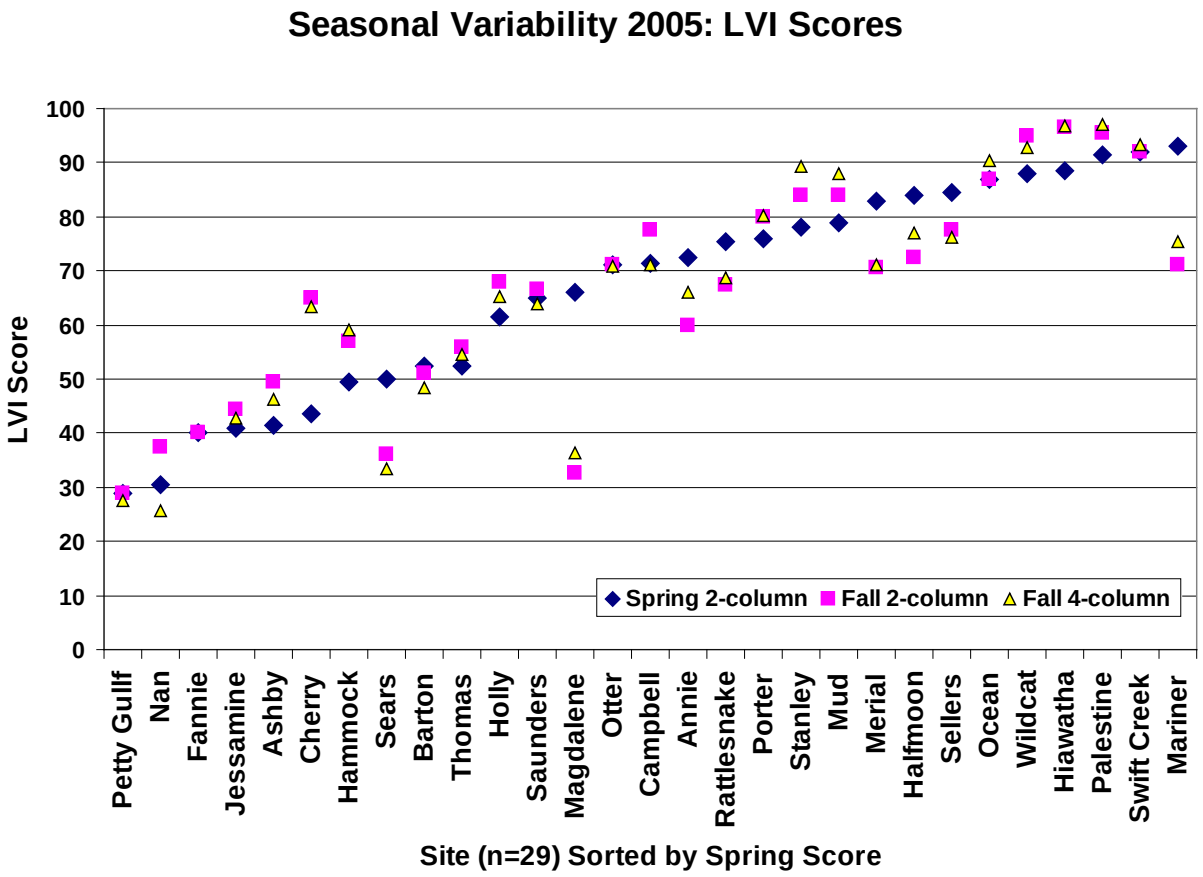


Figure 2. LVI scores for 29 lakes sampled both in the spring and in the fall.

Lakes Halfmoon, Annie, Merial, Sears, Cherry, Mariner, and Magdalene differed by > 10 points between seasons. The following provides possible reasons for those deviations in the order they appear in Figure 3.

- At Halfmoon Lake (11.5 point difference), we observed greater taxa richness in the fall than in the spring, with higher % Exotic and lower % Sensitive in the fall. However, the species that differed between seasons were generally not seasonally-affected species. The differences were more likely caused by the fact that different lake segments were sampled in the spring (1,4,7,10) and fall (3,6,9,12), and thus, species that were not very abundant were spotted in some sections but not others.

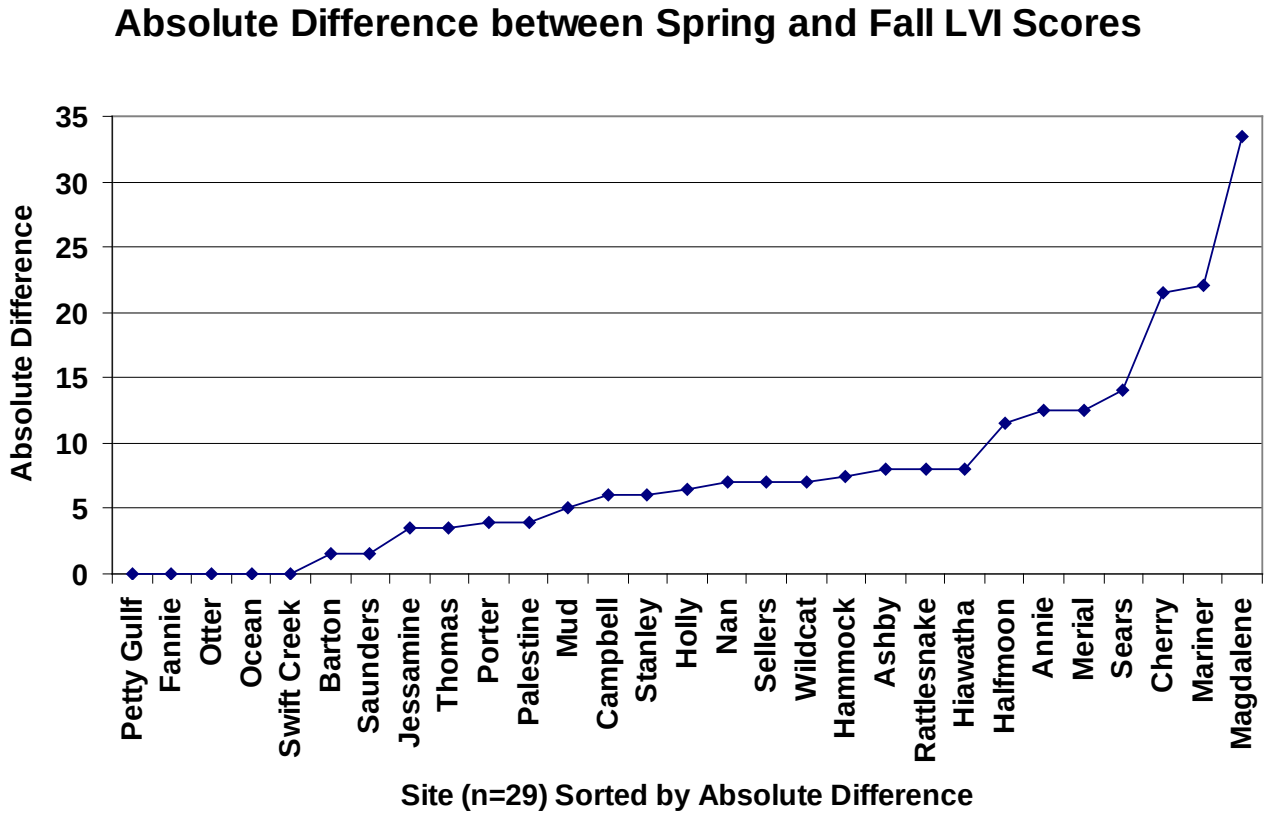


Figure 3. Absolute differences between spring and fall 2-column LVI scores for each lake.

- Lake Annie (12.5 point difference) was sampled in the spring by Bureau of Labs staff and in the fall by staff from DEP's South District. Dominant C of C and % Native metrics were higher in the spring, and these differences may have been due to differences in plant identification. One of the dominant plants in the spring was *Paspalum repens*, which was not identified at all in the fall. Additionally, the exotic *Panicum repens* was listed in the fall but not in the spring. No plant specimens were collected to verify the identifications. Further discussion with samplers revealed that it was indeed *Panicum repens* seen in the spring, but was erroneously recorded as *Paspalum repens*.
- At Merial Lake (12.5 point difference), twice as many taxa were observed in the spring as in the fall, so the % Sensitive value was higher in the spring. Sampling teams were not exactly the same for both seasons, but they had one common sampler, which would allow for some consistency. The same portions of the lake were sampled both seasons. The reason for the difference is not clear.
- Sears Lake (14 point difference) was co-dominated by a high C of C plant (*Vallisneria americana*) and an exotic plant (*Brachiaria mutica*) in the spring, and then dominated by an exotic plant (*Panicum repens*) in the fall, yielding a lower LVI score in the fall. It is possible that the *P. repens* mats grew between sampling events such that it became dominant in the fall, which would be a true seasonal effect of plant growth throughout the summer.
- Cherry Lake (21.5 point difference) scored higher in the fall due to a shift in dominance to an annual plant with a high C of C score, *Najas filifolia,* which is an annual plant, does

not appear until summer, and was not present during the spring sampling. This difference was caused by a true seasonal effect of a late season dominant plant.

- Lake Mariner (22 point difference) had a lower % Native score in the fall, which led to an overall lower score in the fall. Spring and fall sampling teams were different. However, the number of taxa identified between seasons was similar, and there were no major identification (ID) differences. The major difference between the spring and fall sampling was that there were not any genus-level IDs in the spring, but 7 genus-level IDs in the fall. Genus-level IDs reduced the % Native score enough to significantly affect the overall LVI score. An LVI calculation exercise showed that the fall score would have been within 2 points of the spring score if genus-level IDs were excluded from the total taxa calculation.
- At Lake Magdalene (33.5 point difference), the shift in dominant taxa (from *Nymphaea odorata* to *Hydrilla verticillata* and *Najas guadalupensis*) is again the clearest change in a component metric, with a much lower C of C dominant in the fall. *H. verticillata* and *N. guadalupensis* are both prolific species that can increase in abundance over the growing season.

Land Use and Water Chemistry LVI scores for both spring and fall were significantly correlated with landscape development intensity (LDI) scores (Table 1). LVI scores were not strongly correlated with many nutrient analytes. LVI scores for both seasons were significantly correlated with spring Algal Growth Potential (AGP) (Table 1). Spring LVI scores were also significantly correlated with spring TP and fall TKN. As expected, AGP values were significantly correlated with nutrient levels for both seasons (Table 1). Nutrient levels were fairly low overall, so there was not much of a gradient along which to test for relationships (Table 2). Sites with the highest nitrate+nitrite concentrations were Lakes Campbell, Cherry, Halfmoon, Ashby, Sellers, and Swift Creek Pond (range 0.28-0.68 mg/L). Sites with the highest total Kjeldahl nitrogen concentrations were Lakes Halfmoon, Hammock, Fannie, Holly, Jessamine, Magdalene, Palestine, and Swift Creek Pond (range 1.1-1.4 mg/L). Lake Ashby and Hammock Lake were the only sites with total phosphorus concentrations greater than the laboratory practical quantitation limit (range 0.78 – 0.11 mg/L).

Table 1. Correlation matrices for LVI scores, Landscape Development Intensity (LDI), and a) spring (n=29 lakes) and b) fall (n=28 lakes) water chemistry. Correlations statistically significant at p < 0.05 are in bold. AGP – Algal Growth Potential, TKN – Total Kjeldahl Nitrogen, NOx – Nitrate+Nitrite, TP – Total Phosphorus. Fall chemistry data missing for Lake Fannie.

a)

Correlations	LVI Spring	LVI Fall	LDI	AGP Spring	TKN Spring	NOx Spring	TP Spring
LVI Spring	1.0000						
LVI Fall	**0.8508**	1.0000					
LDI	**-0.4901**	**-0.5254**	1.0000				
AGP Spring	**-0.6122**	**-0.4592**	0.0105	1.0000			
TKN Spring	-0.1175	-0.0424	-0.1685	**0.4701**	1.0000		
NOx Spring	-0.0949	0.0927	0.1052	0.2339	-0.1244	1.0000	
TP Spring	**-0.3700**	-0.2025	-0.2845	**0.7464**	0.3170	0.1041	1.0000

b)

Correlations	LVI Spring	LVI Fall	LDI	AGP Fall	TKN Fall	NOx Fall	TP Fall
LVI Spring	1.0000						
LVI Fall	**0.8403**	1.0000					
LDI	**-0.5434**	**-0.5777**	1.0000				
AGP Fall	-0.1179	0.0037	-0.1418	1.0000			

Correlations	LVI Spring	LVI Fall	LDI	AGP Fall	TKN Fall	NOx Fall	TP Fall
TKN Fall	**-0.3765**	-0.2385	0.2875	0.2346	1.0000		
NOx Fall	0.1602	0.2367	-0.3064	**0.5717**	0.1883	1.0000	
TP Fall	-0.3123	-0.2372	-0.1649	**0.7309**	0.3732	0.2992	1.0000

Table 2. Distribution of water chemistry values for spring (n=29) and fall (n=28) sampling of study lakes. AGP – Algal Growth Potential, TKN – Total Kjeldahl Nitrogen, NOx – Nitrate+Nitrite, TP – Total Phosphorus.

Statistic	Spring AGP (mg dry wt/L)	Spring TKN (mg/L)	Spring NOx (mg/L)	Spring TP (mg/L)	Fall AGP (mg dry wt/L)	Fall TKN (mg/L)	Fall NOx (mg/L)	Fall TP (mg/L)
Minimum	0.3	0.11	0.004	0.02	0.3	0.1	0.004	0.004
25th %ile	0.455	0.42	0.004	0.02	0.3	0.365	0.004	0.0115
Median	2.32	0.71	0.004	0.02	0.3265	0.615	0.0055	0.02
75th %ile	4.21	0.95	0.0055	0.0335	0.656	0.8075	0.0145	0.022
Maximum	15.3	1.4	0.068	0.11	3.63	1.0	0.045	0.099

In the bubble plots of the NMDS similarity analysis, lakes close in proximity on the plot have similar plant communities. The size of the bubble representing a lake is determined by the magnitude of its LVI, color, pH, or any other water quality parameter used in that particular plot. In this analysis, highly urban lakes (Saunders, Thomas, Magdalene, Jessamine, Barton, Sears, Nan, Petty Gulf) clustered together, and those tended to have lower mean LVI scores (mean of Spring and Fall; Figure 4). However, Lake Stanley has a fairly high LDI score (Figure 5), but grouped more closely with other panhandle lakes. Most of the high color lakes (Palestine, Ocean Pond, Swift Creek Pond, Otter, Hiawatha) also clustered together (Figure 6). Lake Ashby is a highly colored lake, but it was more similar to the urban lakes, probably due to the high number of exotic species in the lake. There was also a fairly clear separation between lakes of high pH and lakes of low pH (at ~ 6.5 SU; Figure 7), and between lakes with high and low maximum chlorophyll *a* values (Figure 8).

Discussion and Conclusions

Overall, agreement of LVI scores between seasons was very good. However, at 7 lakes (24%), spring and fall LVI scores differed by more than 10 points. LVI scores can be strongly influenced by the dominant species chosen, possible misidentification of plants, identification of plants at the genus level, and the total number of taxa observed. These factors can all be influenced by seasonality, sampler error, and observational differences. Our data suggest that except for lakes containing a high abundance of annual plants or seasonally expanding plants, variability due to samplers and identification level may be greater than that due to seasonal variability.

The dominant species chosen is influenced by sampler bias and by seasonal abundance of plants. Through training, we should continue to make efforts to improve the consistency of dominance assignment. Seasonal variability in dominance is a factor that will not consistently shift the LVI score up or down for a particular season, so it is not something we can correct for or predict (i.e., a late-emerging dominant could have either a high or low C of C score). Based on this study, sampling late in the season would more likely capture species affected by seasonality.

Staff training and ID verification are of the utmost importance to avoid problems of plant misidentification. With additional training, staff become more comfortable with plants they see

and may be more likely to perform at a consistent level of effort. Less familiarity with plant identification led to shorter taxa lists for some teams in a 2005 Biocriteria Meeting interteam variability exercise. In this study, total taxa identified was significantly correlated with the % Exotic (Pearson r = 0.53) and % Native (Pearson r = -0.57) metrics. However, for a single lake, differences in total taxa between seasons did not necessarily lead to differences in % Exotic or % Native metrics, nor were changes that did occur always in the predicted direction (e.g., Lake Barton had more taxa in spring, accompanied by lower % Exotic and higher % Native). Consistency of effort among teams in all aspects of sampling is one of the goals of training.

We can partially address the problem of low scores caused by genus-level identification. Genus-level ID should be avoided if possible, but sometimes genus-level ID is all we can get. A genus-level ID should be counted as native, exotic, or sensitive whenever appropriate. In most cases, CC scores cannot be assigned to genera because of varying sensitivity among species of genera. CC scores for genera would only be necessary to determine a genus' status as sensitive (> 7) or to factor into the index if the genus is the dominant or co-dominant plant. Samplers should make every effort to identify dominant and codominant plants to species level to avoid this problem.

Alternatively, the DEP Macrophyte database could be programmed to discount from calculations of percentage metrics those taxa without the necessary data. For example, a taxon without nativity assigned to it would not be counted in the total taxa portion of the "% Native" metric calculation.

Note

In 2007, several changes were made to the database partially in response to this study. C of C scores were added, native status was assigned at genus level when appropriate, and several plant taxa that were shown to occupy disturbed lakes as often or more often than least disturbed lakes were removed from the Sensitive List. LVI scores for 2005-2007 sampling events were recalculated to reflect these changes. The data presented in this report reflect original scores before those changes were made.

For further information about this study, please contact Nia Wellendorf at (850)245-8190 or nijole.wellendorf@dep.state.fl.us.

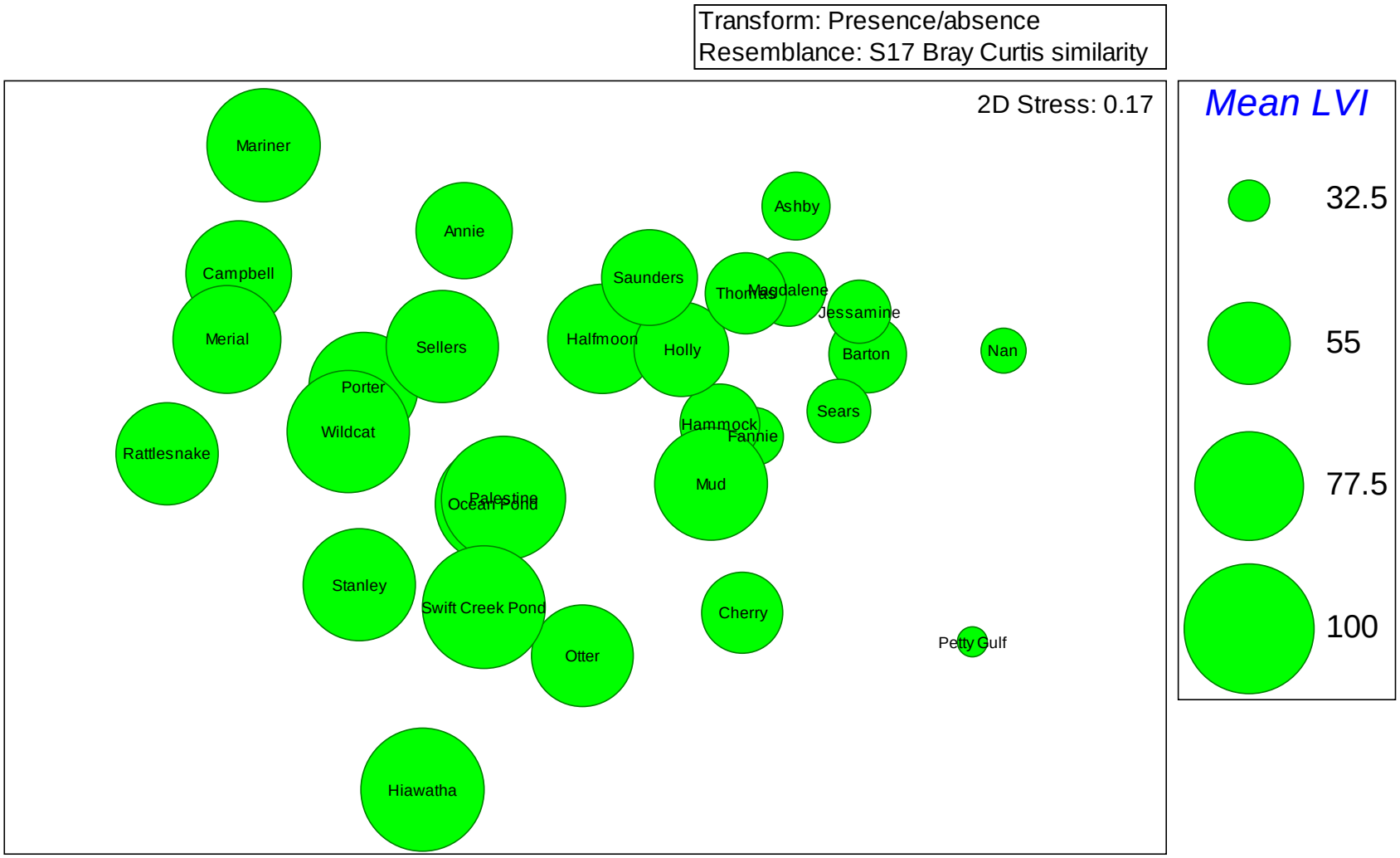


Figure 4. Results of a non-metric multidimentional scaling (NMDS) analysis using Bray-Curtis similarity and presence/absence data (pooled spring and fall) of plant taxa. Size of bubbles indicates the mean Lake Vegetation Index (LVI) score (mean of spring and fall) for each lake.

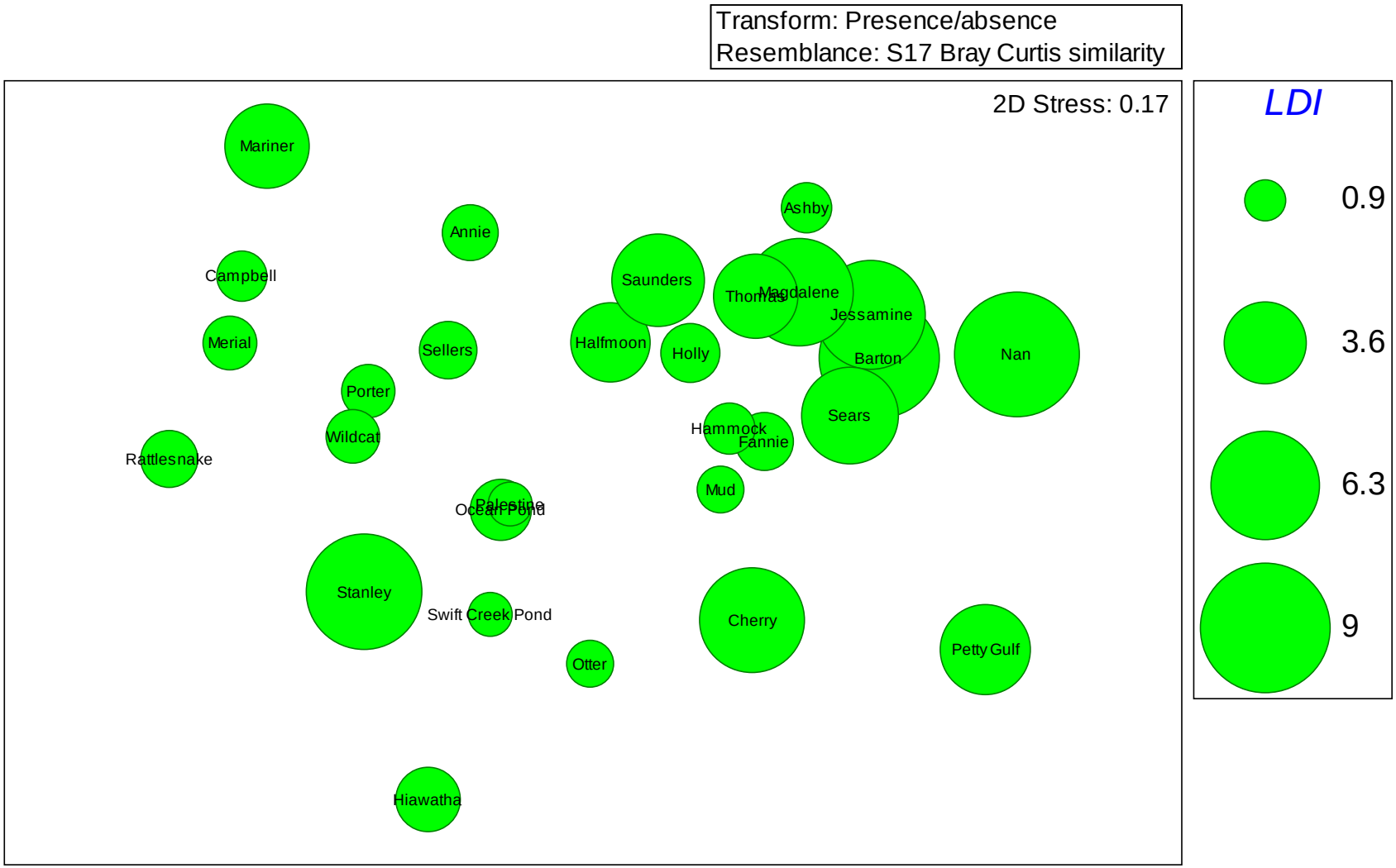


Figure 5. Results of a non-metric multidimentional scaling (NMDS) analysis using Bray-Curtis similarity and presence/absence data (pooled spring and fall) of plant taxa. Size of bubbles indicates the Landscape Development Intensity (LDI) score for each lake.

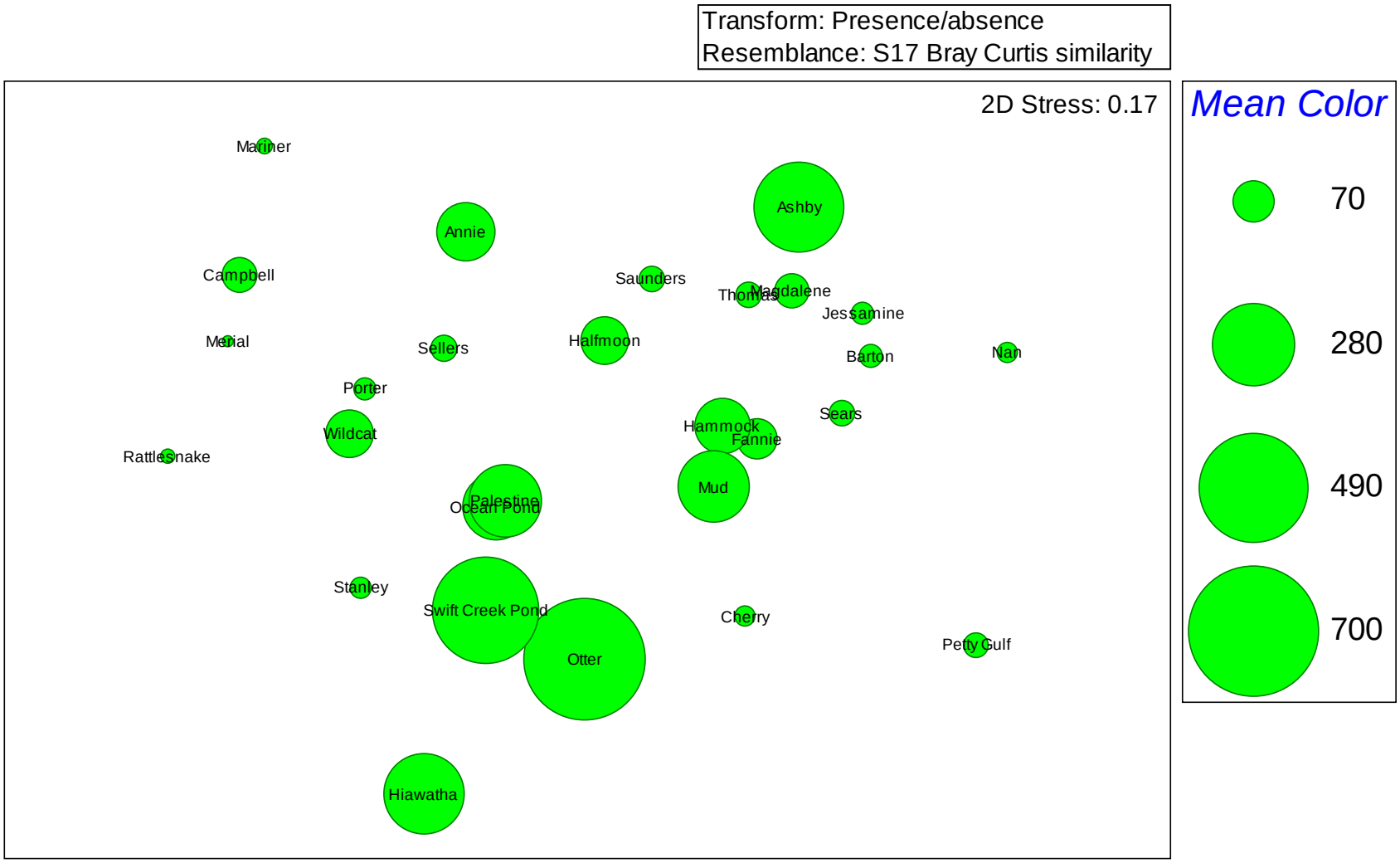


Figure 6. Results of a non-metric multidimentional scaling (NMDS) analysis using Bray-Curtis similarity and presence/absence data (pooled spring and fall) of plant taxa. Size of bubbles indicates the mean color (PCU, mean of data from three quarters of DO Study) for each lake.

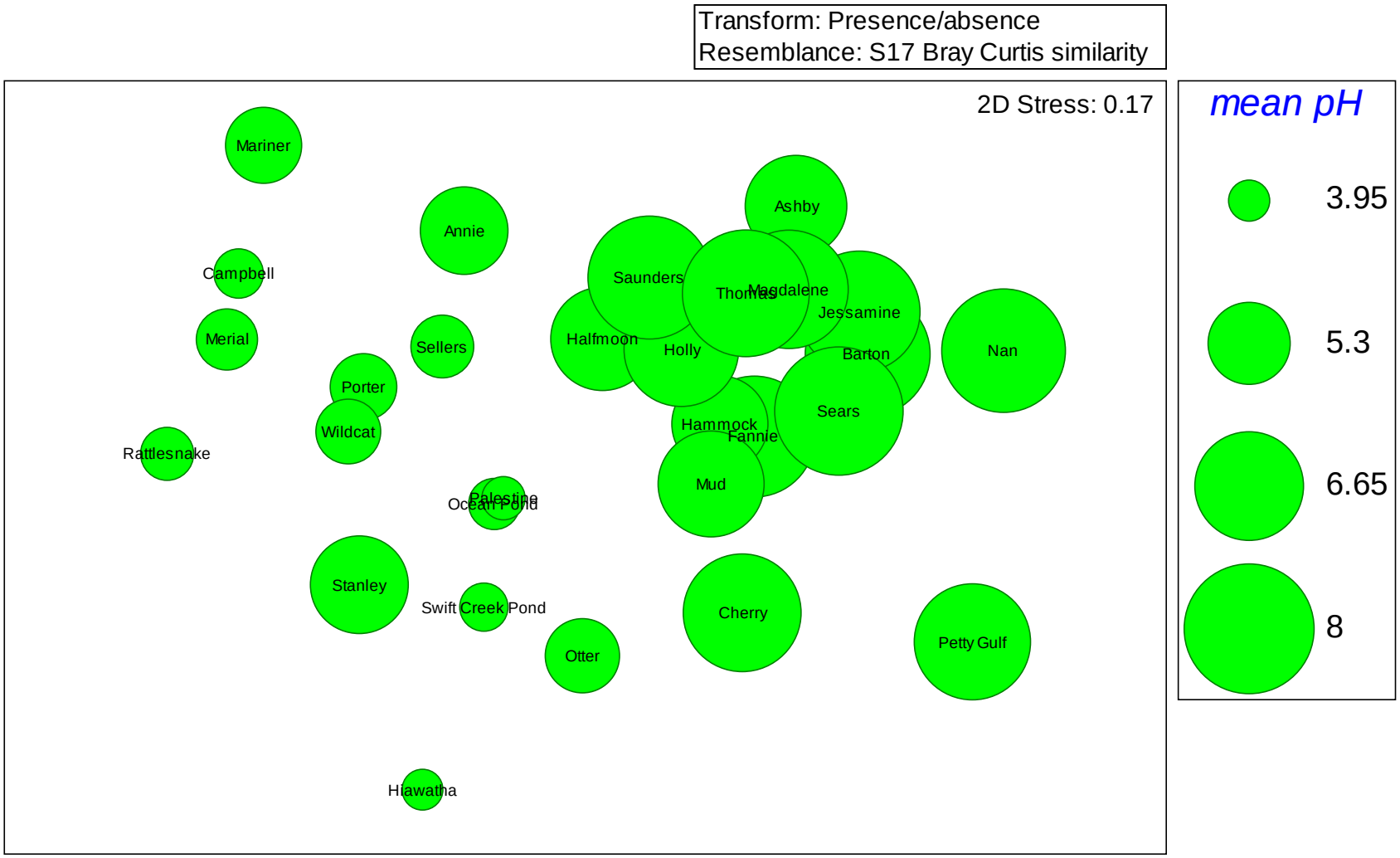


Figure 7. Results of a non-metric multidimentional scaling (NMDS) analysis using Bray-Curtis similarity and presence/absence data (pooled spring and fall) of plant taxa. Size of bubbles indicates the mean pH (SU, mean of spring and fall from LVI sampling) for each lake.

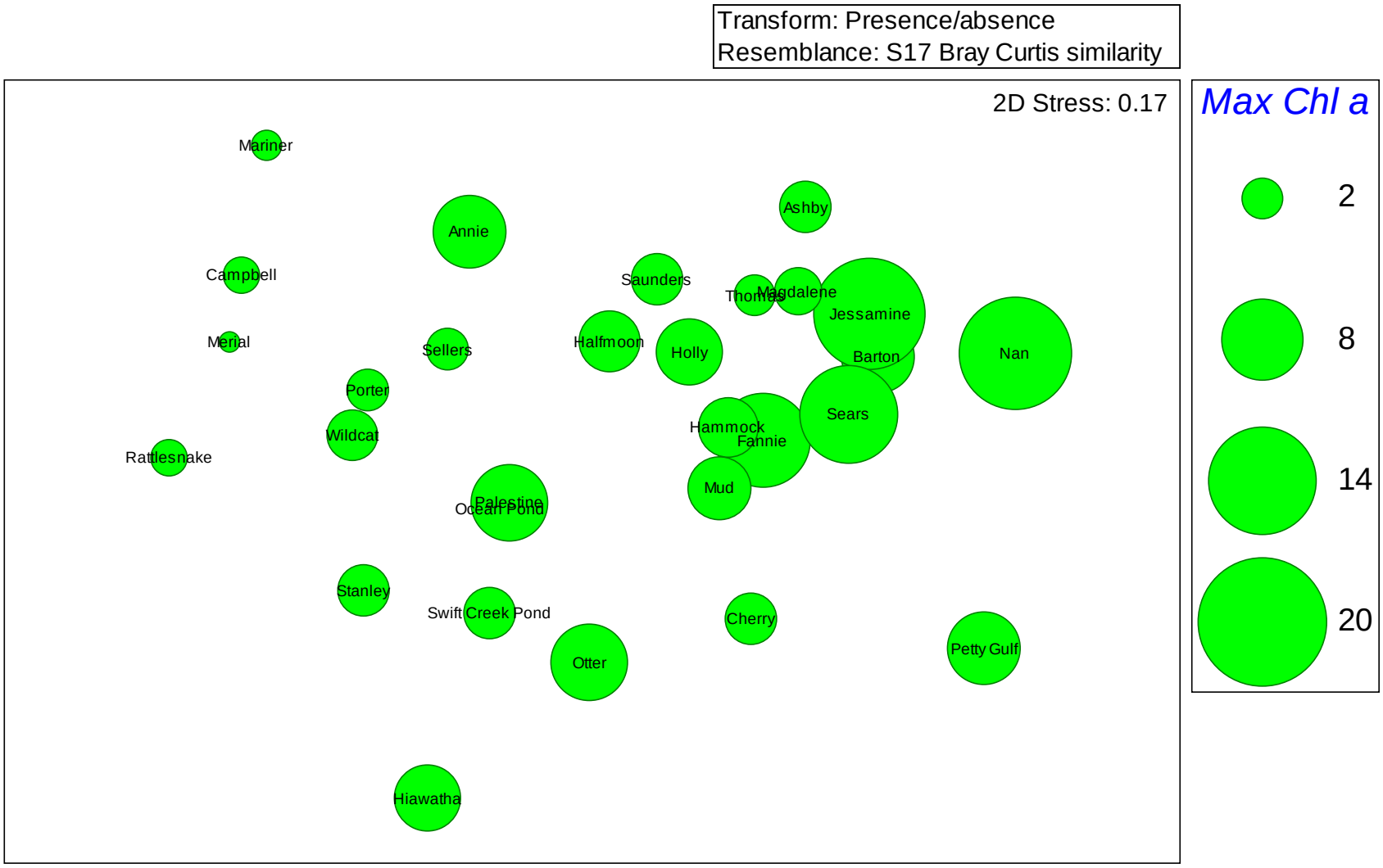


Figure 8. Results of a non-metric multidimentional scaling (NMDS) analysis using Bray-Curtis similarity and presence/absence data (pooled spring and fall) of plant taxa. Size of bubbles indicates the maximum chlorophyll a value (mg/L, maximum of data from three quarters of DO Study) for each lake.