The Winter Haven Chain of Lakes

Purpose

Vegetative surveys were performed during the summer of 2007 to provide macrophyte data for each lake in the Winter Haven Chain of Lakes.

Introduction

The Winter Haven Chain of Lakes (WHCOL) is composed of 21 interconnected lakes located within and around the City of Winter Haven in north-central Polk County (SWFWMD, 1999). The Northern Chain is composed of five lakes: Haines, Rochelle, Conine, Smart, and Fannie (Figure 1). These lakes are inter-connected by canals, and lake stage is managed by a single control structure between Lake Smart and Lake Fannie (operated by the SWFWMD). Lake Fannie's water level is controlled by a second control structure that is located on the eastern shore of Lake Fannie and empties into the Peace Creek Canal.

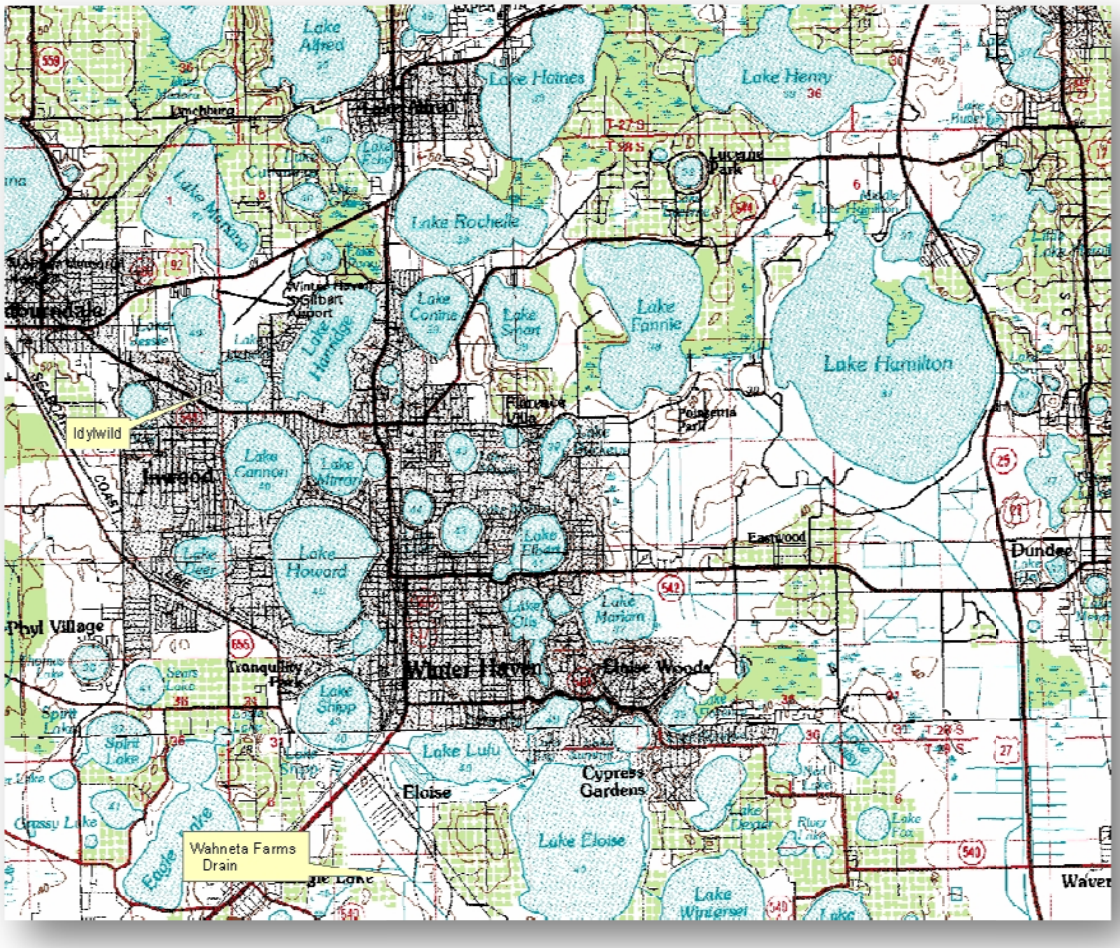


Figure 1. Winter Haven Chain of Lakes Watershed

The southern Chain of Lakes is made up of 16 interconnected lakes: Jessie, Idylwild, Hartridge, Cannon, Mirror, Spring, Howard, May, Shipp, Lulu, Roy, Eloise, Summit, and Winterset, Mariana and Blue. Surface outflows from this group of lakes are controlled by structures on Lakes Hartridge and Lulu. Lake Hartridge can discharge to the Northern Chain via Lake Conine when levels are high but typically flows south via Lakes Idylwild and Cannon through Lakes Howard and Shipp ultimately to Lake Lulu (SWFWMD, 1998). A control structure then discharges to the Wahneta Farms Drainage Canal and eventually to the Peace River via the Peace Creek Canal.

The watershed of the WHCL is approximately 32 square miles and includes portions of the cities of Winter Haven, Lake Alfred and Auburndale. Watershed land use is shown in Figure 2. The Northern Chain is less developed than the southern part of the chain, with agriculture (pasture, row crops and citrus) the predominant land use. The land use in the Southern chain is primarily medium density residential development. Residential development accounts for more than one third of all the land uses in the entire WHCOL watershed (Figure 3).

Historically, the WHCL occupied individual basins and each lake's water level was controlled by natural physical factors. The construction of connecting canals as the area developed changed the hydrology of the lakes. Increasing development of the watershed created the need for man-made control structures in order to provide residential flood protection.

Minimum lake levels have been adopted for all lakes in the Winter Haven Chain of Lakes (SWFWMD, 1998). Adopted levels for all lakes on the Southern Chain of Lakes are the same and are as follows: 10-year flood warning level of 132.60 feet; minimum flood level of 132.00 feet; minimum low management level of 129.50 feet; and minimum extreme low management level of 127.00 feet. The adopted levels for all lakes on the Northern Chain with the exception of Lake Fannie are as follows: 10-yearflood warning level of 129.70 feet; minimum flood level of 128.75 feet; minimum low management level of 126.50 feet; and minimum extreme low management level of 124.50 feet. Adopted levels for Lake Fannie are as follows: 10-yearflood warning Level of 127.00 feet; minimum flood level of 125.75 feet; minimum low management level of 123.50 feet; and minimum extreme low management level of 120.00 feet. During drought periods, some of the canals have been known to go dry, resulting in the hydrological disconnection of some lakes from the chain.

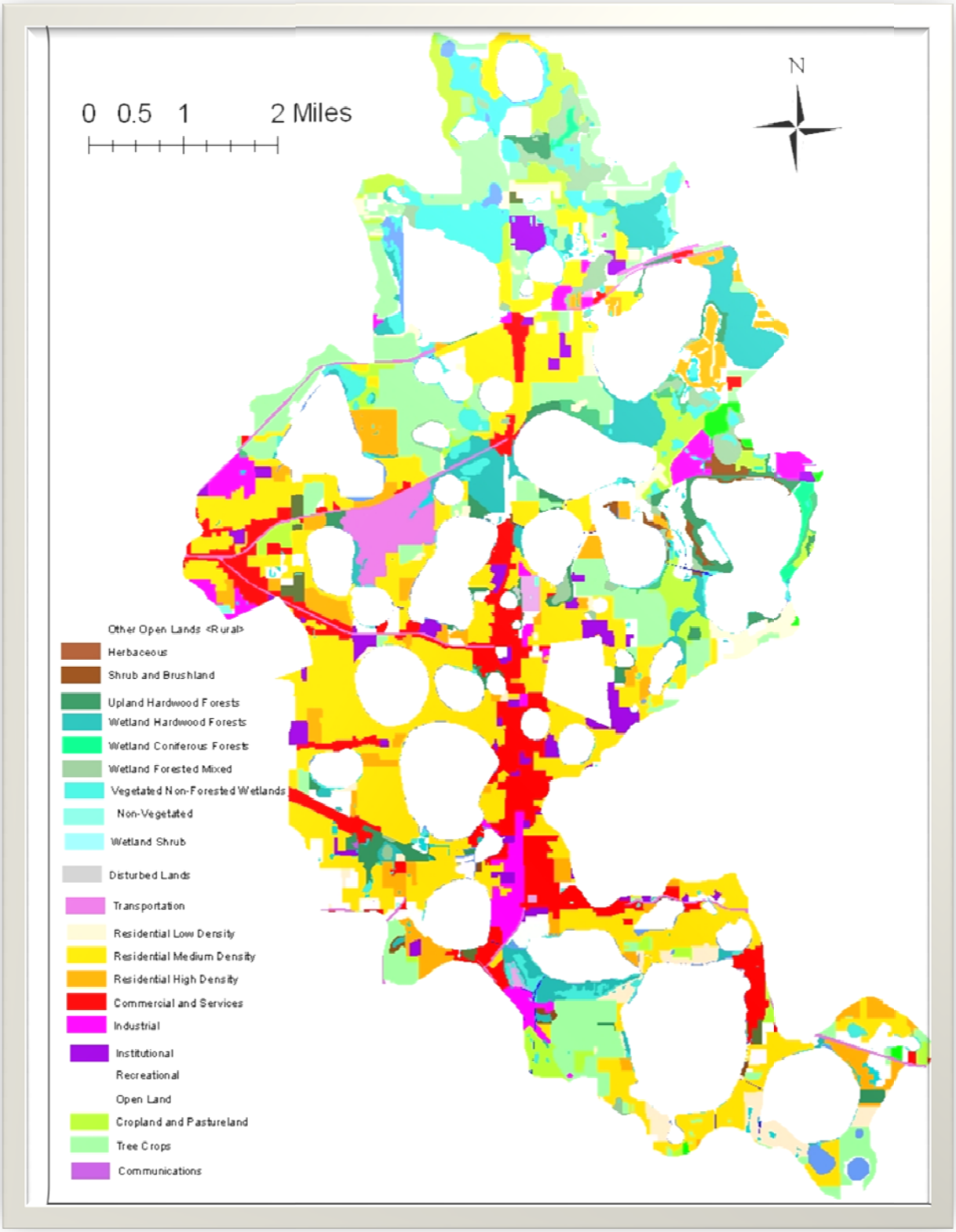


Figure 2. Land use cover in the Winter Haven Chain of Lakes Watershed (2004 SWFWMD land use data).

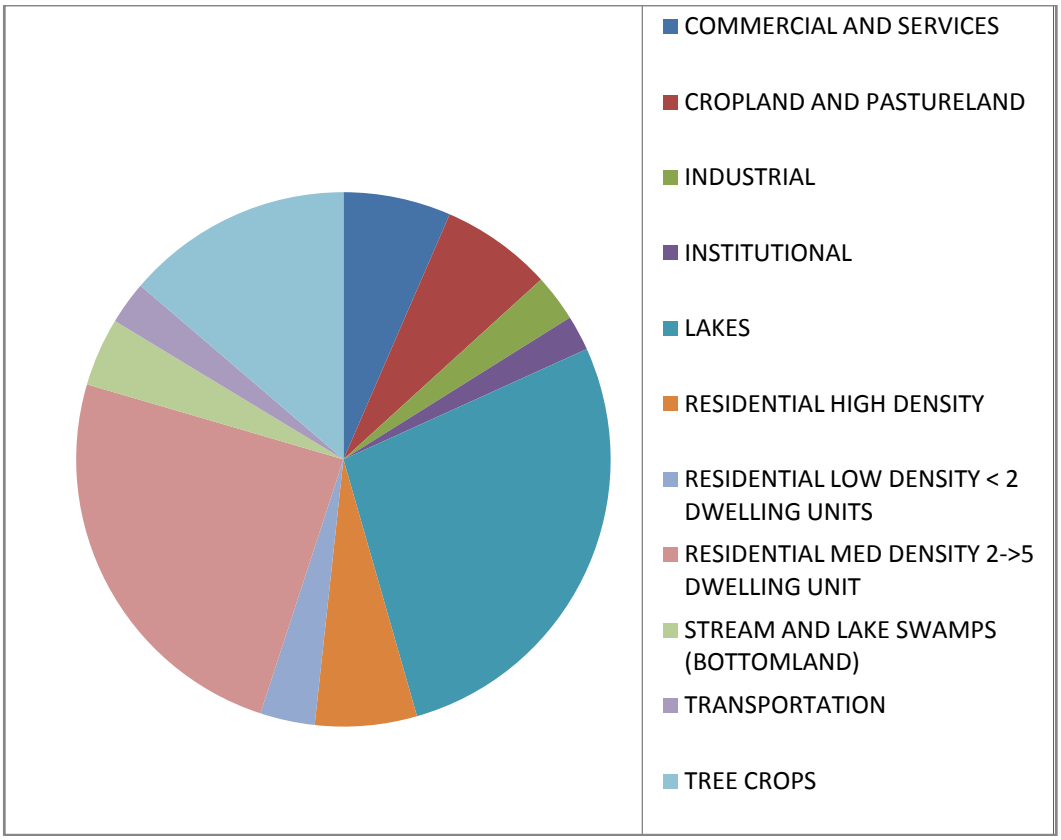


Figure 3. Percentages of Major Land Uses in the Winter Haven Chain of Lakes Watershed. SWFWMD 2004 data.

Methods

Lake Vegetative Index surveys were performed on each lake following the methodology developed by FDEP (FDEP DEP-SOP-002/01 LT 7000; Fore et al, 2007). The LVI consists of four metrics describing plant community structure that were found to be strongly correlated with an independent gradient of human disturbance: percent native taxa, percent invasive exotic taxa, percent sensitive taxa, and the average tolerance value of the dominant taxon or co-dominant taxa.

Each lake was divided into 12 "pie slices" from which 4 diametrically opposite slices were randomly chosen. Emergent plants along the shore were identified from an idling boat, or by wading if the boat wasn't able to get close to shore. A transect from the shoreline to the sublittoral was chosen for each slice, and macrophytes were identified. Uncertain identifications were sent to Dr. David Hall, an expert botanist for verification. Submersed vegetation was collected using a "frotus" collecting device, 4 to 5 times along the transect. A frotus is a specially-adapted garden rake that can be thrown and dragged along the bottom to collect submersed vegetation.

The land use in a 100m buffer zone around each lake was calculated using ArcGIS and 2004 SWFWMD Land Use data. Individual land use categories were combined to create 3 main categories. Natural land use was composed of emergent aquatic vegetation, hardwood conifer mixed, intermittent ponds, rural open lands, stream and lake swamps, streams and waterways, wetland forests mixed, cypress, freshwater marshes, pine flatwoods, wet prairies, wetland coniferous forest, and upland coniferous forest. Agriculture included cropland and pastureland, tree crops, tree plantations, nurseries and vineyards, and shrub and brushland. Urban development consisted of residential (low, medium and high densities), commercial and services, industrial, institutional, non-rural open lands, utilities, golf courses, reservoirs, transportation, and recreational land uses. The LVI results were compared to land use type and amount.

Physiochemical parameters were collected at bottom, mid-depth and surface with a YSI multiprobe sonde. Parameters measured were Dissolved Oxygen (DO), pH, temperature and conductivity. Polk County data were used to summarize surface water quality trends, using data summarized and posted in the Polk County Water Atlas. (http://www.polk.wateratlas.usf.edu/navigator/). The parameters that best reflect water quality in lakes include Trophic State Index (TSI), nutrients (nitrogen and phosphorus), chlorophyll (chl-a) and water clarity (Secchi depth). The TSI describes a lake's stage of eutrophication. Eutrophication is natural aging process in a lake, but can be unnaturally accelerated by an excess of nutrients. These excess nutrients can stimulate excessive plant growth including algae, periphyton (attached algae), and nuisance weeds. Enhanced algae growth in the water column can produce an algal bloom, which often reduces dissolved oxygen (DO) in the water when dead plant material decomposes. This depletion of DO can cause other organisms to die, most notably fish. The amount of chlorophyll, which is manufactured by plant cells, is an indicator of this imbalance of algal growth due to excess nutrients. The TSI value reflects how eutrophic a lake is on a scale of 1 to 100; the higher the TSI, the higher the nutrients and the more likely the lake is receiving excessive nutrients from a human source. A lake with a TSI between 71 and 100 is considered to be extremely eutrophic, with an over abundance of nutrients and a strong potential for an imbalance in biological productivity, accompanied by wildly ranging DO levels that could result in fish kills.

Results

Lake Vegetation Index

Results of the LVI survey are summarized in Table 1. Percentages of major land uses and most abundant plant species are also included. Ten year trends

in TSI scores based on Polk County monitoring data are categorized as increasing, decreasing, or none.

Chapter 62-302 of the Florida Water Quality Standards proposes three categories of aquatic life use support based on two LVI scores per site. Lakes with LVIs of 46 or lower are defined as impaired. Those with scores between 46 and 77 are within the range of expected values for healthy plant communities but may reflect a range of potential environmental impacts. Those with LVIs 78 or higher are exceptionally healthy and indicate fewer human impacts or greater ability to assimilate inputs. Of the Winterhaven Chain of Lakes, 16 out of 21 lakes qualified as impaired. Lake May had the lowest LVI score (18) and Lake Idylwild had the highest (58). The average value was 41 and the median value was 42. Given the general urbanization of the entire region and the interconnection of all the lakes, low LVI scores are not surprising. Nuisance and exotic flora would be readily distributed via boats travelling between lakes. The lakes scoring in the impaired category were Rochelle, Fannie, May, Conine, Smart, Spring, Jesse, Hartridge, Cannon, Mirrow, Lulu, Roy, Summit, Winterset, Mariana, and Blue. Lakes receiving a mid-range score were Haines, Idlewild, Shipp, Eloise and Howard. None of the lakes were in the exceptional category.

The LVI scores were not correlated with land use percentages (Figures 4, 5 and 6).

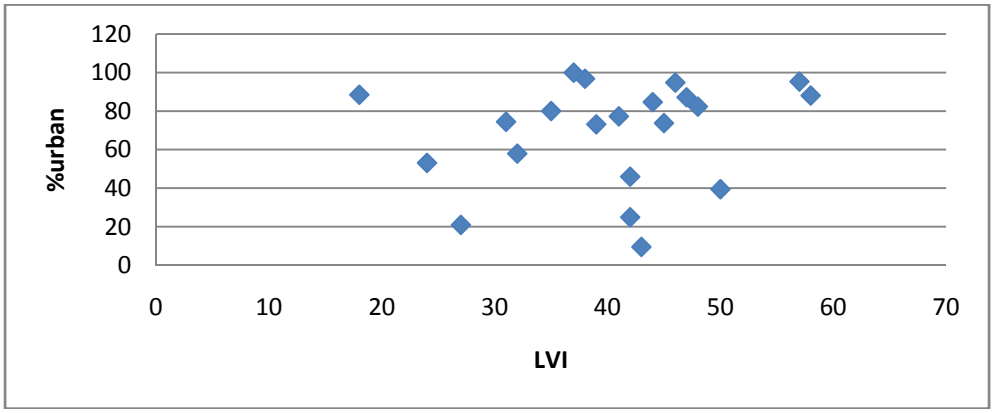


Fig. 4. LVI scores for lakes with varying percentage of urban land uses within a 100 m buffer of the lake shore.

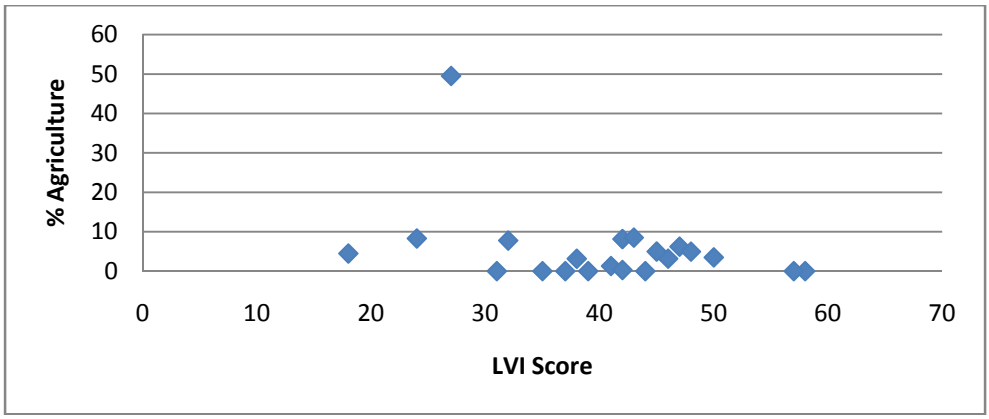


Fig. 5. LVI scores for lakes with varying percentage of agricultural land uses within a 100 m buffer of the lake shore.

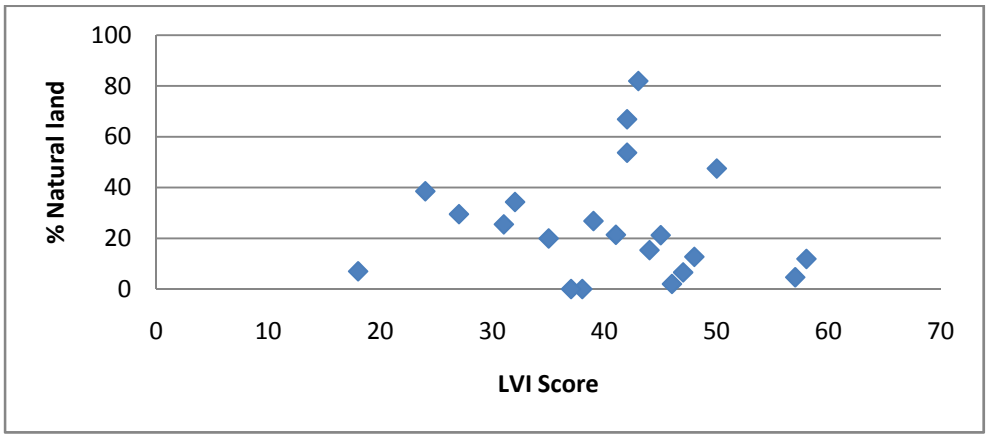


Fig. 6. LVI scores for lakes with varying percentage of natural land uses within a 100 m buffer of the lake shore.

The lakes with the highest relative percentage of natural land use did not have the highest LVI scores. In fact, the lakes with the highest LVI scores had some of the least natural buffers and some of the densest urbanization. This apparent lack of correlation with land use percentages is likely due to the fact that the Winterhaven Chain of Lakes are interconnected. They, in effect, operate as a single entity and land use water quality trends, as well as exotic and/or nuisance vegetation, are distributed thoughout the entire chain regardless of where it originated.

Water Quality and Aquatic Vegetation

Land use percentages (100 meter buffer), TSI ranges and 10 year TSI potential trends summarized on the Polk County Water Atlas are shown in Table 1. (http://www.polk.wateratlas.usf.edu/navigator/). Water quality data ranges were variable, however most extended from the late 1980s to the 2009. The

potential trends in TSI were inferred from the 10 year graphs of annual average values. The majority of the Winterhaven lakes experienced TSI values ranging higher than 70, indicating periods of eutrophication. Lakes with scores never falling into the eutrophication range were Hartridge, Roy, Summit and Winterset. Of the latter, the TSI for Lake Hartridge may show a slight increase over the last ten years, while it may be decreasing for Lake Winterset. The ten year TSI graphs for Lakes May and Roy show no obvious trends.

The ten year TSI graphs suggest that Lakes Smart, Fannie, Jessie, Idylwild, Hartridge, Mariana and Blue may becoming more eutrophic. Lakes Mirror and Winterset may be becoming less eutrophic. The rest of the lake show no apparent trend.

Table 1. Summary of LVI results, water quality trends, and land cover

Lake	LVI	Historical TSI range	potential TSI 10 yr trend	% exotic	% sensitive species	Total Taxa	% urban land uses	% natural land	% Agriculture	Most abundant species
Haines	50	47-92	none	12.9	9.7	31	39.5	47.49	3.5	H. verticillata, T. latifolia
Rochelle	42	50-74	none	16.1	12.9	31	24.97	66.88	8.14	*T. latifolia*
Conine	24	48-95	none	18.2	9.1	22	53.16	38.53	8.3	*T. latifolia, V. americana*
Smart	27	41-87	increasing	17.6	8.8	34	20.98	29.5	49.52	*T. latifolia, P. hemitomon*
Fannie	43	41-73	increasing	7.9	13.2	38	9.55	81.95	8.51	*H. verticillata, L. peruviana, Nuphar*
Jessie	39	45-77	increasing	14.3	7.1	42	73.2	26.79	0	*V. americana, T. latifolia, P. repens*
Idylwild	58	48-74	increasing	7.9	7.9	38	88.11	11.88	0	*V, americana, T. latifolia*
Hartridge	41	18-69	increasing	11.8	5.9	51	77.32	21.39	1.3	*P. repens*
Cannon	46	22-78	none	7.9	10.5	38	94.84	2	3.18	*T. latifolia*
Mirror	35	41-76	decreasing	16	4	25	80.08	19.92	0	*P. repens*
Spring	31	22-78	none	10.8	0	46	74.51	25.49	0	*L. peruviana, T. domingensis*
Howard	57	28-75	none	11.4	6.8	44	95.37	4.64	0	*P. geminatum*
May	18	49-78	none	20	4	25	88.54	6.98	4.48	*Typha*
Shipp	47	54-106	none	13.5	13.5	37	87.23	6.55	6.22	*T. latifolia, S. californicus*
Lulu	42	50-71	none	14.6	12.2	41	46	53.71	0.3	*Typha*
Roy	38	35-65	none	20.9	2.9	34	96.85	0	3.15	*V.americana, P. repens*
Eloise	48	37-75	none	14.6	7.3	41	82.37	12.7	4.95	*P. illinoensis, P. repens*
Summit	44	38-62	none	18.42	3.1	38	84.69	15.32	0	*V. americana, Najas, P. repens*
Winterset	45	37-63	decreasing	13.5	8.1	37	73.8	21.22	4.98	*P. hemitomon, P. repens*
Mariana	32	37-73	increasing	11.9	5.1	59	57.96	34.29	7.77	*T. latifolia, V. americana, P. repens*
Blue	37	51-88	increasing	16.1	6.45	31	100	0	0	*P. repens, P. geminatum*

The cattails, *Typha latifolia* and *T. domingensis*, were present in nearly every lake. The exotic invasive emergent grass (*Panicum repens*) and the native submerged tape grass, *Vallisneria americana*, were also very abundant. The exotic submerged grass, *Hydrilla verticulata*, was noted in many of the lakes, but was particularly invasive in Lakes Haines and Fannie. The highly invasive water spinach (*Ipomoea aquatica*) was creeping toward the water on the south side of Lake Lulu.

Field parameters are summarized in Table 2. Data for Lakes Blue and Spring was lost.

Dissolved Oxygen (DO) was hyper-saturated at Lakes Lulu and Shipp, indicating strong algal blooms. Lakes Mirror, Cannon and May had surface DO values greater than 9.0 mg/l at the surface, reflecting probable lesser algal blooms. Most of the lakes were shallow and well mixed, showing little or no stratification of temperature and DO, excepting Summit, Smart, Mirror and Roy. These four lakes exhibit anoxia at bottom depth. The deepest lake, Lake Winterset at 7 m, was well oxygenated from surface to bottom, indicating its water is better circulated.

Secchi depth, which measures how far light penetrates into the water column, was less than 1 meter in all the lakes. Lakes Howard and May had the lowest secchi depth, only 0.1 meter.

Table 2. Field parameters for surface, middle and bottom depths in Winter Haven Chain of Lakes. Data from Spring Lake and Lake Blue was lost.

Lake	Sample Date	Sample depth (m)	Conductivity (umho/cm)	Dissolved Oxygen (mg/l)	pH (SU)	Secchi Depth (m)	Temperature (^{0}C)
Lake Cannon	9/27/2007	0.2	229	9.65	8.74	0.45	30.22
Lake Cannon	9/27/2007	2	229	9.97	8.77		
Lake Cannon	9/27/2007	4	229	6.29	7.5		27.99
Lake Howard	9/26/2007	0.2	233	8.51	7.97	0.1	28.4
Lake Howard	9/26/2007	2	233	8.42	7.92		28.1
Lake Howard	9/26/2007	4	233	7.73	7.47		27.8
Lake May	9/26/2007	0.2	239	9.84	8.2	0.1	28.69
Lake May	9/26/2007	1.2	238	8.85	8.01		28.35
Lake Winterset	9/27/2007	0.2	249	8.11	7.91	0.9	29.22
Lake Winterset	9/27/2007	3.5	248	8.44	8.01		28.21
Lake Winterset	9/27/2007	7	247	7.38	7.37		27.97
Lake Smart	9/7/2007	0.5	267	7.14	8.46	0.45	30.25
Lake Smart	9/7/2007	1.5	267	7.06	8.43		30.16
Lake Smart	9/7/2007	3	267	0.6	8.26		29.87
Lake Mariana	6/27/2007	0.3	251	7.47	8.49	0.7	30.05
Lake Mariana	6/27/2007	1.07	251	7.34	8.42		29.76
Lake Mariana	6/27/2007	2.04	250	6.69	7.98		29.28
Lake Hartridge	6/27/2007	0.3	239	8.21	8.76	0.75	30.75
Lake Hartridge	6/27/2007	2	239	7.93	8.69		30.39
Lake Hartridge	6/27/2007	3.9	240	6.2	7.55		29.5
Lake Rochelle	6/26/2007	0.3	251	6.82	8.83	0.6	30.28
Lake Rochelle	6/26/2007	1.5	250	6.57	8.76		30.13
Lake Rochelle	6/26/2007	2.9	251	5.5	8.14		29.47
Lake Haines	6/26/2007	0.3	254	6.47	8.49	0.8	29.9
Lake Haines	6/26/2007	1.8	255	5.81	8.22		29.47
Lake Haines	6/26/2007	3.6	258	3.23	7.32		29.07

Table 2 continued. Field parameters for surface, middle and bottom depths in Winter Haven Chain of Lakes

Lake	Sample Date	Sample depth (m)	Conductivity (umho/cm)	Dissolved Oxygen (m)	pH (SU)	Secchi Depth (m)	Temperature (^{o}C)
Lake Jessie	7/11/2007	0.3	238	8.9	8.75	0.3	31.59
Lake Jessie	7/11/2007	1.4	238	8.89	8.74		31.47
Lake Jessie	7/11/2007	2.5	238	5.49	7.74		30.59
Lake Idylwild	7/11/2007	0.3	238	8.34	8.63	0.4	31.7
Lake Idylwild	7/11/2007	1.4	238	7.99	8.56		
Lake Idylwild	7/11/2007	2.6	243	1.56	6.94		30.1
Lake Fannie	7/6/2007	0.3	296	5.23	8.5	0.75	30.16
Lake Fannie	7/6/2007	0.9	297	4.47	7.55		29.13
Lake Fannie	7/6/2007	1.7	297	4.95	7.09		29.13
Lake Lulu	7/25/2007	0.3	273	12.69	8.92	0.5	32.08
Lake Lulu	7/25/2007	1.1	272	10.42	8.75		28.76
Lake Lulu	7/25/2007	2.2	273	3.7	7.29		27.91
Lk Shipp	7/25/2007	0.3	255	14.19	9.3	0.4	29
Lk Shipp	7/25/2007	1.2	258	6.98	8.5		28.2
Lk Shipp	7/25/2007	2.1	257	8.51	8.51		27.98
Lake Summit	7/20/2007	0.3	298	8	8.48	0.8	32
Lake Summit	7/20/2007	2.5	296	7.45	8.33		31.47
Lake Summit	7/20/2007	4.6	300	0.46	6.83		30.12
Lake Mirror	7/18/2007	0.3	243	9.99	8.7	0.3	32.7
Lake Mirror	7/18/2007	2	243	9.3	8.4		31.4
Lake Mirror	7/18/2007	3.8	306	0.23	6		29
Lake Roy	7/18/2007	0.3	262	8.03	8.5	0.9	32.1
Lake Roy	7/18/2007	3	262	6.85	8.3		31.2
Lake Roy	7/18/2007	6	294	0.31	6.4		26.6
Lake Conine	7/31/2007	0.3	264	7.3	8.61	0.7	30.03
Lake Conine	7/31/2007	1.5	265	6.26	8.32		29.82
Lake Conine	7/31/2007	3	319	4.33	7.7		29.49
Lake Eloise	8/3/2007	0.3	287	7.7	8.18	0.9	29.47
Lake Eloise	8/3/2007	2.3	287	7.89	8.24		
Lake Eloise	8/3/2007	4.6	286	6.9	7.93		20.65

Conclusions

Sixteen out of the 21 lakes in the Winter Haven Chain of Lakes scored in the Category 3 range (impaired) as proposed in Chapter 62-302 of DEP's Surface Water Quality Standards (≤ 46). These were Rochelle, Fannie, May, Conine, Smart, Spring, Jesse, Hartridge, Cannon, Mirrow, Lulu, Roy, Summit, Winterset, Mariana, and Blue. Lakes Haines, Idlewild, Shipp, Eloise and Howard scored above 46. None of the lakes scored in Category 1 (exceptional).

The aquatic macrophyte community and resulting LVI scores were not correlated to individual lake natural land use categories, or percentages of urbanization and agriculture. Because the lakes are linked to one another by canals, land uses tend to affect them as one unit. This connected hydrology also facilitates the spread of exotic and invasive plants chain-wide.

Lakes Lulu and Shipp were experiencing an algal bloom at the time of the LVI surveys, based upon the saturated oxygen and pH levels; however, no dead fish were observed. Lake Lulu received a LVI scored of 42, but Lake Shipp managed one point over the impaired threshold range (47).

References

Dames and Moore, lnc. 1990. Winter Haven Lake Pollution Study. Tampa, Florida. 74 pp +figures and tables.

Fore, L. 2007. Assessing the Biological Condition of Florida Lakes: Development of the Lake Vegetation Index (LVI)

Polk County Water Atlas, http://www.polk.wateratlas.usf.edu/

SWFWMD, 1998. Winter Haven Chain of Lakes Surface Water Improvement and Management (S. W. I. M.) Plan.

Whitmore, T.J and M. Brenner, 2002. Paleolimnological Characterization of Pre-disturbance Water Quality Conditions in EPA-Defined Florida Lake Regions. Prepared for the Department of Environmental Protection, Tallahassee, Florida.

Whitmore, T.J. and M. Brenner. 1995. Historic Water Quality Assessment of Selected Lakes in the Winter Haven Chain of Lakes. Final Report to Southwest Florida Water Management District. Department of Fisheries and Aquatic Sciences. University of Florida, Gainesville, Florida. 31 pp. + appendicies.

Water and Air Research, Inc. 1980. Lake Howard Restoration Study. Prepared in cooperation with the Central Florida Regional Planning Council. 51 pp + appendices.