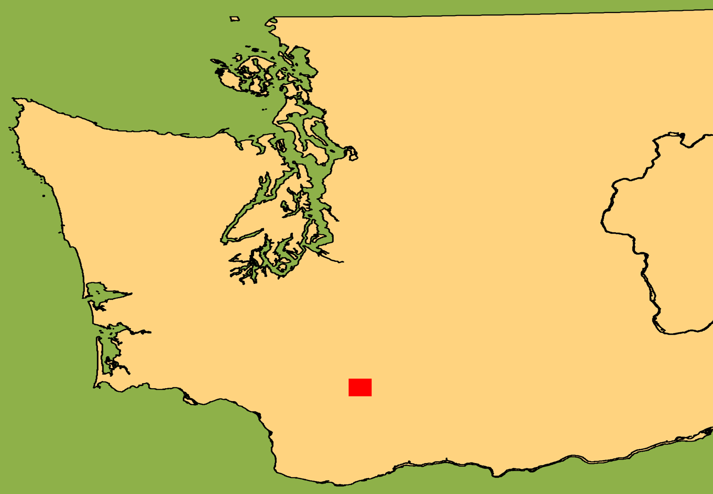
The Role of Sediments and Aquatic Plants in the Nutrient Budget of Spirit Lake at Mount St. Helens, WA



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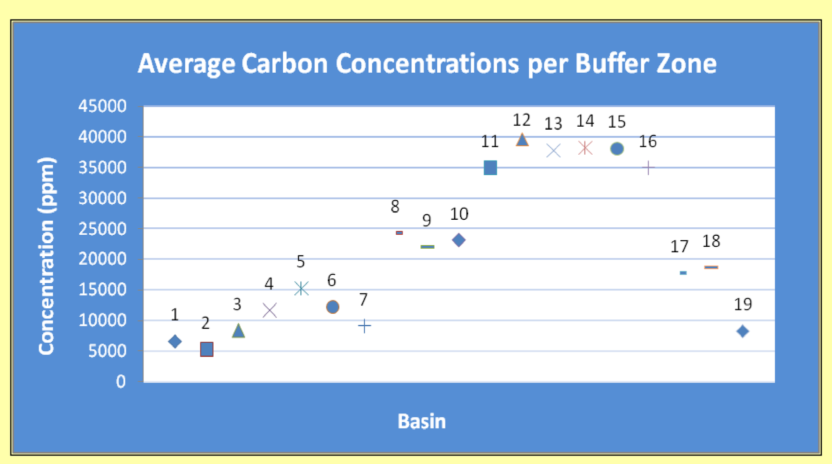
Introduction

The 1980 eruption of Mount St. Helens caused the bathymetry of Spirit Lake to change drastically, resulting in an increase in surface area and a decrease in average depth. Subsequently, Spirit Lake is experiencing an increase in productivity. This analysis examines concentrations of carbon, nitrogen and phosphorus obtained from sediment samples collected over the summer of 2010, as well as aquatic plant height data, in order to identify sources of the lake's increasing productivity. The results of these analyses will be used as part of a larger nutrient cycling model examining changes in the lake over time.

Figure 1. Zonal statistics for carbon concentrations in parts per million for each 200 meter buffer zone for all calculated drainage basins.

BASIN	AREA	MIN	MAX	RANGE	MEAN	STD
1	54026.5	3862.5	11991.4	8128.9	6641.9	2260.6
2	61468.9	3838.2	6823.8	2985.6	5337.8	827.6
3	59263.7	6604.1	9846.9	3242.7	8365.0	927.6
4	50443.1	9581.0	13654.1	4073.2	11655.6	1122.8
5	42449.4	14612.2	15739.9	1127.6	15265.7	267.7
6	63122.7	6820.8	15407.9	8587.1	12224.1	2041.9
7	53475.2	7608.7	10340.8	2732.0	9106.1	676.7
8	3307.7	22864.3	24704.2	1839.9	24295.1	519.8
9	55680.3	21348.2	22645.7	1297.4	22027.8	343.3
10	60641.9	20316.4	24654.4	4338.1	23134.5	1049.4
11	71392.1	34219.5	36031.0	1811.6	34940.5	440.4
12	85725.6	38655.2	40459.4	1804.2	39647.7	428.7
13	54302.1	36495.4	38678.4	2183.0	37807.8	544.2
14	9096.3	37439.6	38680.1	1240.6	38223.7	320.4
15	44930.2	37280.6	38987.7	1707.1	38107.6	378.1
16	65603.5	33499.6	36354.7	2855.1	34979.3	767.5
17	48513.6	11915.4	19204.2	7288.8	17817.9	2015.8
18	30596.6	18119.2	19263.4	1144.2	18636.4	285.3
19	58161.1	7796.0	8970.1	1174.1	8297.9	309.7

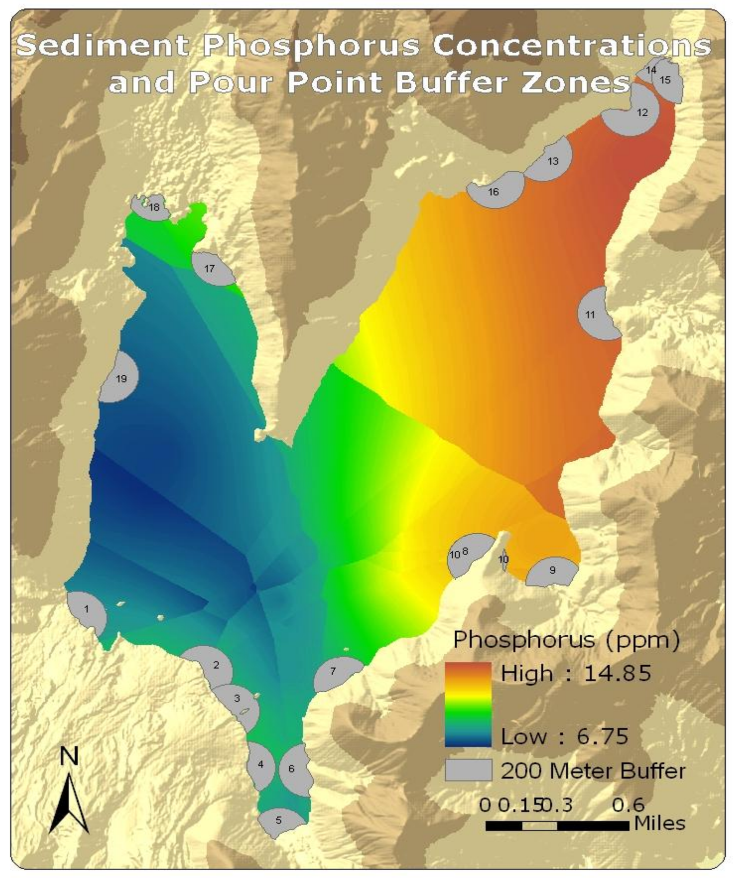
Figure 2. Mean carbon concentrations per buffer zone obtained from zonal statistics output.



Objectives

To calculate nutrient concentrations in immediate areas surrounding determined watershed drainage basin entry points in order to identify major source areas of nutrient input. To create surfaces of sediment Carbon, Nitrogen, Phosphorus and plant height to determine total nutrients in the lake sediment as well as photic zone.

Figure 3. Kriging interpolation of sediment phosphorus concentrations derived from sampling point data



Figures 4. Zonal statistics for phosphorus concentrations in parts per million for each 200 meter buffer zone for all calculated drainage basins.

VALUE	AREA	MIN	MAX	RANGE	MEAN	STD
1	56720	7.97	8.46	0.49	8.20	0.12
2	63808	8.21	9.09	0.89	8.73	0.18
3	62464	8.82	9.33	0.51	9.14	0.13
4	51584	8.87	9.29	0.42	9.11	0.10
5	44544	8.44	8.74	0.30	8.58	0.08
6	63456	8.44	9.22	0.78	8.92	0.16
7	57088	8.62	9.93	1.31	9.32	0.29
8	1744	12.17	12.91	0.74	12.65	0.16
9	58368	12.88	13.13	0.25	13.00	0.06
10	64480	12.18	12.90	0.73	12.55	0.16
11	71056	14.09	14.39	0.30	14.23	0.06
12	91248	14.17	14.73	0.55	14.48	0.14
13	64080	13.90	14.34	0.44	14.16	0.10
14	3728	14.04	14.17	0.13	14.11	0.03
15	51760	13.94	14.47	0.54	14.19	0.15
16	70144	13.31	13.90	0.59	13.64	0.15
17	50544	8.68	10.25	1.58	9.90	0.44
18	36704	9.73	10.34	0.61	9.98	0.21
19	63312	7.27	7.51	0.24	7.38	0.06

Figure 5. Mean phosphorus concentrations per buffer zone obtained from zonal statistics output.

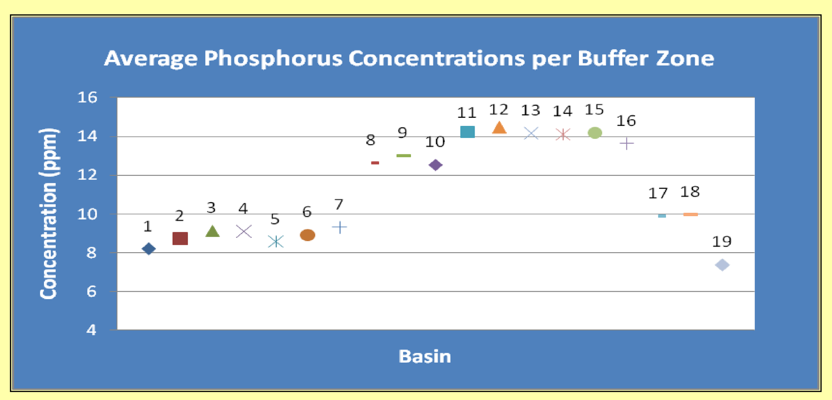
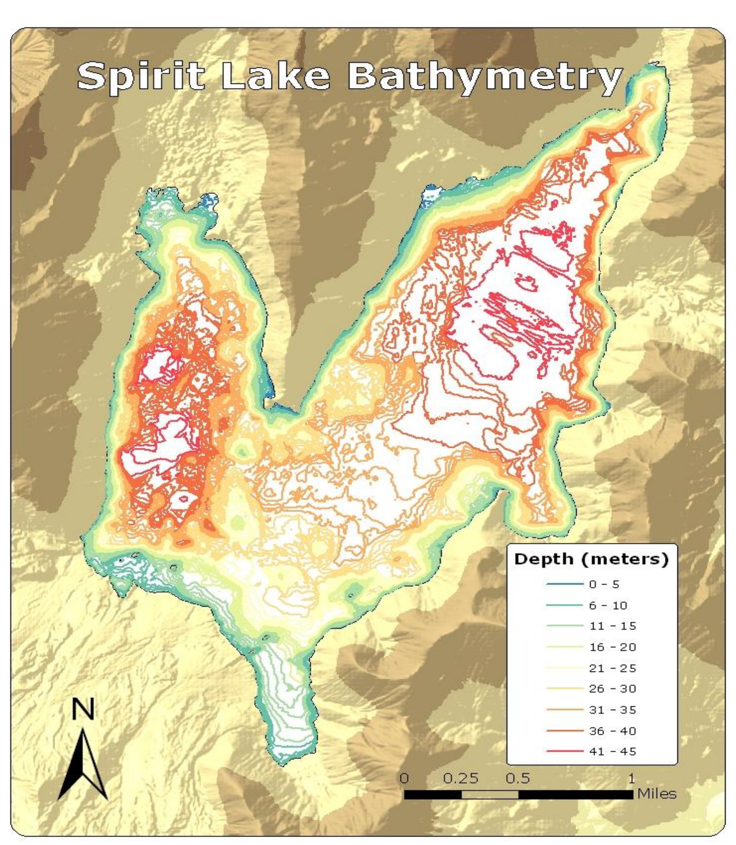


Figure 6. Bathymetry of lake classified in 5 meter increments.



Methods

Nutrient concentration results and GPS sediment sampling location data were added to ArcMap and joined. The resulting table was added as a layer as XY data. Kriging Interpolations were done for Carbon, Nitrogen and Phosphorus concentrations for the lake in total. A bathymetric point shapefile was obtained from PSU and was interpolated using IDW. Field calculator was used to calculate depth in meters from the given the elevation attribute.

Figure 6. Plant heights in the lake's photic zone, which includes areas of lake less than or equal to 10 meters in depth.

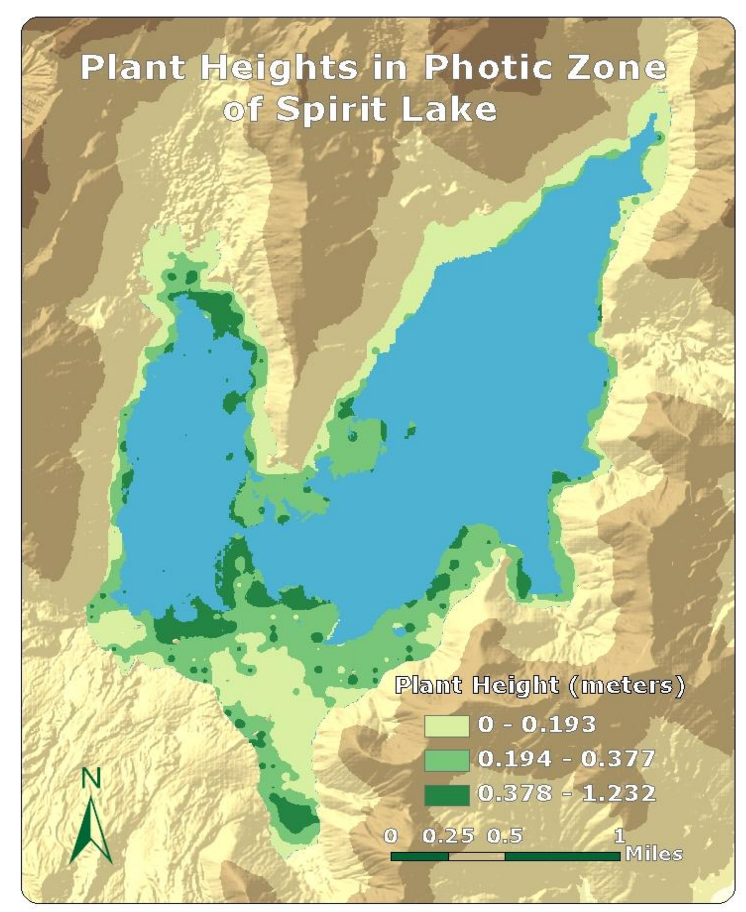


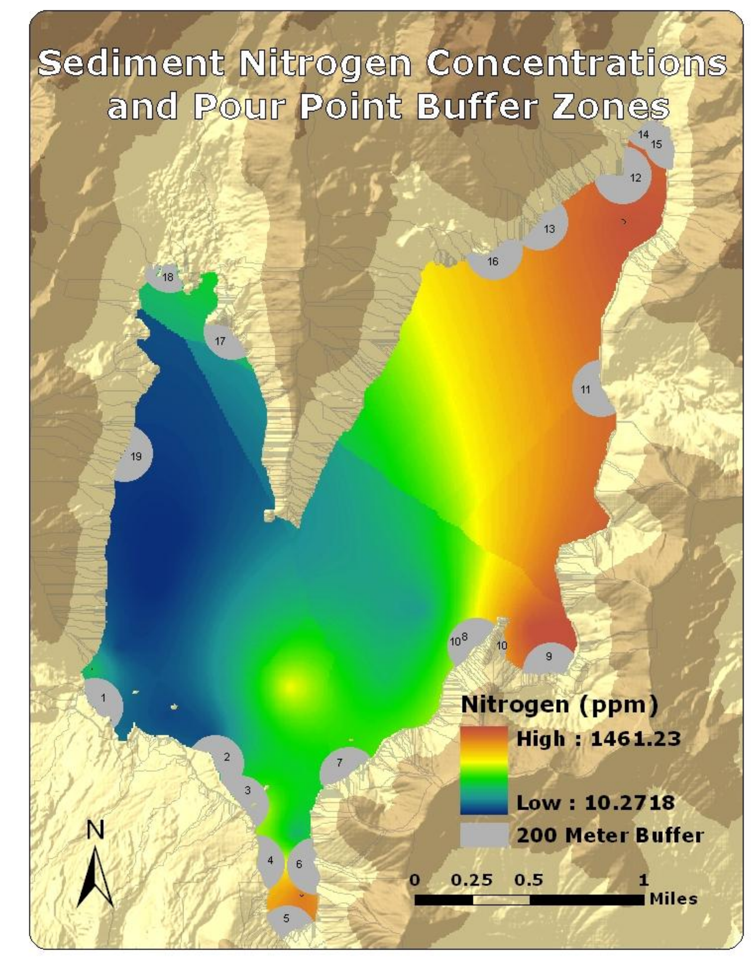
Figure 7. Zonal statistics for plant heights in photic and sub-photic zones. These plant heights and area totals will be used to determine total plant nutrients in each zone as well as total nutrient concentrations in lake sediment.

ZONE	VALUE	COUNT	AREA	MIN	MAX	RANGE	MEAN	STD	SUM
Photic (≤ 10m)	2	42455	4245500	0.0000	1.2161	1.2161	0.2377	0.13807	10093.2
Sub-Photic (≥ 10m)	1	61201	6120100	0.0382	1.9647	1.9264	0.3178	0.12559	19448.9

Methods Contd. 1

In order to classify regions of the lake with nutrient inputs broken down by drainage basin, the Spatial Analyst hydrology tools Flow Direction and Flow Accumulation were used together with a bare earth LiDAR layer, and pour points - a single entry point in which the majority of watershed streams enter the lake – was created. 200 meter buffer zones were then created around

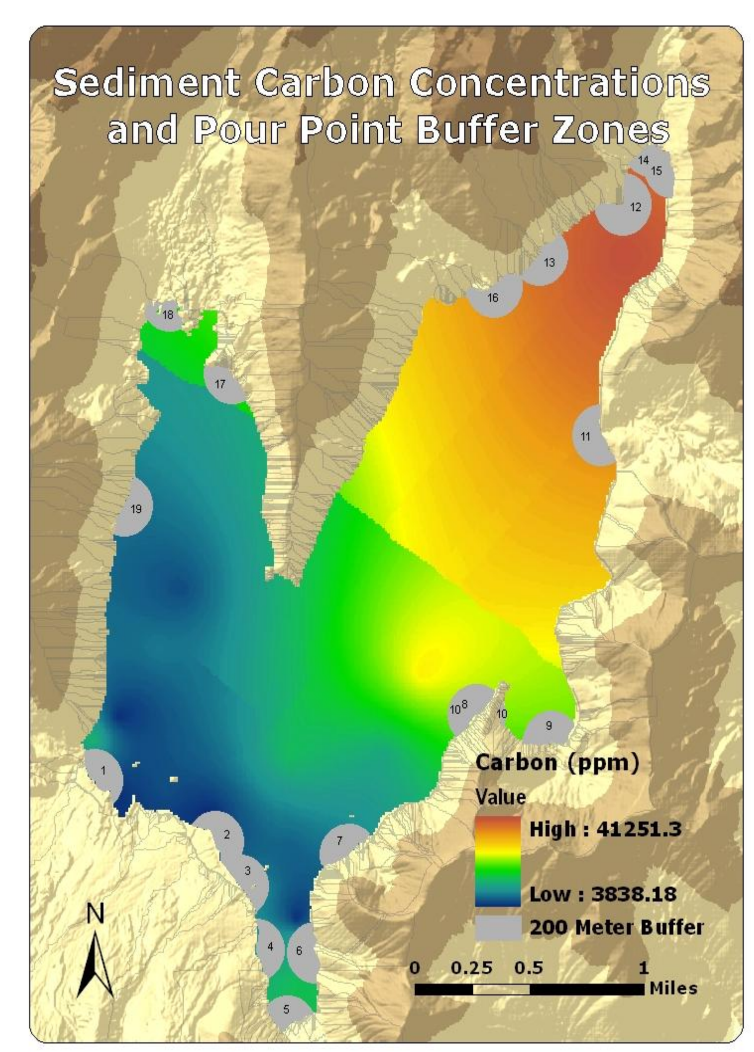
Figure 8. Kriging interpolation of nitrogen concentrations derived from sediment sampling data



Methods Contd. 2

these entry points in which nutrients can be attributed to the surrounding drainage basin areas. Zonal statistics were run to determine C, N, P values within each buffer per drainage basin. This analysis tells us how much C, N, and P are being contributed to the lake by each basin in the surrounding watershed. To

Figure 9. Kriging interpolation of sediment carbon concentrations derived from sediment sampling data



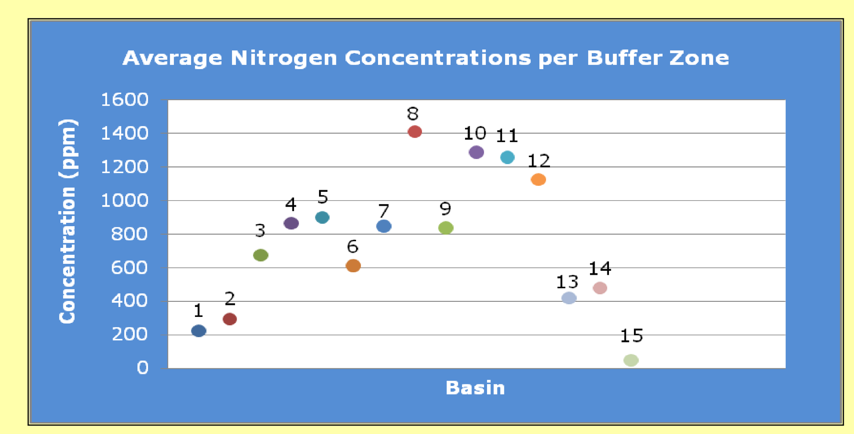
Methods Contd. 3

determine mean plant height, a point shapefile containing canopy heights was manipulated to exclude any values over 2 meters to eliminate inaccuracies caused by logs still lodged in the lake floor from the eruption. Next, an IDW interpolation was performed on the plant height attribute. Using the bathymetry layer reclassified into photic (≤10m deep) and sub-photic (≥10 m deep) zones, zonal statistics were run to determine total lake area per zone as well as average plant heights per zone.

Figure 10. Zonal statistics for nitrogen concentrations in parts per million for each 200 meter buffer zone for all calculated drainage basins

BASIN	AREA (m)	MIN	MAX	RANGE	MEAN	STD
1	47780	159	391	232	225	56
2	64447	91	518	427	294	119
3	62003	481	818	336	674	88
4	51780	707	1057	349	865	93
6	60003	537	1238	701	900	184
7	52225	556	658	102	612	29
8	1111	663	1068	405	846	151
9	56003	1293	1459	165	1411	41
10	61558	661	1195	534	837	105
11	69781	1236	1338	102	1287	25
13	44447	1199	1305	106	1258	26
16	66670	1051	1193	142	1125	38
17	47336	246	463	218	419	55
18	32224	445	527	82	479	26
19	60892	41	60	20	49	4

Figure 11. Mean nitrogen concentrations per buffer zone obtained from zonal statistics output



Results

The outputs of these analyses will be used to determine total C, N and P due to plant biomass as well as total C, N and P in the lake sediment by volume. These results will be used in conjunction with land cover data per drainage basin in order to identify sources of high nutrient input in the surrounding areas.

Projected Coordinate System:

NAD_1983_UTM_Zone_10N

Data Sources:

WAGDA, Portland State University, Bellarmine High School

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